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Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Time 1 hour 30 minutes

Paper reference **WME02/01**

Mathematics

International Advanced Subsidiary/Advanced Level
Mechanics M2

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. 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).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- 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 $g = 9.8\,\text{m s}^{-2}$, and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. 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.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ▶

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1. Three particles of masses $2m$, $3m$ and $4m$ are placed at the points with coordinates $(-2, 5)$, $(2, -3)$ and $(3k, k)$ respectively, where k is a constant.
The centre of mass of the three particles is at the point $(\bar{x}, \bar{y})$.

(a) Show that $\bar{x} = \dfrac{2 + 12k}{9}$

(2)

The centre of mass of the three particles lies at a point on the straight line with equation $x + 2y = 3$

(b) Find the value of k.

(4)

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Question 1 continued

Q1

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2. A car of mass 900 kg is moving down a straight road which is inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{12}$

The engine of the car is working at a constant rate of 15 kW.
The resistance to the motion of the car is modelled as a constant force of magnitude 400 N.

Find the acceleration of the car at the instant when it is moving at $16\,\text{m s}^{-1}$

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Question 2 continued

Q2

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3. A particle P of mass 0.2 kg is moving with velocity $(4\mathbf{i} - 3\mathbf{j})\,\text{m s}^{-1}$

The particle receives an impulse $\lambda(\mathbf{i} + \mathbf{j})\,\text{N s}$, where λ is a constant.

Immediately after receiving the impulse, the speed of P is $7\,\text{m s}^{-1}$

Find the possible values of λ

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Question 3 continued

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4. At time t seconds ($0 \leqslant t < 5$), a particle P has velocity $\mathbf{v}\,\text{m s}^{-1}$, where

$$\mathbf{v} = \left(\sqrt{5 - t}\right)\mathbf{i} + \left(t^2 + 2t - 3\right)\mathbf{j}$$

When $t = \lambda$, particle P is moving in a direction parallel to the vector $\mathbf{i}$.

(a) Find the acceleration of P when $t = \lambda$

(5)

The position vector of P is measured relative to the fixed point O
When $t = 1$, the position vector of P is $(-2\mathbf{i} + \mathbf{j})$m.

Given that $1 \leqslant T < 5$

(b) find, in terms of T, the position vector of P when $t = T$

(5)

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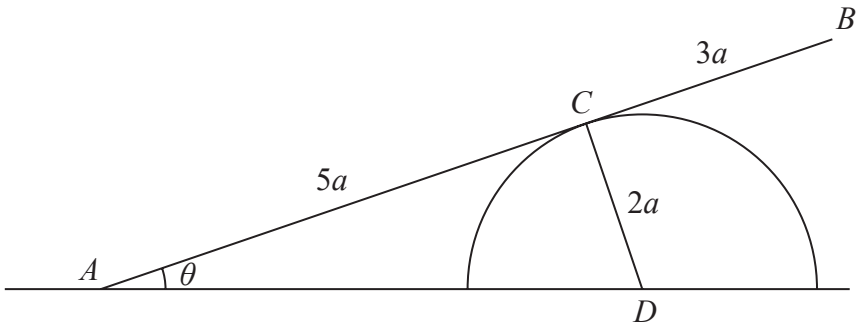


Figure 1

A uniform rod AB has length $8a$ and weight W.
The end A of the rod is freely hinged to horizontal ground.
The rod rests in equilibrium against a block which is also fixed to the ground.
The block is modelled as a smooth solid hemisphere with radius $2a$ and centre D.
The point of contact between the rod and the block is C, where $AC = 5a$
The rod is at an angle θ to the ground, as shown in Figure 1.
Points A, B, C and D all lie in the same vertical plane.

(a) Show that $AD = \sqrt{29}a$

(1)

(b) Show that the magnitude of the normal reaction at C between the rod and the block is $\frac{4}{\sqrt{29}}W$

(3)

The resultant force acting on the rod at A has magnitude kW and acts at an angle α to the ground.

(c) Find (i) the exact value of k
(ii) the exact value of $\tan\alpha$

(8)

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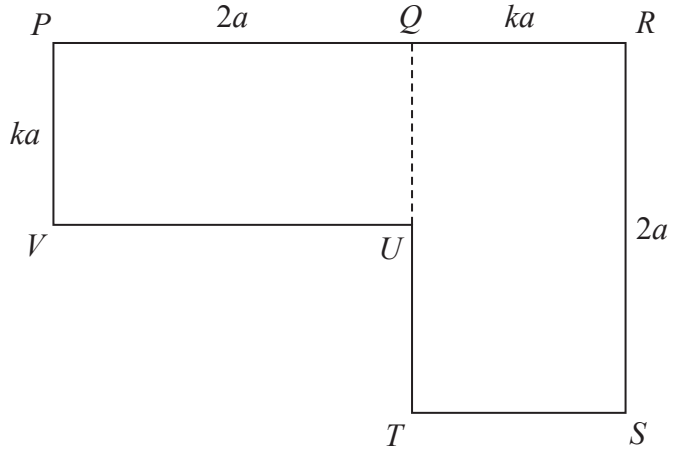


Figure 2

The uniform lamina $PQRSTUV$ shown in Figure 2 is formed from two identical rectangles, $PQUV$ and $QRSTU$.
The rectangles have sides $PQ = RS = 2a$ and $PV = QR = ka$.

(a) Show that the centre of mass of the lamina is $\left(\frac{6+k}{4}\right)a$ from PV

(3)

The lamina is freely suspended from P and hangs in equilibrium with PR at an angle of α to the downward vertical.

Given that $\tan\alpha = \frac{7}{15}$

(b) find the value of k.

(6)

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Question 6 continued

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7. Particle A has mass m and particle B has mass $2m$.
The particles are moving in the same direction along the same straight line on a smooth horizontal surface.
Particle A collides directly with particle B.
Immediately before the collision, the speed of A is $3u$ and the speed of B is u.
The coefficient of restitution between A and B is e.

(a) (i) Show that the speed of B immediately after the collision is $\frac{5 + 2e}{3}u$

(ii) Find the speed of A immediately after the collision.

(7)

After the collision, B hits a smooth fixed vertical wall that is perpendicular to the direction of motion of B.

The coefficient of restitution between B and the wall is $\frac{1}{3}$

Particle B rebounds and there is a second collision between A and B.
The first collision between A and B occurs at a distance d from the wall.
The time between the two collisions is T.

Given that $e = \frac{1}{2}$

(b) find T in terms of d and u.

(6)

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

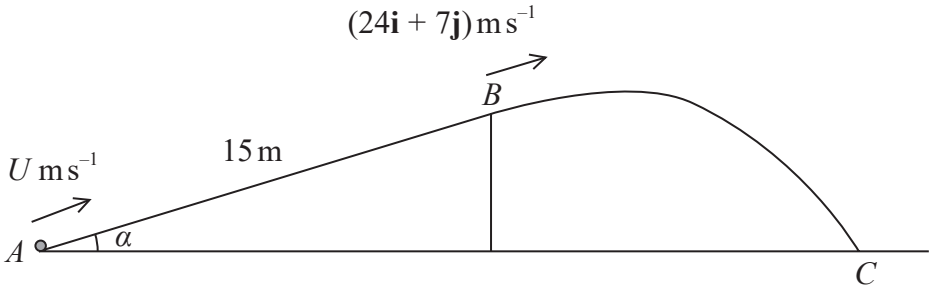


Figure 3

A rough ramp is fixed to horizontal ground.

The ramp is inclined to the ground at an angle α, where $\tan\alpha = \frac{7}{24}$

The point A is at the bottom of the ramp and the point B is at the top of the ramp.
The line AB is a line of greatest slope of the ramp and $AB = 15\,\text{m}$, as shown in Figure 3.

A particle P of mass $0.3\,\text{kg}$ is projected with speed $U\,\text{m s}^{-1}$ from A directly towards B.
At the instant P reaches the point B, the velocity of P is $(24\mathbf{i} + 7\mathbf{j})\,\text{m s}^{-1}$
The particle leaves the ramp at B, and moves freely under gravity until it hits the horizontal ground at the point C.

The coefficient of friction between P and the ramp is $\frac{1}{5}$

(a) Find the work done against friction as P moves from A to B.

(3)

(b) Use the work-energy principle to find the value of U.

(4)

(c) Find the time taken by P to move from B to C.

(3)

At the instant immediately before P hits the ground at C, the particle is moving downwards at $\theta°$ to the horizontal.

(d) Find the value of θ

(4)

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