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 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 $g = 9.8\,\text{m s}^{-2}$, 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.**

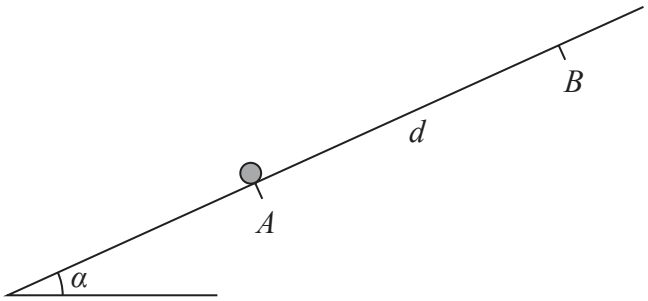


**Figure 1**

A particle of mass $m$ is held at rest at a point $A$ on a rough plane.

The plane is inclined at an angle $\alpha$ to the horizontal, where $\tan\alpha = \frac{5}{12}$

The coefficient of friction between the particle and the plane is $\frac{1}{5}$

The points $A$ and $B$ lie on a line of greatest slope of the plane, with $B$ above $A$, and $AB = d$, as shown in Figure 1.

The particle is pushed up the line of greatest slope from $A$ to $B$.

(a) Show that the work done against friction as the particle moves from $A$ to $B$ is $\frac{12}{65}mgd$

**(3)**

The particle is then held at rest at $B$ and released.

(b) Use the work-energy principle to find, in terms of $g$ and $d$, the speed of the particle at the instant it reaches $A$.

**(4)**

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**Question 1 continued**

**Q1**

**(Total 7 marks)**

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**2.** A vehicle of mass 450 kg is moving on a straight road that is inclined at angle $\theta$ to the horizontal, where $\sin\theta = \frac{1}{15}$

At the instant when the vehicle is moving **down** the road at $12\,\text{m s}^{-1}$

- the engine of the vehicle is working at a rate of $P$ watts
- the **acceleration** of the vehicle is $0.5\,\text{m s}^{-2}$
- the resistance to the motion of the vehicle is modelled as a constant force of magnitude $R$ newtons

At the instant when the vehicle is moving **up** the road at $12\,\text{m s}^{-1}$

- the engine of the vehicle is working at a rate of $2P$ watts
- the **deceleration** of the vehicle is $0.5\,\text{m s}^{-2}$
- the resistance to the motion of the vehicle from non-gravitational forces is modelled as a constant force of magnitude $R$ newtons

Find the value of $P$.

**(8)**

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**Question 2 continued**

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**Question 2 continued**

**Q2**

**(Total 8 marks)**

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

At time $t = 0$, $P$ is instantaneously at rest at $O$.

At time $t$ seconds, $t > 0$, the $x$ coordinate of $P$ is given by

$$x = 2t^{\frac{7}{2}} - 14t^{\frac{5}{2}} + \frac{56}{3}t^{\frac{3}{2}}$$

Find

(a) the non-zero values of $t$ for which $P$ is at instantaneous rest

**(3)**

(b) the total distance travelled by $P$ in the interval $0 \leqslant t \leqslant 4$

**(3)**

(c) the acceleration of $P$ when $t = 4$

**(3)**

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**Question 3 continued**

**Q3**

**(Total 9 marks)**

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**4.** A particle $P$ of mass 0.75 kg is moving with velocity $4\mathbf{i}\,\text{m s}^{-1}$ when it receives an impulse $\mathbf{J}$ Ns. Immediately after $P$ receives the impulse, the speed of $P$ is $8\,\text{m s}^{-1}$

Given that $\mathbf{J} = c(-\mathbf{i} + 2\mathbf{j})$, where $c$ is a constant, find the two possible values of $c$.

**(6)**

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**Question 4 continued**

**Q4**

**(Total 6 marks)**

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**5.**

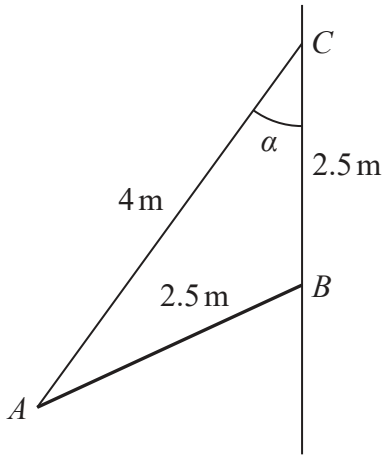


**Figure 2**

A pole $AB$ has length 2.5 m and weight 70 N.
The pole rests with end $B$ against a rough vertical wall. One end of a cable of length 4 m is attached to the pole at $A$. The other end of the cable is attached to the wall at the point $C$.
The point $C$ is vertically above $B$ and $BC = 2.5$ m.
The angle between the cable and the wall is $\alpha$, as shown in Figure 2.
The pole is in a vertical plane perpendicular to the wall.
The cable is modelled as a light inextensible string and the pole is modelled as a uniform rod.

Given that $\tan\alpha = \frac{3}{4}$

(a) show that the tension in the cable is 56 N.

**(4)**

Given also that the pole is in limiting equilibrium,

(b) find the coefficient of friction between the pole and the wall.

**(6)**

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**Question 5 continued**

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**Question 5 continued**

**Q5**

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**6.** Two particles, $A$ and $B$, are moving in opposite directions along the same straight line on a smooth horizontal surface when they collide directly.
The mass of $A$ is $2m$ and the mass of $B$ is $3m$.

Immediately **after** the collision, $A$ and $B$ are moving in opposite directions with the same speed $v$.
In the collision, $A$ receives an impulse of magnitude $5mv$.

(a) Find the coefficient of restitution between $A$ and $B$.

**(6)**

After the collision with $A$, particle $B$ strikes a smooth fixed vertical wall and rebounds. The wall is perpendicular to the direction of motion of the particles.
The coefficient of restitution between $B$ and the wall is $f$.

As a result of its collision with $A$ and with the wall, the total kinetic energy lost by $B$ is $E$.
As a result of its collision with $B$, the kinetic energy lost by $A$ is $2E$.

(b) Find the value of $f$.

**(4)**

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**Question 6 continued**

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**Question 6 continued**

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**Q6**

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**7. In this question you may use, without proof, the formula for the centre of mass of a uniform sector of a circle, as given in the formulae book.**

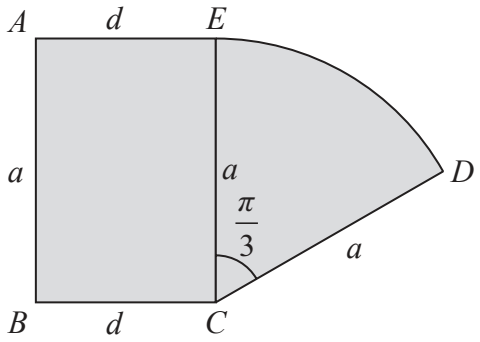


**Figure 3**

The uniform lamina $ABCDE$, shown shaded in Figure 3, is formed by joining a rectangle to a sector of a circle.

- The rectangle $ABCE$ has $AB = EC = a$ and $AE = BC = d$
- The sector $CDE$ has centre $C$ and radius $a$
- Angle $ECD = \frac{\pi}{3}$ radians

The centre of mass of the lamina lies on $EC$.

(a) Show that $a = \sqrt{3}d$

**(4)**

The lamina is freely suspended from $B$ and hangs in equilibrium with $BC$ at an angle $\beta$ radians to the downward vertical.

(b) Find the value of $\beta$

**(7)**

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**Q7**

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**8.**

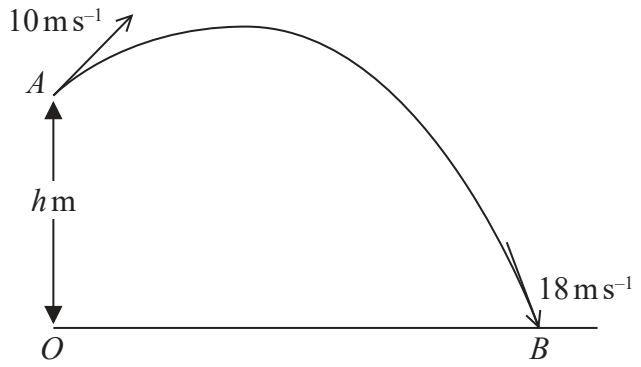


**Figure 4**

The fixed point $A$ is $h$ metres vertically above the point $O$ that is on horizontal ground. At time $t = 0$, a particle $P$ is projected from $A$ with speed $10\,\text{m s}^{-1}$. The particle moves freely under gravity. At time $t = 2.5$ seconds, $P$ strikes the ground at the point $B$. At the instant when $P$ strikes the ground, the speed of $P$ is $18\,\text{m s}^{-1}$, as shown in Figure 4.

(a) By considering energy, find the value of $h$.

**(3)**

(b) Find the distance $OB$.

**(5)**

As $P$ moves from $A$ to $B$, the speed of $P$ is less than or equal to $8\,\text{m s}^{-1}$ for $T$ seconds.

(c) Find the value of $T$

**(6)**

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**Q8**

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