Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
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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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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**

**(Total 6 marks)**

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**2.** A car of mass 900 kg is moving down a straight road which is inclined at an angle $\alpha$ 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**

**(Total 5 marks)**

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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 $\lambda$ is a constant.

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

Find the possible values of $\lambda$

**(6)**

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**Question 3 continued**

**Q3**

**(Total 6 marks)**

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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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**Question 4 continued**

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**5.**

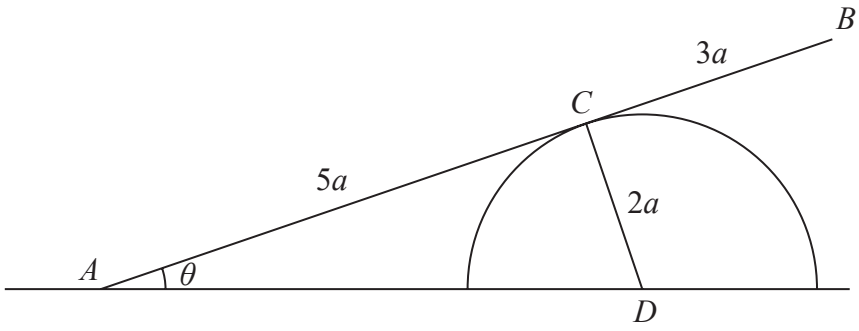


**Figure 1**

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 $\theta$ 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 $\dfrac{4}{\sqrt{29}}W$

**(3)**

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

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

**(8)**

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**Question 5 continued**

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**6.**

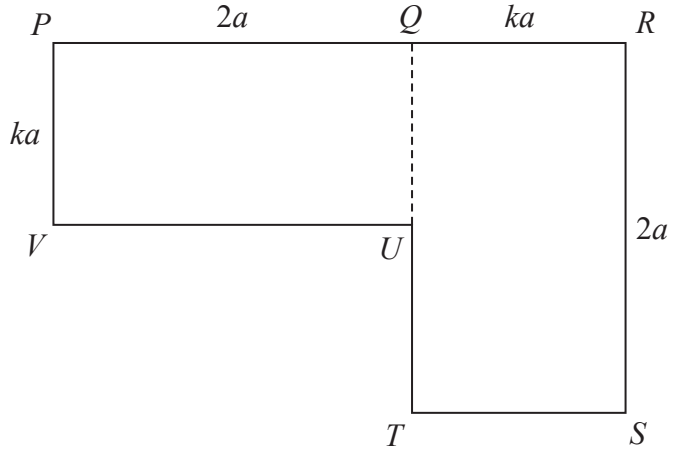


**Figure 2**

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 $\alpha$ 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**

**Q6**

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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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**Question 7 continued**

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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.*]

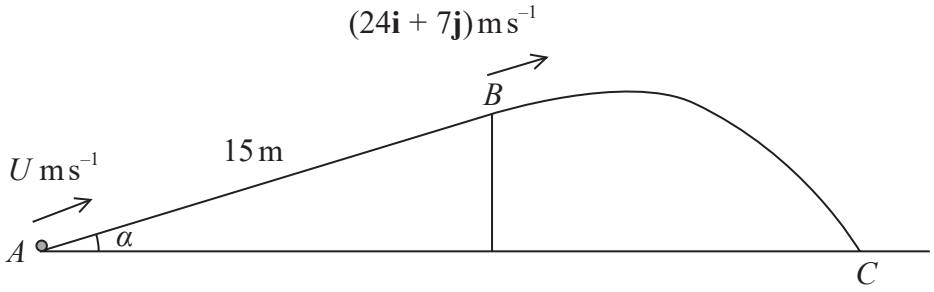


**Figure 3**

A rough ramp is fixed to horizontal ground.

The ramp is inclined to the ground at an angle $\alpha$, 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 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 $\theta$

**(4)**

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**Question 8 continued**