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Centre Number | Candidate Number

October 2021

# Pearson Edexcel International Advanced Level

**Time** 1 hour 30 minutes

**Paper reference** **WME01/01**

# Mathematics

## International Advanced Subsidiary/Advanced Level
## Mechanics M1

**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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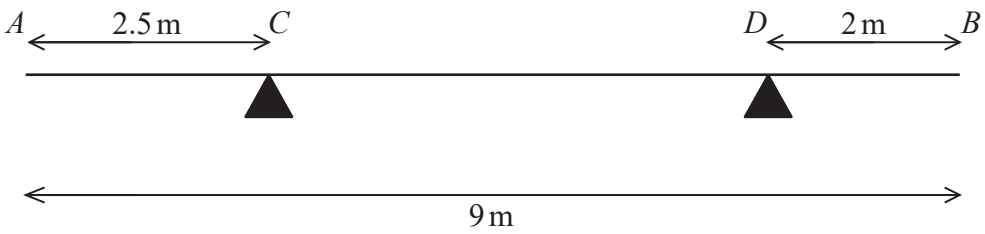


**Figure 1**

A non-uniform rod $AB$ has length 9 m and mass $M$ kg.

The rod rests in equilibrium in a horizontal position on two supports, one at $C$ where $AC = 2.5$ m and the other at $D$ where $DB = 2$ m, as shown in Figure 1.

The magnitude of the force acting on the rod at $D$ is twice the magnitude of the force acting on the rod at $C$.

The centre of mass of the rod is $d$ metres from $A$.

Find the value of $d$.

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**Question 1 continued**

**Q1**

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**2.** A particle $P$ of mass $2m$ is moving on a rough horizontal plane when it collides directly with a particle $Q$ of mass $4m$ which is at rest on the plane. The speed of $P$ immediately before the collision is $3u$. The speed of $Q$ immediately after the collision is $2u$.

(a) Find, in terms of $u$, the speed of $P$ immediately after the collision.

**(3)**

(b) State clearly the direction of motion of $P$ immediately after the collision.

**(1)**

Following the collision, $Q$ comes to rest after travelling a distance $\frac{6u^2}{g}$ along the plane.

The coefficient of friction between $Q$ and the plane is $\mu$.

(c) Find the value of $\mu$.

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**Question 2 continued**

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**Q2**

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**3.** A car is moving at a constant speed of $25\,m\,s^{-1}$ along a straight horizontal road.

The car is modelled as a particle.

At time $t = 0$, the car is at the point $A$ and the driver sees a road sign 48 m ahead.

Let $t$ seconds be the time that elapses after the car passes $A$.

In a **first** model, the car is assumed to decelerate uniformly at $6\,m\,s^{-2}$ from $A$ until the car reaches the road sign.

(a) Use this first model to find the speed of the car as it reaches the sign.

**(2)**

The road sign indicates that the speed limit immediately after the sign is $13\,m\,s^{-1}$.

In a **second** model, the car is assumed to decelerate uniformly at $6\,m\,s^{-2}$ from $A$ until it reaches a speed of $13\,m\,s^{-1}$. The car then maintains this speed until it reaches the road sign.

(b) Use this second model to find the value of $t$ at which the car reaches the sign.

**(4)**

In a **third** model, the car is assumed to move with constant speed $25\,m\,s^{-1}$ from $A$ until time $t = 0.2$, the car then decelerates uniformly at $6\,m\,s^{-2}$ until it reaches a speed of $13\,m\,s^{-1}$. The car then maintains this speed until it reaches the road sign.

(c) Use this third model to find the value of $t$ at which the car reaches the sign.

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**Q3**

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**4.** The position vector, **r** metres, of a particle $P$ at time $t$ seconds, relative to a fixed origin $O$, is given by

$$\mathbf{r} = (t - 3)\mathbf{i} + (1 - 2t)\mathbf{j}$$

(a) Find, to the nearest degree, the size of the angle between **r** and the vector **j**, when $t = 2$

**(3)**

(b) Find the values of $t$ for which the distance of $P$ from $O$ is 2.5 m.

**(5)**

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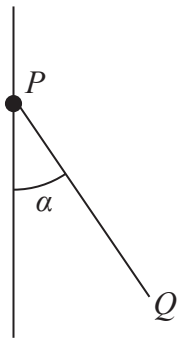


**Figure 2**

A small bead of mass 0.2 kg is attached to the end $P$ of a light rod $PQ$. The bead is threaded onto a fixed vertical rough wire.

The bead is held in equilibrium with the rod $PQ$ inclined to the wire at an angle $\alpha$, where $\tan\alpha = \frac{4}{3}$, as shown in Figure 2.

The thrust in the rod is $T$ newtons.

The bead is modelled as a particle.

(a) Find the magnitude and direction of the friction force acting on the bead when $T = 2.5$

**(3)**

The coefficient of friction between the bead and the wire is $\mu$.

Given that the greatest possible value of $T$ is 6.125

(b) find the value of $\mu$.

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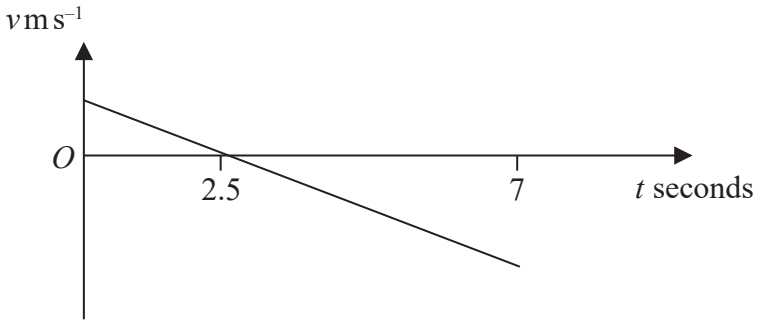


**Figure 3**

A small ball is thrown vertically upwards at time $t = 0$ from a point $A$ which is above horizontal ground. The ball hits the ground 7 s later.

The ball is modelled as a particle moving freely under gravity.

The velocity-time graph shown in Figure 3 represents the motion of the ball for $0 \leqslant t \leqslant 7$

(a) Find the speed with which the ball is thrown.

**(2)**

(b) Find the height of $A$ above the ground.

**(3)**

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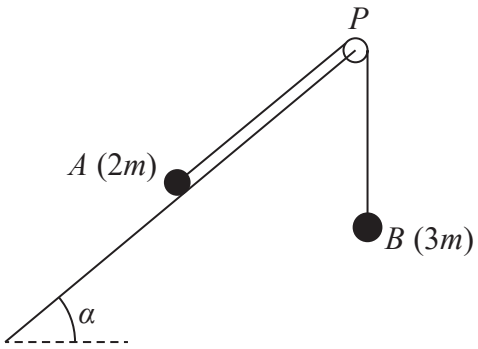


**Figure 4**

One end of a light inextensible string is attached to a particle $A$ of mass $2m$. The other end of the string is attached to a particle $B$ of mass $3m$. The string passes over a small, smooth, light pulley $P$ which is fixed at the top of a rough inclined plane. The plane is inclined to the horizontal at an angle $\alpha$, where $\tan\alpha = \frac{3}{4}$

Particle $A$ is held at rest on the plane with the string taut and $B$ hanging freely below $P$, as shown in Figure 4. The section of the string $AP$ is parallel to a line of greatest slope of the plane.

The coefficient of friction between $A$ and the plane is $\frac{1}{2}$

Particle $A$ is released and begins to move up the plane.

For the motion before $A$ reaches the pulley,

(a) (i) write down an equation of motion for $A$,

(ii) write down an equation of motion for $B$,

**(4)**

(b) find, in terms of $g$, the acceleration of $A$,

**(5)**

(c) find the magnitude of the force exerted on the pulley by the string.

**(4)**

(d) State how you have used the information that $P$ is a smooth pulley.

**(1)**

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**8.** [*In this question* **i** *and* **j** *are horizontal unit vectors directed due east and due north respectively and position vectors are given relative to a fixed origin.*]

At 7 am a ship leaves a port and moves with constant velocity. The position vector of the port is $(-2\mathbf{i} + 9\mathbf{j})$ km.

At 7.36 am the ship is at the point with position vector $(4\mathbf{i} + 6\mathbf{j})$ km.

(a) Show that the velocity of the ship is $(10\mathbf{i} - 5\mathbf{j})\,\text{km h}^{-1}$

**(2)**

(b) Find the position vector of the ship $t$ hours after leaving port.

**(2)**

At 8.48 am a passenger on the ship notices that a lighthouse is due east of the ship.

At 9 am the same passenger notices that the lighthouse is now north east of the ship.

(c) Find the position vector of the lighthouse.

**(4)**

(d) Find the position vector of the ship when it is due south of the lighthouse.

**(4)**

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Q8

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