# Pearson Edexcel International Advanced Level

## Thursday 23 October 2025

Afternoon (Time: 1 hour 30 minutes)

**Paper reference** **WME02/01A**

# Mathematics

**International Advanced Subsidiary/Advanced Level**
**Mechanics M2**
**Question Paper**

**You must have:**
Answer book (sent separately).
Do not return this question paper with the answer book.

*Turn over* ▶

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**1** A particle of mass 4 kg is moving with velocity $(2\mathbf{i} + 3\mathbf{j})\,\text{m s}^{-1}$ when it receives an impulse of $(7\mathbf{i} - 5\mathbf{j})\,\text{N s}$.

Find the speed of the particle immediately after receiving the impulse.

**(5)**

**(Total for Question 1 is 5 marks)**

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**2** Three particles of masses $m$, $4m$ and $km$ are placed at the points whose coordinates are $(-3, 2)$, $(4, 3)$ and $(6, -4)$ respectively.

The centre of mass of the three particles is at the point with coordinates $(c, 0)$.

Find

(a) the value of $k$,

**(3)**

(b) the value of $c$.

**(3)**

**(Total for Question 2 is 6 marks)**

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**3.** **In this question you must show all stages of your working.**
**Solutions relying on calculator technology are not acceptable.**

At time $t$ seconds ($t \geqslant 0$) a particle $P$ has position vector $\mathbf{r}$ metres, with respect to a fixed origin $O$, where

$$\mathbf{r} = (16t - 3t^3)\mathbf{i} + (t^3 - t^2 + 2)\mathbf{j}$$

Find

(a) the velocity of $P$ at the instant when it is moving parallel to the vector $\mathbf{j}$,

**(5)**

(b) the magnitude of the acceleration of $P$ when $t = 4$

**(4)**

**(Total for Question 3 is 9 marks)**

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**4.**

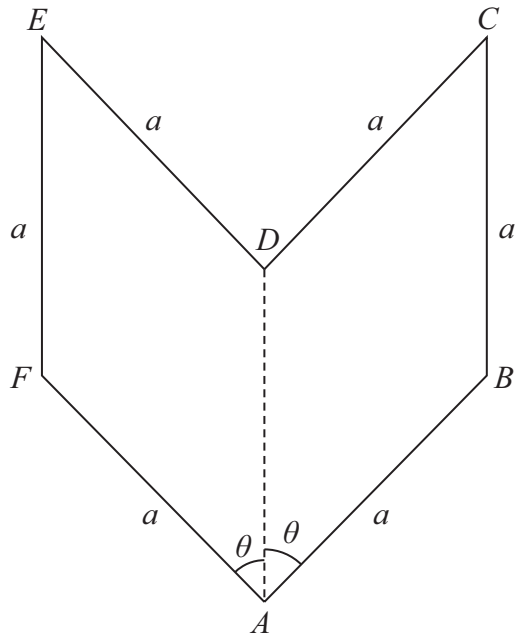



**Figure 1**

The uniform plane lamina $ABCDEF$ shown in Figure 1 is made from two identical rhombuses.

Each rhombus has sides of length $a$ and angle $BAD$ = angle $DAF = \theta$.

The centre of mass of the lamina is $0.9a$ from $A$.

(a) Show that $\cos\theta = 0.8$

**(5)**

The weight of the lamina is $W$.

A particle of weight $kW$ is fixed to the lamina at the point $A$.

The lamina is freely suspended from $B$ and hangs in equilibrium with $DA$ horizontal.

(b) Find the value of $k$.

**(4)**

**(Total for Question 4 is 9 marks)**

**5**

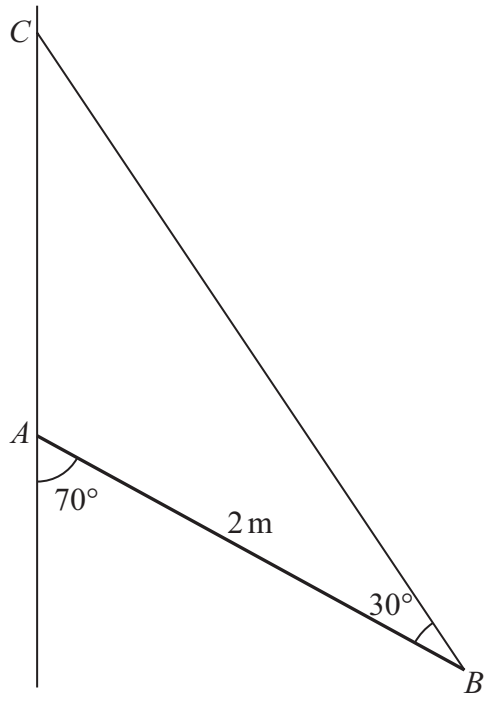



**Figure 2**

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 2.

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)**

**(Total for Question 5 is 11 marks)**

**6.** **In this question you must show all stages of your working.**
**Solutions relying on calculator technology are not acceptable.**

A particle $P$ moves on the $x$-axis.

At time $t$ seconds, $t \geqslant 0$

- the acceleration of $P$ is $(2t - 3)\,\text{m s}^{-2}$ in the positive $x$ direction
- the velocity of $P$ is $v\,\text{m s}^{-1}$ in the positive $x$ direction

When $t = 3$, $v = 2$

(a) Find $v$ in terms of $t$.

**(4)**

The particle first comes to instantaneous rest at the point $A$ and then comes to instantaneous rest again at the point $B$.

(b) Find the distance $AB$.

**(6)**

**(Total for Question 6 is 10 marks)**

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**7.** A particle $P$ is projected from a fixed point $A$ with speed $12\,\text{m s}^{-1}$ at an angle $\alpha$ above the horizontal and moves freely under gravity.

As $P$ passes through the point $B$ on its path, $P$ is moving with speed $8\,\text{m s}^{-1}$ at an angle $\beta$ below the horizontal.

(a) By using the principle of the conservation of mechanical energy, find the vertical distance between $A$ and $B$.

**(4)**

Particle $P$ takes 1.5 seconds to travel from $A$ to $B$.

(b) Find the size of angle $\alpha$.

**(3)**

(c) Find the size of angle $\beta$.

**(3)**

(d) Find the length of time for which the speed of $P$ is less than $8\,\text{m s}^{-1}$.

**(4)**

**(Total for Question 7 is 14 marks)**

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**8.** Three particles $A$, $B$ and $C$, each of mass $m$, lie at rest in a straight line $L$ on a smooth horizontal surface, with $B$ **between** $A$ and $C$.

Particles $A$ and $B$ are projected directly **towards** each other with speeds $5u$ and $4u$ respectively.

**At the same instant**, particle $C$ is projected directly **away** from $B$ with speed $3u$.

In the subsequent motion, $A$, $B$ and $C$ move along $L$.

Particles $A$ and $B$ collide directly.

The coefficient of restitution between $A$ and $B$ is $e$.

(a) Find

(i) the speed of $A$ immediately after the collision,

(ii) the speed of $B$ immediately after the collision.

**(7)**

Given that the direction of motion of $A$ is **reversed** in the collision between $A$ and $B$, and that there is **no** collision between $B$ and $C$,

(b) find the set of possible values of $e$.

**(4)**

**(Total for Question 8 is 11 marks)**

**TOTAL FOR PAPER IS 75 MARKS**

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# Pearson Edexcel International Advanced Level

## Thursday 23 October 2025

Afternoon (Time: 1 hour 30 minutes) | Paper reference **WME02/01A**

# Mathematics

## International Advanced Subsidiary/Advanced Level
## Mechanics M2
## Answer Book

**You must have:** Question paper (sent separately)
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 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 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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**Question 1**

**Write the answer to Question 1 on these 2 pages**

Impulse = change in momentum: $I = mv - mu$

$(7i - 5j) = 4v - 4(2i + 3j)$

$4v = 7i - 5j + 8i + 12j = 15i + 7j$

$v = \frac{15}{4}i + \frac{7}{4}j$

Speed $= |v| = \frac{1}{4}\sqrt{(15^2 + 7^2)}$

$= \frac{\sqrt{274}}{4} = 4.1382...$

Speed $= 4.14\ m\ s^{-1}$

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**Question 1 continued**

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**(Total for Question 1 is 5 marks)**

**Question 2**

**Write the answer to Question 2 on these 2 pages**

(a) Total mass = $m + 4m + km = (5 + k)m$

Moments about the x-axis ($\bar{y} = 0$):

$m \times 2 + 4m \times 3 + km \times (-4) = (5 + k)m \times 0$

$2 + 12 - 4k = 0$

$k = 3.5$

(b) Moments about the y-axis:

$m \times (-3) + 4m \times 4 + km \times 6 = (5 + k)m \times c$

$m \times (-3) + 4m \times 4 + 3.5m \times 6 = 8.5m \times c$

$-3 + 16 + 21 = 8.5c$

$34 = 8.5c$

$c = 4$

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**Question 2 continued**

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**(Total for Question 2 is 6 marks)**

**Question 3**

**Write the answer to Question 3 on these 4 pages**

(a) $v = \frac{dr}{dt} = (16 - 9t^2)i + (3t^2 - 2t)j$

Moving parallel to $j$ $\Rightarrow$ $i$ component $= 0$:

$16 - 9t^2 = 0 \quad \Rightarrow \quad t^2 = \frac{16}{9} \quad \Rightarrow \quad t = \frac{4}{3} \quad (t \geqslant 0)$

$j$ component: $3\left(\frac{4}{3}\right)^2 - 2\left(\frac{4}{3}\right) = 3 \times \frac{16}{9} - \frac{8}{3} = \frac{16}{3} - \frac{8}{3} = \frac{8}{3}$

$v = \frac{8}{3}j \text{ m s}^{-1}$

(b) $a = \frac{dv}{dt} = -18t\,i + (6t - 2)j$

$t = 4$: $a = -18(4)i + (6(4) - 2)j = -72i + 22j$

$|a| = \sqrt{((-72)^2 + 22^2)} = \sqrt{(5184 + 484)} = \sqrt{5668}$

$= 75.286...$

Magnitude of acceleration $= 75.3 \text{ m s}^{-2}$

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**(Total for Question 3 is 9 marks)**

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**Question 4**

**Write the answer to Question 4 on these 4 pages**

(a) Rhombus ABCD: AD = a vertical, AB = a at angle θ to AD, BC = a parallel to AD.

Height of C above A (measured along AD) = a cos θ + a = a + a cos θ

The centre of mass of each rhombus is at its centre, the midpoint of AC,

so it is at height $\frac{1}{2}(a + a\cos\theta)$ above A (similarly for rhombus ADEF).

By symmetry both centres are at this height, so the centre of mass of the lamina lies on AD at the same height:

$0.9a = \frac{1}{2}(a + a\cos\theta)$

$1.8a = a + a\cos\theta$

$a\cos\theta = 0.8a$

$\cos\theta = 0.8$ as required

(b) $\sin\theta = 0.6$. With DA horizontal, B is vertically below the point on AD at distance $a\cos\theta = 0.8a$ from A. G (lamina) is $0.9a$ from A on AD.

Moments about B:

$kW \times (a\cos\theta) = W \times (0.9a - a\cos\theta)$

$kW \times 0.8a = W \times (0.9a - 0.8a)$

$0.8k = 0.1$

$k = \frac{1}{8}$

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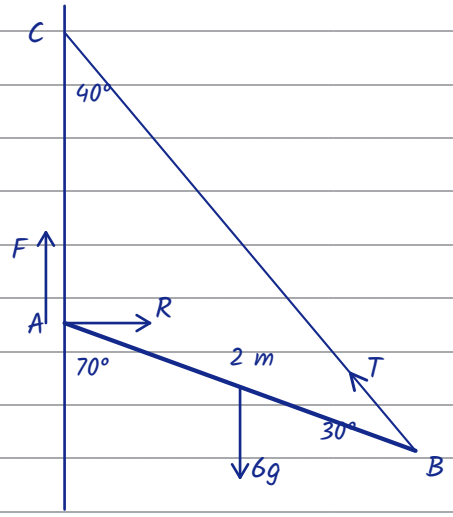
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**(Total for Question 4 is 9 marks)**

**Question 5**

**Write the answer to Question 5 on these 4 pages**




(a) Moments about A:

$6g \times 1 \times \sin 70° = T \times 2 \sin 30°$

$T = \dfrac{6g \sin 70°}{2 \sin 30°} = 6g \sin 70° = 55.253...$

$T = 55.3$ N

(b) In triangle ABC, angle CAB = 110° so angle ACB = 40°;
the string makes 40° with the vertical (50° with the horizontal).

$R(\rightarrow)$: $R = T \cos 50° = 55.253... \times \cos 50° = 35.516...$

$R(\uparrow)$: $F + T \sin 50° = 6g$

$F = 6g - T \sin 50° = 58.8 - 42.326... = 16.473...$

Limiting equilibrium: $F = \mu R$

$\mu = \dfrac{F}{R} = \dfrac{16.473...}{35.516...} = 0.46381...$

$\mu = 0.46$

(c) The force at A has components R = 35.516... (horizontal, away from the wall)
and F = 16.473... (vertically upwards).

$\tan \theta = \dfrac{R}{F} = \dfrac{35.516...}{16.473...} \Rightarrow \theta = 65.117...°$

The force acts at 65° to the upward vertical (25° above the horizontal),
directed away from the wall.

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**(Total for Question 5 is 11 marks)**

**Question 6**

**Write the answer to Question 6 on these 4 pages**

(a) $v = \int a\,dt = \int (2t - 3)\,dt = t^2 - 3t + c$

$t = 3,\ v = 2$: $2 = 9 - 9 + c \Rightarrow c = 2$

$v = t^2 - 3t + 2$

(b) Instantaneous rest: $v = 0$

$t^2 - 3t + 2 = 0 \Rightarrow (t - 1)(t - 2) = 0 \Rightarrow t = 1,\ t = 2$

A is reached when $t = 1$ and B when $t = 2$.

$$s = \int_1^2 (t^2 - 3t + 2)\,dt = \left[\frac{1}{3}t^3 - \frac{3}{2}t^2 + 2t\right]_1^2$$

$$= \left[\frac{1}{3}(2)^3 - \frac{3}{2}(2)^2 + 2(2)\right] - \left[\frac{1}{3} - \frac{3}{2} + 2\right]$$

$$= \frac{2}{3} - \frac{5}{6} = -\frac{1}{6}$$

Distance AB = $\frac{1}{6}$ m (0.167 m)

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**(Total for Question 6 is 10 marks)**

**Question 7**

**Write the answer to Question 7 on these 4 pages**

(a) Taking B to be h above A, conservation of mechanical energy:

$\frac{1}{2} m \times 12^2 = \frac{1}{2} m \times 8^2 + mgh$

$72 = 32 + 9.8h$

$h = \frac{40}{9.8} = 4.0816...$

Vertical distance AB = 4.08 m

(b) Vertically from A to B, $t = 1.5$: $s = ut + \frac{1}{2}at^2$

$4.0816... = 12 \sin \alpha \times 1.5 - \frac{1}{2} \times 9.8 \times 1.5^2$

$4.0816... = 18 \sin \alpha - 11.025$

$\sin \alpha = \frac{15.106...}{18} = 0.83925...$

$\alpha = 57.06...° = 57.1°$

(c) Horizontal component of velocity is constant:

$12 \cos \alpha = 8 \cos \beta$

$\cos \beta = \frac{12 \cos 57.06...°}{8} = \frac{6.5248...}{8} = 0.81560...$

$\beta = 35.35...° = 35.4°$

(d) By energy, the speed is less than 8 m $s^{-1}$ exactly when P is higher than B.

Vertical velocity at B: $v_V = 12 \sin \alpha - 1.5g = 10.071... - 14.7 = -4.6289...$

so at the level of B, P moves vertically at 4.6289... m $s^{-1}$.

On the way up P passes the level of B with vertical speed 4.6289... upwards.

Time above this level: $0 = 4.6289...T - \frac{1}{2} \times 9.8T^2$

$T = \frac{2 \times 4.6289...}{9.8} = 0.94467...$

Length of time = 0.945 s

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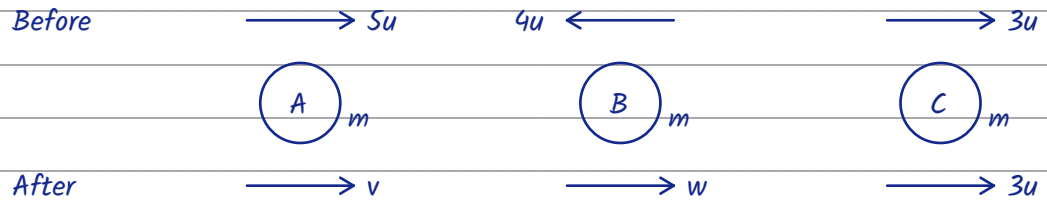
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**(Total for Question 7 is 14 marks)**

**Question 8**

**Write the answer to Question 8 on these 7 pages**

(a)




Take the direction of motion of A (towards C) as positive.

CLM: $m(5u) - m(4u) = mv + mw$

$u = v + w$ (1)

NEL: $w - v = e(5u + 4u) = 9ue$ (2)

(1) + (2): $2w = u + 9ue \Rightarrow w = \frac{u}{2}(1 + 9e)$

(1) − (2): $2v = u - 9ue \Rightarrow v = \frac{u}{2}(1 - 9e)$

(i) Speed of A $= \left|\frac{u}{2}(1 - 9e)\right|$

(ii) Speed of B $= \frac{u}{2}(1 + 9e)$

(b) Direction of A reversed $\Rightarrow v < 0$:

$\frac{u}{2}(1 - 9e) < 0 \Rightarrow 1 - 9e < 0 \Rightarrow e > \frac{1}{9}$

After the collision B moves towards C, which moves at 3u in the same direction.

No collision between B and C $\Rightarrow w \leq 3u$:

$\frac{u}{2}(1 + 9e) \leq 3u \Rightarrow 1 + 9e \leq 6 \Rightarrow e \leq \frac{5}{9}$

Set of possible values: $\frac{1}{9} < e \leq \frac{5}{9}$

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