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| Candidate surname | Other names |
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**Pearson Edexcel**
**International Advanced Level**

Centre Number | | | | | |

Candidate Number | | | | |

# Tuesday 12 January 2021

Afternoon (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 (Blue), 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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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.** A particle $P$ of mass 1.5 kg is moving with velocity $(4\mathbf{i} + 6\mathbf{j})\,\text{m s}^{-1}$ when it receives an impulse of magnitude 15 Ns. Immediately after $P$ receives the impulse, the velocity of $P$ is $v\mathbf{i}\,\text{m s}^{-1}$.

Find the two possible values of $v$.

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**2.**

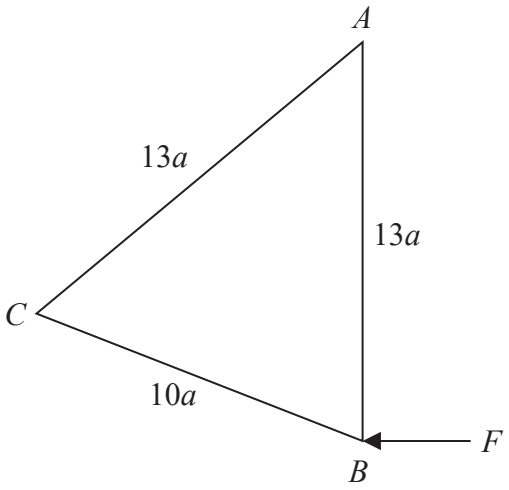



**Figure 1**

The uniform lamina $ABC$ has sides $AB = AC = 13a$ and $BC = 10a$. The lamina is freely suspended from $A$. A horizontal force of magnitude $F$ is applied to the lamina at $B$, as shown in Figure 1. The line of action of the force lies in the vertical plane containing the lamina. The lamina is in equilibrium with $AB$ vertical. The weight of the lamina is $W$.

Find $F$ in terms of $W$.

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**3.** A car of mass 600 kg travels along a straight horizontal road with the engine of the car working at a constant rate of $P$ watts. The resistance to the motion of the car is modelled as a constant force of magnitude $R$ newtons. At the instant when the speed of the car is $15\,\text{m s}^{-1}$, the magnitude of the acceleration of the car is $0.2\,\text{m s}^{-2}$.

Later the same car travels up a straight road inclined at angle $\theta$ to the horizontal, where $\sin\theta = \frac{1}{20}$. The resistance to the motion of the car from non-gravitational forces is modelled as a constant force of magnitude $R$ newtons. When the engine of the car is working at a constant rate of $P$ watts, the car has a constant speed of $10\,\text{m s}^{-1}$.

Find the value of $P$.

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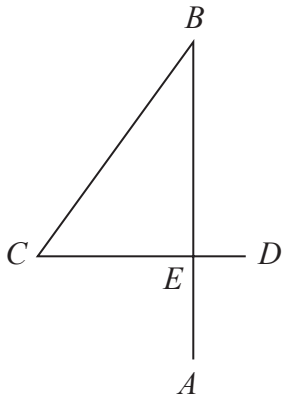



**Figure 2**

The number "4", shown in Figure 2, is a rigid framework made from three uniform rods, $AB$, $BC$ and $CD$, where

$$AB = 6a,\ BC = 5a \text{ and } CD = 4a$$

The point $E$ is on $AB$ and $CD$, where $BE = 4a$, $CE = 3a$ and angle $CEB = 90°$

The three rods are all made from the same material and they all lie in the same plane.

The framework is suspended from $B$ and hangs in equilibrium with $BA$ at an angle $\theta$ to the downward vertical.

Find $\theta$ to the nearest degree.

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**5.** At time $t$ seconds, $t \geqslant 0$, a particle $P$ has velocity $\mathbf{v}\,\text{m s}^{-1}$, where

$$\mathbf{v} = (5t^2 - 12t + 15)\mathbf{i} + (t^2 + 8t - 10)\mathbf{j}$$

When $t = 0$, $P$ is at the origin $O$.

At time $T$ seconds, $P$ is moving in the direction of $(\mathbf{i} + \mathbf{j})$.

(a) Find the value of $T$.

**(3)**

When $t = 3$, $P$ is at the point $A$.

(b) Find the magnitude of the acceleration of $P$ as it passes through $A$.

**(4)**

(c) Find the position vector of $A$.

**(4)**

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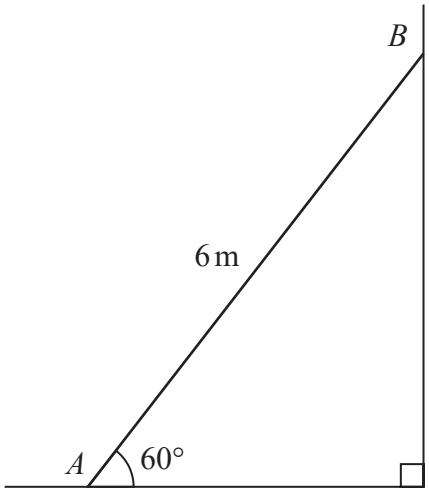



**Figure 3**

A ladder $AB$ has length 6 m and mass 30 kg. The ladder rests in equilibrium at 60° to the horizontal with the end $A$ on rough horizontal ground and the end $B$ against a smooth vertical wall, as shown in Figure 3.

A man of mass 70 kg stands on the ladder at the point $C$, where $AC = 2$ m, and the ladder remains in equilibrium. The ladder is modelled as a uniform rod in a vertical plane perpendicular to the wall. The man is modelled as a particle.

(a) Find the magnitude of the force exerted on the ladder by the ground.

**(6)**

The man climbs further up the ladder. When he is at the point $D$ on the ladder, the ladder is about to slip.

Given that the coefficient of friction between the ladder and the ground is 0.4

(b) find the distance $AD$.

**(4)**

(c) State how you have used the modelling assumption that the ladder is a rod.

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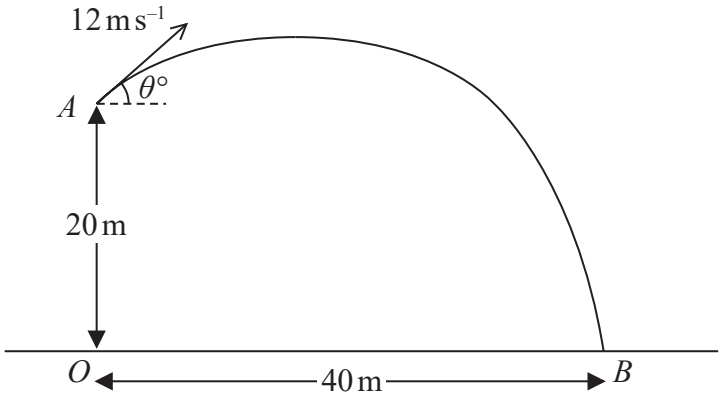



**Figure 4**

The fixed point $A$ is 20 m vertically above the point $O$ which is on horizontal ground. At time $t = 0$, a particle $P$ is projected from $A$ with speed $12\,\text{m s}^{-1}$ at an angle $\theta°$ above the horizontal. The particle moves freely under gravity. At time $t = 5$ seconds, $P$ strikes the ground at the point $B$, where $OB = 40$ m, as shown in Figure 4.

(a) By considering energy, find the speed of $P$ as it hits the ground at $B$.

**(4)**

(b) Find the least speed of $P$ as it moves from $A$ to $B$.

**(2)**

(c) Find the length of time for which the speed of $P$ is more than $10\,\text{m s}^{-1}$.

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**8.** Two particles, $A$ and $B$, have masses $3m$ and $4m$ respectively. The particles are moving towards each other along the same straight line on a smooth horizontal surface. The particles collide directly. Immediately after the collision, $A$ and $B$ are moving in the same direction with speeds $\frac{u}{3}$ and $u$ respectively. In the collision, $A$ receives an impulse of magnitude $8mu$.

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

**(6)**

When $A$ and $B$ collide they are at a distance $d$ from a smooth vertical wall, which is perpendicular to their direction of motion. After the collision with $A$, particle $B$ collides directly with the wall and rebounds so that there is a second collision between $A$ and $B$. This second collision takes place at distance $x$ from the wall.

Given that the coefficient of restitution between $B$ and the wall is $\frac{1}{4}$

(b) find $x$ in terms of $d$.

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**TOTAL FOR PAPER: 75 MARKS**

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