www.dynamicpapers.com

Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
| | |

Centre Number | Candidate Number

# Pearson Edexcel International Advanced Level

## Tuesday 16 May 2023

Morning (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* ▶

P72902A

©2023 Pearson Education Ltd.
N:1/1/1/1/1/

P 7 2 9 0 2 A 0 1 2 8

Pearson

www.dynamicpapers.com

**1.** A particle $A$ has mass 4 kg and a particle $B$ has mass 2 kg.

The particles move towards each other in opposite directions along the same straight line on a smooth horizontal table and collide directly.

Immediately before the collision, the speed of $A$ is $2u\,\text{m s}^{-1}$ and the speed of $B$ is $3u\,\text{m s}^{-1}$

Immediately after the collision, the speed of $B$ is $2u\,\text{m s}^{-1}$

The direction of motion of $B$ is reversed by the collision.

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

**(3)**

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

**(1)**

(c) Find, in terms of $u$, the magnitude of the impulse received by $B$ in the collision. State the units of your answer.

**(3)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 1 continued**

**(Total for Question 1 is 7 marks)**

www.dynamicpapers.com

[*In this question* **i** *and* **j** *are horizontal perpendicular unit vectors*.]

**2.** A particle $P$ rests in equilibrium on a smooth horizontal plane.

A system of **three** forces, $\mathbf{F}_1$ N, $\mathbf{F}_2$ N and $\mathbf{F}_3$ N where

$$\mathbf{F}_1 = (3c\mathbf{i} + 4c\mathbf{j})$$
$$\mathbf{F}_2 = (-14\mathbf{i} + 7\mathbf{j})$$

is applied to $P$.

Given that $P$ remains in equilibrium,

(a) find $\mathbf{F}_3$ in terms of $c$, **i** and **j**.

**(2)**

The force $\mathbf{F}_3$ is **removed** from the system.

Given that $c = 2$

(b) find the size of the angle between the direction of **i** and the direction of the resultant force acting on $P$.

**(4)**

The mass of $P$ is $m$ kg.

Given that the magnitude of the acceleration of $P$ is $8.5\,\text{m s}^{-2}$

(c) find the value of $m$.

**(4)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 2 continued**

**(Total for Question 2 is 10 marks)**

www.dynamicpapers.com

**3.** Two students observe a book of mass 0.2 kg fall vertically from rest from a shelf that is 1.5 m above the floor.

Student *A* suggests that the book is modelled as a particle falling freely under gravity.

(a) Use student *A*'s model to find the time taken for the book to reach the floor.

**(3)**

Student *B* suggests an improved model where the book is modelled as a particle experiencing a constant resistance to motion of magnitude *R* newtons.

Given that the time taken for the book to reach the floor is 0.6 seconds,

(b) use student *B*'s model to find the value of *R*

**(5)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 3 continued**

**(Total for Question 3 is 8 marks)**

www.dynamicpapers.com

**4.**

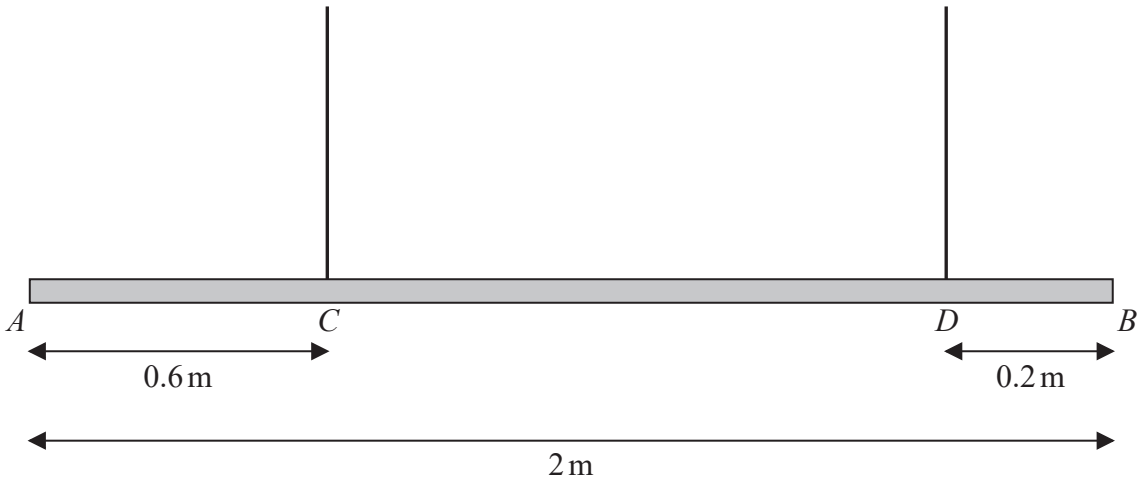



**Figure 1**

Figure 1 shows a beam $AB$, of mass $m$ kg and length 2 m, suspended by two light vertical ropes.
The ropes are attached to the points $C$ and $D$ on the beam, where $AC = 0.6$ m and $DB = 0.2$ m
The beam is in equilibrium in a horizontal position.

A particle of mass $pm$ kg is attached to the beam at $A$ and the beam remains in equilibrium in a horizontal position.

The beam is modelled as a uniform rod.

(a) Given that the tension in the rope attached at $C$ is four times the tension in the rope attached at $D$, use the model to find the exact value of $p$.

**(7)**

The particle of mass $pm$ kg at $A$ is removed and replaced by a particle of mass $qm$ kg at $A$.
The beam remains in equilibrium in a horizontal position but is now on the point of tilting.

(b) Using the model, find the exact value of $q$

**(4)**

(c) State how you have used the modelling assumption that the beam is uniform.

**(1)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 4 continued**

www.dynamicpapers.com

**Question 4 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 4 continued**

**(Total for Question 4 is 12 marks)**

www.dynamicpapers.com

**5.**

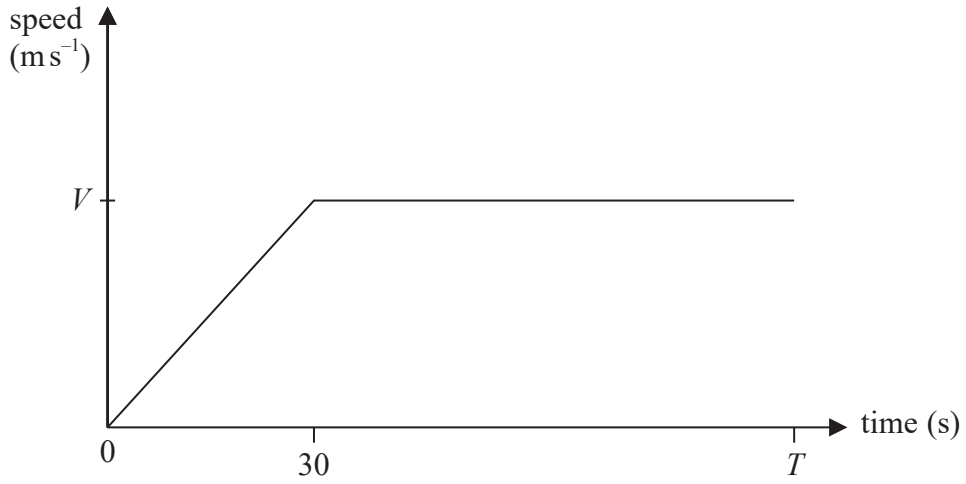



**Figure 2**

The speed-time graph in Figure 2 illustrates the motion of a car travelling along a straight horizontal road.
At time $t = 0$, the car starts from rest and accelerates uniformly for 30 s until it reaches a speed of $V$ m s$^{-1}$
The car then travels at a constant speed of $V$ m s$^{-1}$ until time $t = T$ seconds.

(a) Show that the distance travelled by the car between $t = 0$ and $t = T$ seconds is $V(T - 15)$ metres.

**(2)**

A motorbike also travels along the same road.

- The motorbike starts from rest at time $\boldsymbol{t = 10}$ **s** and accelerates uniformly for 40 s
- The acceleration of the motorbike is the **same** as the acceleration of the car
- The motorbike then travels at a constant speed for a further 10 s before decelerating uniformly until it reaches a speed of $V$ m s$^{-1}$ at time $T$ seconds

(b) On Figure 2, sketch a speed-time graph for the motion of the motorbike.

[*If you need to redraw your sketch, there is a copy of Figure 2 on page 15.*]

**(2)**

(c) Show that the constant speed of the motorbike is $\frac{4V}{3}$ m s$^{-1}$

**(2)**

At time $t = T$ seconds, the distance travelled by each vehicle is the same.

(d) Find the value of $T$

**(5)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 5 continued**

www.dynamicpapers.com

**Question 5 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 5 continued**

**Only use this copy of Figure 2 if you need to redraw your sketch.**

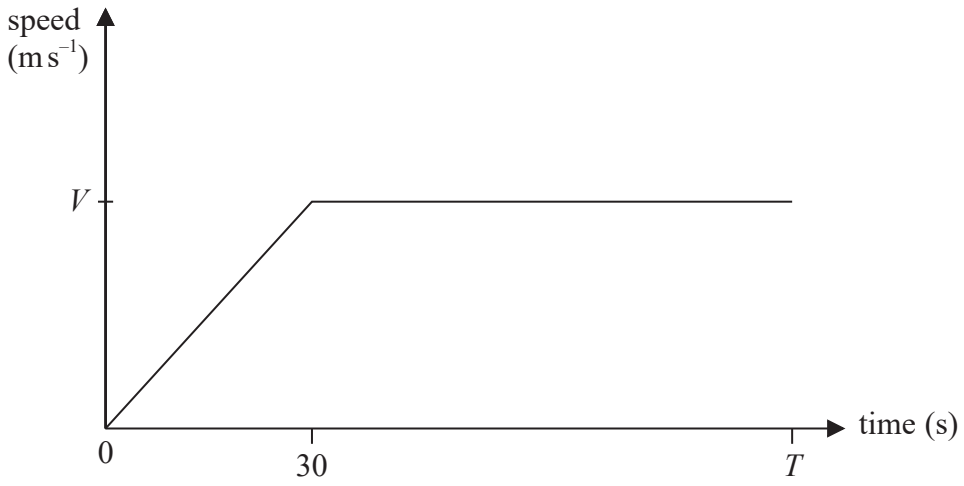



**Figure 2**

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

www.dynamicpapers.com

**6.**

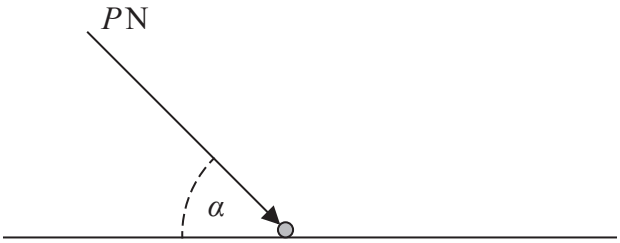



**Figure 3**

A particle of weight $W$ newtons lies at rest on a rough horizontal surface, as shown in Figure 3.
A force of magnitude $P$ newtons is applied to the particle.

The force acts at an angle $\alpha$ to the horizontal, where $\tan\alpha = \frac{4}{3}$

The coefficient of friction between the particle and the surface is $\frac{1}{4}$

Given that the particle does not move, show that

$$P \leqslant \frac{5W}{8}$$

**(7)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**Question 6 continued**

**(Total for Question 6 is 7 marks)**

www.dynamicpapers.com

**7.**

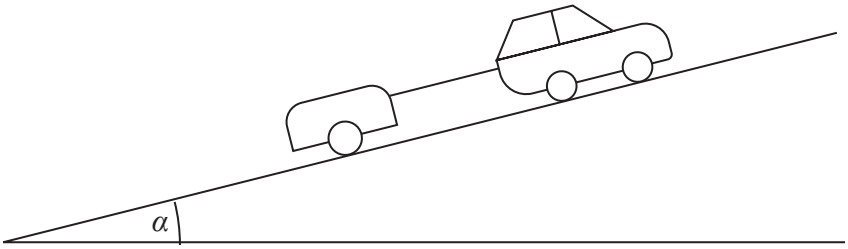



**Figure 4**

A car of mass 1200 kg is towing a trailer of mass 600 kg up a straight road, as shown in Figure 4.

The road is inclined at an angle $\alpha$ to the horizontal, where $\sin\alpha = \frac{1}{12}$

The driving force produced by the engine of the car is 3000 N.

The car moves with acceleration $0.75\,\text{m s}^{-2}$

The non-gravitational resistance to motion of

- the **car** is modelled as a constant force of magnitude $2R$ newtons
- the **trailer** is modelled as a constant force of magnitude $R$ newtons

The car and the trailer are modelled as particles.
The tow bar between the car and trailer is modelled as a light rod that is parallel to the direction of motion.

Using the model,

(a) show that the value of $R$ is 60

**(4)**

(b) find the tension in the tow bar.

**(3)**

When the car and trailer are moving at a speed of $12\,\text{m s}^{-1}$, the tow bar breaks.

Given that the non-gravitational resistance to motion of the trailer remains unchanged,

(c) use the model to find the further distance moved by the trailer before it first comes to rest.

**(4)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**Question 7 continued**

www.dynamicpapers.com

**Question 7 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 7 continued**

**(Total for Question 7 is 11 marks)**

www.dynamicpapers.com

**8.**

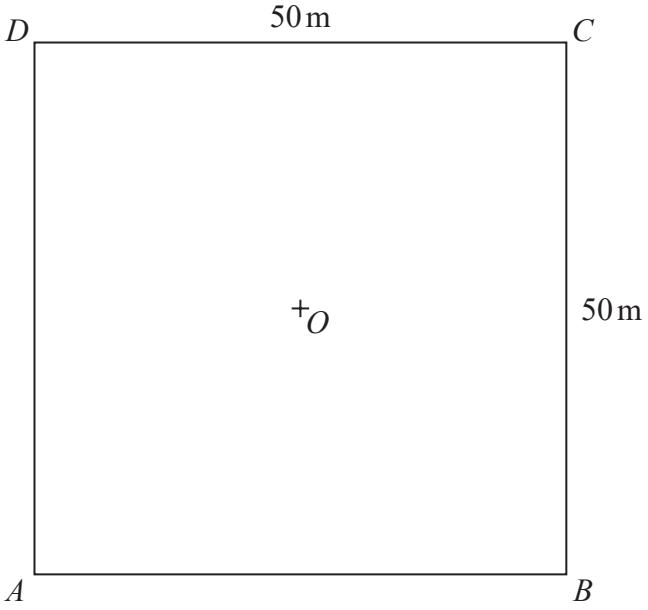



**Figure 5**

A square floor space $ABCD$, with centre $O$, is modelled as a flat horizontal surface measuring 50 m by 50 m, as shown in Figure 5.
The horizontal unit vectors **i** and **j** are in the direction of $\overrightarrow{AB}$ and $\overrightarrow{AD}$ respectively.

All position vectors are given relative to $O$.

A small robot $R$ is programmed to travel across the floor at a constant velocity.

- At time $t = 0$, $R$ is at the point with position vector $(-2\mathbf{i} + \mathbf{j})$ m
- At time $t = 11$ s, $R$ is at the point with position vector $(9\mathbf{i} + 23\mathbf{j})$ m
- At time $t$ seconds, the position vector of $R$ is **r** metres

(a) Find, in terms of $t$, **i** and **j**, an expression for **r**

**(3)**

A second robot $S$ is at the point $C$.

- At time $t = 0$, $S$ leaves $C$ and moves with constant velocity $(-\mathbf{i} - \mathbf{j})\,\text{m s}^{-1}$
- At time $t$ seconds, the position vector of $S$ is **s** metres

(b) Write down, in terms of $t$, **i** and **j**, an expression for **s**

**(1)**

(c) Show that

$$\overrightarrow{SR} = [(2t - 27)\mathbf{i} + (3t - 24)\mathbf{j}]\ \text{m}$$

**(2)**

(d) Find the time when the distance between $R$ and $S$ is a minimum.

**(3)**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 8 continued**

www.dynamicpapers.com

**Question 8 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 8 continued**

www.dynamicpapers.com

**Question 8 continued**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

www.dynamicpapers.com

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

**Question 8 continued**

www.dynamicpapers.com

**Question 8 continued**

**(Total for Question 8 is 9 marks)**

**TOTAL FOR PAPER IS 75 MARKS**

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA