

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 ►

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1. A particle  $A$  has mass  $4\text{ kg}$  and a particle  $B$  has mass  $2\text{ kg}$ .

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)

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[In this question  $\mathbf{i}$  and  $\mathbf{j}$  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  $c$ ,  $\mathbf{i}$  and  $\mathbf{j}$ .

(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  $\mathbf{i}$  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)



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3. Two students observe a book of mass  $0.2\text{ kg}$  fall vertically from rest from a shelf that is  $1.5\text{ m}$  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)

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**Question 3 continued**

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(Total for Question 3 is 8 marks)



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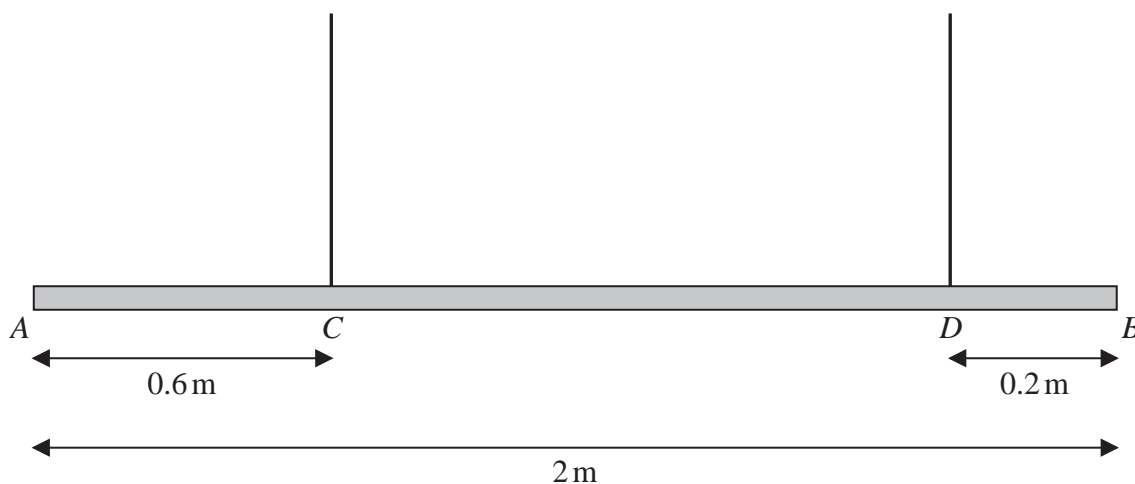


Figure 1

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)





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Question 4 continued

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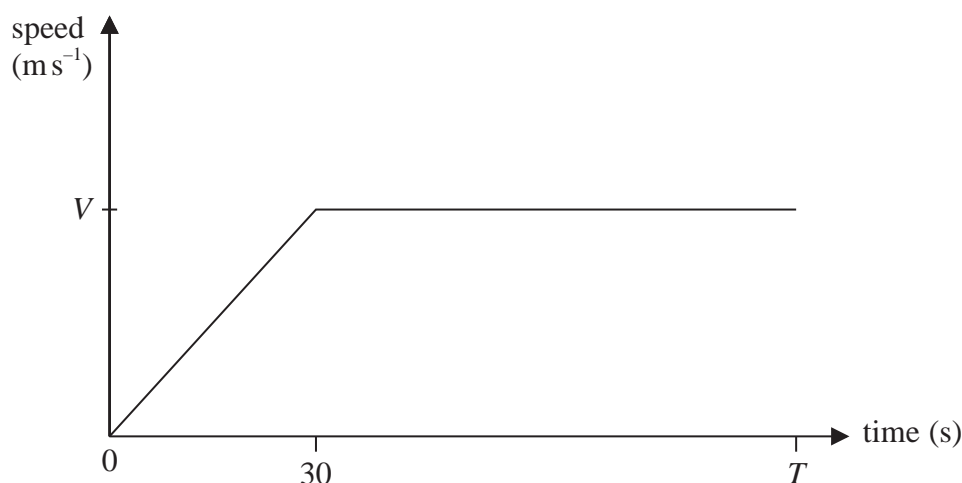


Figure 2

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  $V \text{ m s}^{-1}$ .

The car then travels at a constant speed of  $V \text{ m s}^{-1}$  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  $t = 10 \text{ s}$  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  $V \text{ m s}^{-1}$  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  $\frac{4V}{3} \text{ m s}^{-1}$

(2)

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

- (d) Find the value of  $T$

(5)



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Question 5 continued

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## Question 5 continued

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

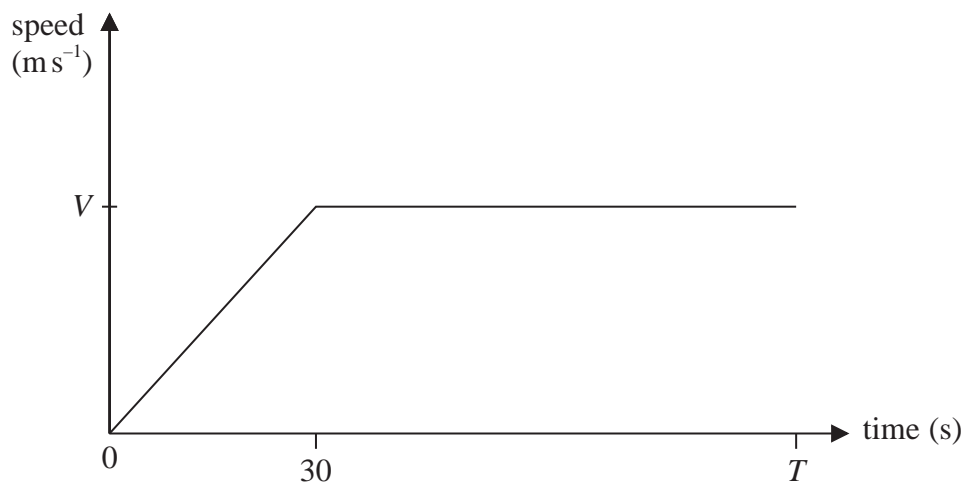


Figure 2

(Total for Question 5 is 11 marks)



P 7 2 9 0 2 A 0 1 5 2 8

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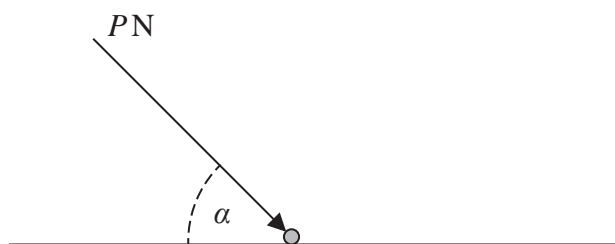


Figure 3

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

$$P \leq \frac{5W}{8} \quad (7)$$

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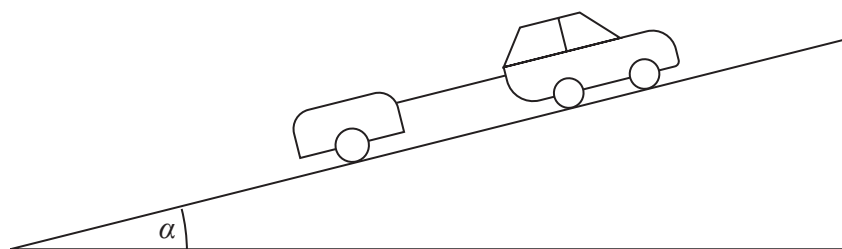


Figure 4

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)

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Question 7 continued

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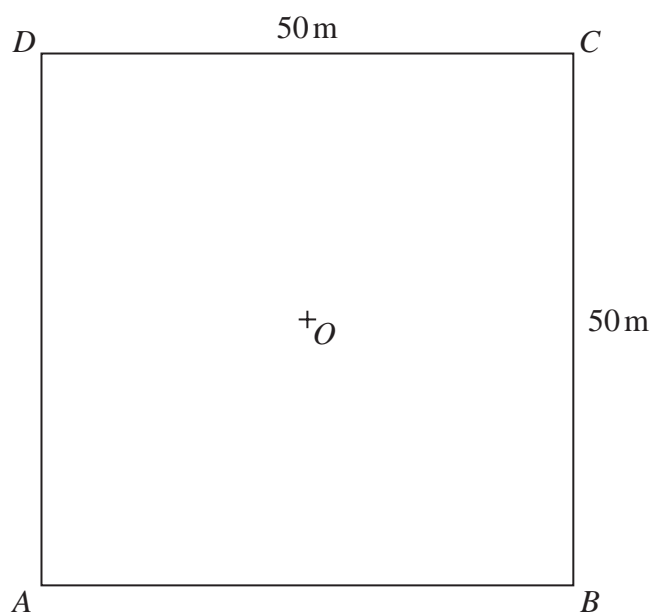


Figure 5

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  $\mathbf{i}$  and  $\mathbf{j}$  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  $\mathbf{r}$  metres

(a) Find, in terms of  $t$ ,  $\mathbf{i}$  and  $\mathbf{j}$ , an expression for  $\mathbf{r}$

(3)

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

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

(b) Write down, in terms of  $t$ ,  $\mathbf{i}$  and  $\mathbf{j}$ , an expression for  $\mathbf{s}$

(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)



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**Question 8 continued**

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(Total for Question 8 is 9 marks)

**TOTAL FOR PAPER IS 75 MARKS**

