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Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M2

Advanced/Advanced Subsidiary

Friday 17 June 2016 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
WME02/01

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

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 formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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1. A particle of mass 3 kg is moving with velocity $(3\mathbf{i} + 5\mathbf{j})$ m s^{-1} when it receives an impulse $(-4\mathbf{i} + 3\mathbf{j})$ N s.

Find

(a) the speed of the particle immediately after receiving the impulse,

(5)

(b) the kinetic energy gained by the particle as a result of the impulse.

(3)

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2. A truck of mass 1800 kg is moving along a straight horizontal road. The engine of the truck is working at a constant rate of 10 kW. The non-gravitational resistance to motion is modelled as a constant force of magnitude R newtons. At the instant when the truck is moving with speed 15 m s^{-1}, the acceleration of the truck is 0.25 m s^{-2}.

(a) Find the value of R.

(4)

The truck now moves up a straight road at a constant speed V m s^{-1}. The road is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{14}$. The non-gravitational resistance to motion is now modelled as a constant force of magnitude $30V$ newtons. The engine of the truck is now working at a constant rate of 12 kW.

(b) Find the value of V.

(6)

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Question 2 continued

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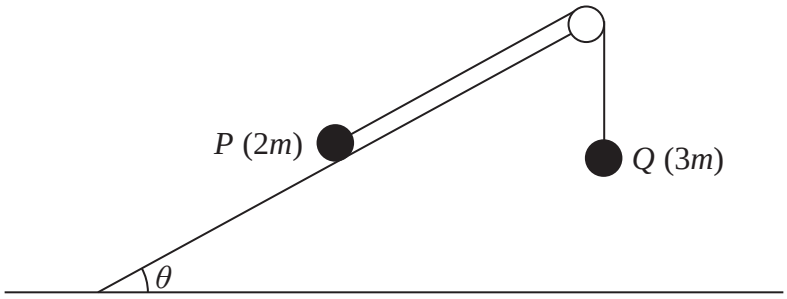

Figure 1

Two particles P and Q, of mass $2m$ and $3m$ respectively, are connected by a light inextensible string. Initially P is held at rest on a fixed rough plane inclined at θ to the horizontal ground, where $\sin\theta = \frac{2}{5}$. The string passes over a small smooth pulley fixed at the top of the plane. The particle Q hangs freely below the pulley, as shown in Figure 1. The part of the string from P to the pulley lies along a line of greatest slope of the plane. At time $t = 0$ the system is released from rest with the string taut. When P moves the friction between P and the plane is modelled as a constant force of magnitude $\frac{3}{5}mg$. At the instant when each particle has moved a distance d, they are both moving with speed v, particle P has not reached the pulley and Q has not reached the ground.

(a) Show that the total potential energy lost by the system when each particle has moved a distance d is $\frac{11}{5}mgd$.

(3)

(b) Use the work-energy principle to find v^2 in terms of g and d.

(4)

When $t = T$ seconds, $d = 1.5$ m.

(c) Find the value of T.

(2)

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Question 3 continued

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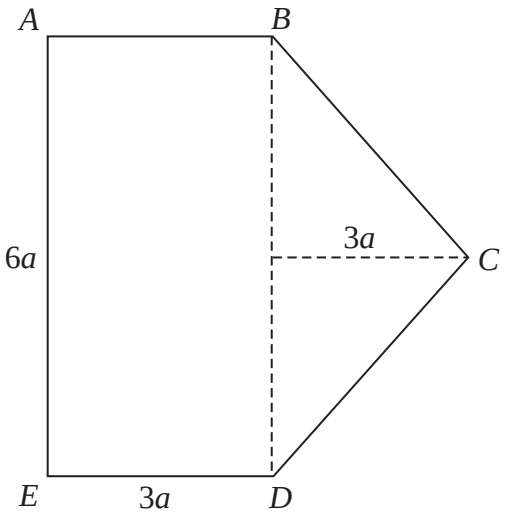

Figure 2

The uniform lamina *ABCDE* is made by joining a rectangular lamina *ABDE* to a triangular lamina *BCD* along the edge *BD*. The rectangle has length 6*a* and width 3*a*. The triangle is isosceles, with *BC* = *CD*, and the distance from *C* to *BD* is 3*a*, as shown in Figure 2.

(a) Find the distance of the centre of mass of the lamina, *ABCDE*, from *AE*.

(5)

The lamina *ABCDE* is freely suspended from *A*. A horizontal force of magnitude *F* newtons is applied to the lamina at *D*. The line of action of the force lies in the vertical plane containing the lamina. The lamina is in equilibrium with *AE* vertical. The mass of the lamina is 4 kg.

(b) Find the magnitude of the force exerted on the lamina at *A*.

(5)

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Question 4 continued

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5.

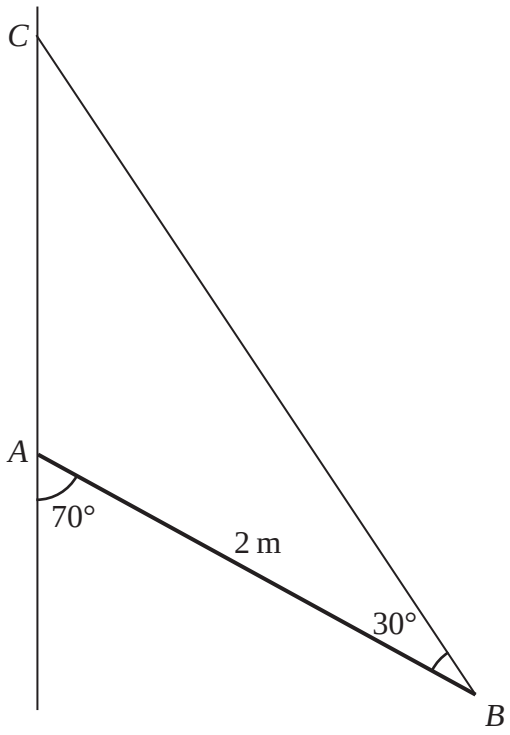

Figure 3

A uniform rod AB has mass 6 kg and length 2 m. The end A of the rod rests against a rough vertical wall. One end of a light string is attached to the rod at B. The other end of the string is attached to the wall at C, which is vertically above A. The angle between the rod and the string is 30° and the angle between the rod and the wall is 70°, as shown in Figure 3. The rod is in a vertical plane perpendicular to the wall and rests in limiting equilibrium.

Find

(a) the tension in the string,

(4)

(b) the coefficient of friction between the rod and the wall,

(5)

(c) the direction of the force exerted on the rod by the wall at A.

(2)

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Question 5 continued

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6. [*In this question the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertically upwards.*]

At $t = 0$ a particle P is projected from a fixed point O with velocity $(7\mathbf{i} + 7\sqrt{3}\mathbf{j})$ m s^{-1}. The particle moves freely under gravity. The position vector of a point on the path of P is $(x\mathbf{i} + y\mathbf{j})$ m relative to O.

(a) Show that

$$y = \sqrt{3}x - \frac{g}{98}x^2$$

(5)

(b) Find the direction of motion of P when it passes through the point on the path where $x = 20$

(4)

At time T seconds P passes through the point with position vector $(2\lambda\mathbf{i} + \lambda\mathbf{j})$ m where λ is a positive constant.

(c) Find the value of T.

(4)

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Question 6 continued

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7. Two particles A and B, of mass m and $2m$ respectively, are moving in the same direction along the same straight line on a smooth horizontal surface, with B in front of A. Particle A has speed 3 m s^{-1} and particle B has speed 2 m s^{-1}. Particle A collides directly with particle B. The coefficient of restitution between A and B is $\frac{2}{3}$. The direction of motion of both particles is not changed by the collision. Immediately after the collision, A has speed $v\text{ m s}^{-1}$ and B has speed $w\text{ m s}^{-1}$.

(a) (i) Show that $w = \frac{23}{9}$.

(ii) Find the value of v.

(7)

When A and B collide they are 3 m from a smooth vertical wall which is perpendicular to their direction of motion. After the collision with A, particle B hits the wall and rebounds. The coefficient of restitution between B and the wall is $\frac{1}{2}$.

There is a second collision between A and B at a point d m from the wall.

(b) Find the value of d.

(7)

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Question 7 continued