6678

Edexcel GCE

Mechanics M2

Advanced/Advanced Subsidiary

Wednesday 21 January 2004 − Afternoon

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 $g = 9.8$ 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.

1. A car of mass 400 kg is moving up a straight road inclined at an angle θ to the horizontal, where $\sin \theta = \frac{1}{14}$. The resistance to motion of the car from non-gravitational forces is modelled as a constant force of magnitude R newtons. When the car is moving at a constant speed of 20 m s^{-1}, the power developed by the car's engine is 10 kW.

   Find the value of R.

   (5)

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2. A particle P of mass 0.75 kg is moving under the action of a single force $\mathbf{F}$ newtons. At time t seconds, the velocity $\mathbf{v}$ m s^{-1} of P is given by

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

   (*a*) Find the magnitude of $\mathbf{F}$ when $t = 4$.
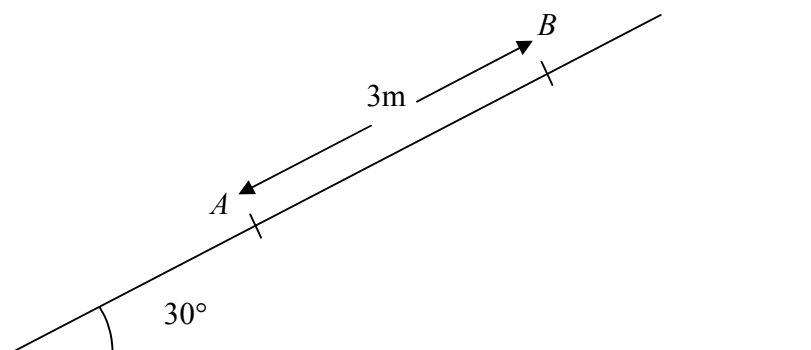
   (5)

   When $t = 5$, the particle P receives an impulse of magnitude $9\sqrt{2}$ Ns in the direction of the vector $\mathbf{i} - \mathbf{j}.$

   (*b*) Find the velocity of P immediately after the impulse.

   (4)

3.

<div align="center">Figure 1</div>

A particle P of mass 2 kg is projected from a point A up a line of greatest slope AB of a fixed plane. The plane is inclined at an angle of 30° to the horizontal and $AB = 3$ m with B above A, as shown in Fig. 1. The speed of P at A is 10 m s^{-1}.

Assuming the plane is smooth,
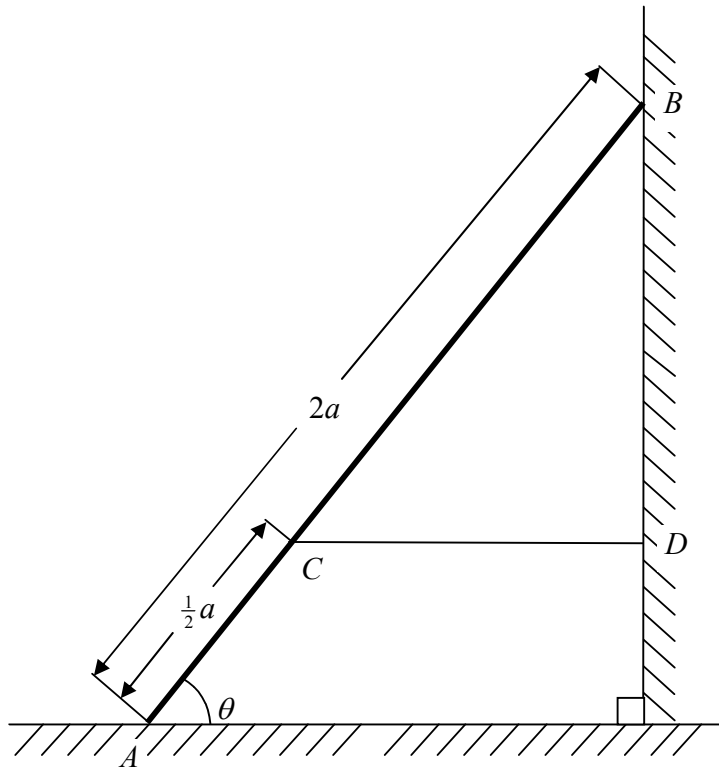
(*a*) find the speed of P at B.

(4)

The plane is now assumed to be rough. At A the speed of P is 10 m s^{-1} and at B the speed of P is 7 m s^{-1}. By using the work-energy principle, or otherwise,

(*b*) find the coefficient of friction between P and the plane.

(5)

4.
Figure 2

A uniform ladder, of weight W and length $2a$, rests in equilibrium with one end A on a smooth horizontal floor and the other end B on a rough vertical wall. The ladder is in a vertical plane perpendicular to the wall. The coefficient of friction between the wall and the ladder is μ. The ladder makes an angle θ with the floor, where $\tan \theta = 2$. A horizontal light inextensible string CD is attached to the ladder at the point C, where $AC = \frac{1}{2}a$. The string is attached to the wall at the point D, with BD vertical, as shown in Fig. 2. The tension in the string is $\frac{1}{4}W$. By modelling the ladder as a rod,

(*a*) find the magnitude of the force of the floor on the ladder,

(5)

(*b*) show that $\mu \geq \frac{1}{2}$.

(4)

(*c*) State how you have used the modelling assumption that the ladder is a rod.

(1)

5. A particle P is projected with velocity $(2u\mathbf{i} + 3u\mathbf{j})$ m s^{-1} from a point O on a horizontal plane, where $\mathbf{i}$ and $\mathbf{j}$ are horizontal and vertical unit vectors respectively. The particle P strikes the plane at the point A which is 735 m from O.

(*a*) Show that $u = 24.5$.

(6)

(*b*) Find the time of flight from O to A.

(2)

The particle P passes through a point B with speed 65 m s^{-1}.

(*c*) Find the height of B above the horizontal plane.

(4)

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6. A smooth sphere A of mass m is moving with speed u on a smooth horizontal table when it collides directly with another smooth sphere B of mass $3m$, which is at rest on the table. The coefficient of restitution between A and B is e. The spheres have the same radius and are modelled as particles.

(*a*) Show that the speed of B immediately after the collision is $\frac{1}{4}(1 + e)u$.

(5)

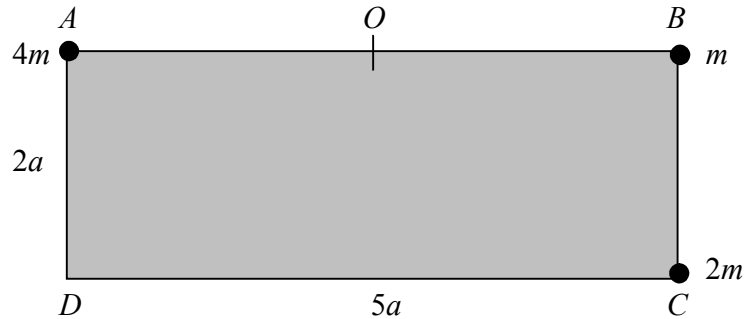(*b*) Find the speed of A immediately after the collision.

(2)

Immediately after the collision the total kinetic energy of the spheres is $\frac{1}{6}mu^2$.

(*c*) Find the value of e.

(6)

(*d*) Hence show that A is at rest after the collision.

(1)

7.

Figure 3

A loaded plate L is modelled as a uniform rectangular lamina $ABCD$ and three particles. The sides CD and AD of the lamina have lengths $5a$ and $2a$ respectively and the mass of the lamina is $3m$. The three particles have mass $4m$, m and $2m$ and are attached at the points A, B and C respectively, as shown in Fig. 3.

(*a*) Show that the distance of the centre of mass of L from AD is $2.25a$.

(3)

(*b*) Find the distance of the centre of mass of L from AB.

(2)

The point O is the mid-point of AB. The loaded plate L is freely suspended from O and hangs at rest under gravity.

(*c*) Find, to the nearest degree, the size of the angle that AB makes with the horizontal.

(3)

A horizontal force of magnitude P is applied at C in the direction CD. The loaded plate L remains suspended from O and rests in equilibrium with AB horizontal and C vertically below B.

(*d*) Show that $P = \frac{5}{4} mg$.

(4)

(*e*) Find the magnitude of the force on L at O.

(4)

END