Paper Reference(s)

6678

Edexcel GCE

Mechanics M2

Advanced Subsidiary

Thursday 7 June 2007 – Morning

Time: 1 hour 30 minutes

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Green)	Nil

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulas stored in them.

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.
There are 8 questions in this question paper.
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.

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1. A cyclist and his bicycle have a combined mass of 90 kg. He rides on a straight road up a hill inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{21}$. He works at a constant rate of 444 W and cycles up the hill at a constant speed of 6 m s^{-1}.

Find the magnitude of the resistance to motion from non-gravitational forces as he cycles up the hill.

(4)

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2. A particle P of mass 0.5 kg moves under the action of a single force **F** newtons. At time t seconds, the velocity **v** m s^{-1} of P is given by

$$\mathbf{v} = 3t^2\mathbf{i} + (1 - 4t)\mathbf{j}.$$

Find

(*a*) the acceleration of P at time t seconds,

(2)

(*b*) the magnitude of **F** when $t = 2$.

(4)

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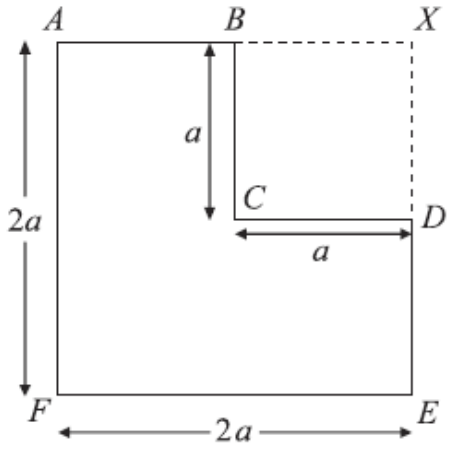
3. **Figure 1**



A uniform lamina $ABCDEF$ is formed by taking a uniform sheet of card in the form of a square $AXEF$, of side $2a$, and removing the square $BXDC$ of side a, where B and D are the mid-points of AX and XE respectively, as shown in Figure 1.

(*a*) Find the distance of the centre of mass of the lamina from AF.

(4)

The lamina is freely suspended from A and hangs in equilibrium.

(*b*) Find, in degrees to one decimal place, the angle which AF makes with the vertical.

(4)

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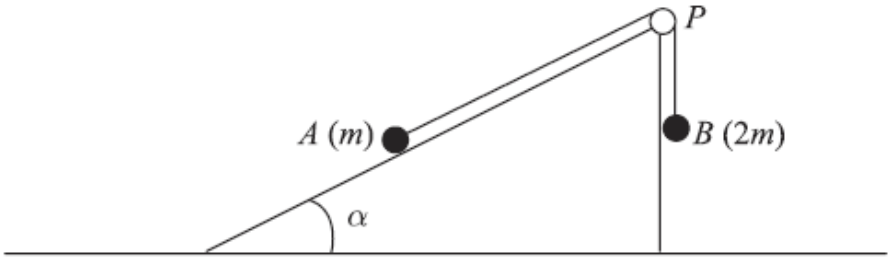
4. **Figure 2**



Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The string passes over a small light smooth pulley P fixed at the top of the plane. The particle B hangs freely below P, as shown in Figure 2. The particles are released from rest with the string taut and the section of the string from A to P parallel to a line of greatest slope of the plane. The coefficient of friction between A and the plane is $\frac{5}{8}$. When each particle has moved a distance h, B has not reached the ground and A has not reached P.

(a) Find an expression for the potential energy lost by the system when each particle has moved a distance h.

(2)

When each particle has moved a distance h, they are moving with speed v. Using the work-energy principle,

(b) find an expression for v^2, giving your answer in the form kgh, where k is a number.

(5)

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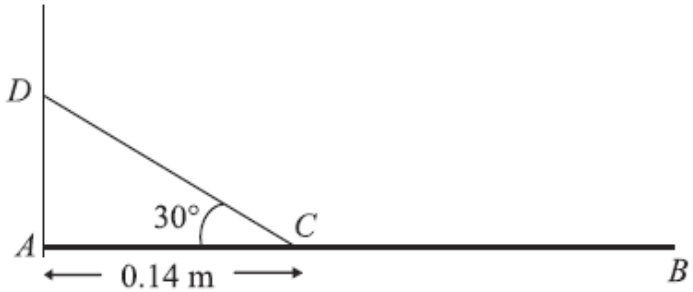
5. **Figure 3**



A uniform beam AB of mass 2 kg is freely hinged at one end A to a vertical wall. The beam is held in equilibrium in a horizontal position by a rope which is attached to a point C on the beam, where $AC = 0.14$ m. The rope is attached to the point D on the wall vertically above A, where $\angle ACD = 30°$, as shown in Figure 3. The beam is modelled as a uniform rod and the rope as a light inextensible string. The tension in the rope is 63 N.

Find

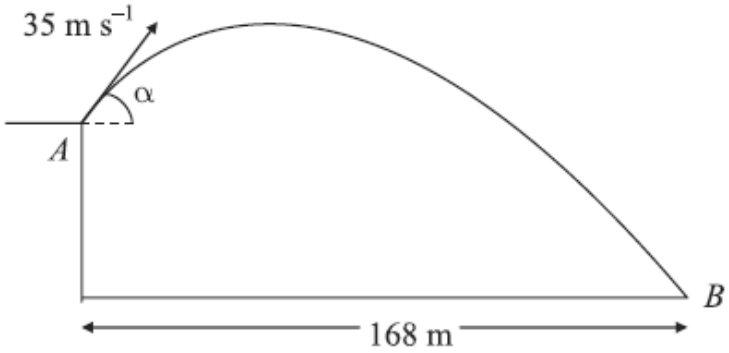
(*a*) the length of AB,

(4)

(*b*) the magnitude of the resultant reaction of the hinge on the beam at A.

(5)

6. **Figure 4**



A golf ball P is projected with speed 35 m s^{-1} from a point A on a cliff above horizontal ground. The angle of projection is α to the horizontal, where $\tan \alpha = \frac{4}{3}$. The ball moves freely under gravity and hits the ground at the point B, as shown in Figure 4.

(*a*) Find the greatest height of P above the level of A.

(3)

The horizontal distance from A to B is 168 m.

(*b*) Find the height of A above the ground.

(6)

By considering energy, or otherwise,

(*c*) find the speed of P as it hits the ground at B.

(3)

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7. Two small spheres P and Q of equal radius have masses m and $5m$ respectively. They lie on a smooth horizontal table. Sphere P is moving with speed u when it collides directly with sphere Q which is at rest. The coefficient of restitution between the spheres is e, where $e > \frac{1}{5}$.

(a) (i) Show that the speed of P immediately after the collision is $\frac{u}{6}(5e - 1)$.

(ii) Find an expression for the speed of Q immediately after the collision, giving your answer in the form λu, where λ is in terms of e.

(6)

Three small spheres A, B and C of equal radius lie at rest in a straight line on a smooth horizontal table, with B between A and C. The spheres A and C each have mass $5m$, and the mass of B is m. Sphere B is projected towards C with speed u. The coefficient of restitution between each pair of spheres is $\frac{4}{5}$.

(b) Show that, after B and C have collided, there is a collision between B and A.

(3)

(c) Determine whether, after B and A have collided, there is a further collision between B and C.

(4)

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8. A particle P moves on the x-axis. At time t seconds the velocity of P is v m s^{-1} in the direction of x increasing, where v is given by

$$v = \begin{cases} 8t - \frac{3}{2}t^2, & 0 \leq t \leq 4 \\ 16 - 2t, & t > 4. \end{cases}$$

When $t = 0$, P is at the origin O.

Find

(a) the greatest speed of P in the interval $0 \leq t \leq 4$,

(4)

(b) the distance of P from O when $t = 4$,

(3)

(c) the time at which P is instantaneously at rest for $t > 4$,

(1)

(d) the total distance travelled by P in the first 10 s of its motion.

(8)

TOTAL FOR PAPER: 75 MARKS

END