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Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 25 May 2023

Morning (Time: 1 hour 30 minutes)

Paper reference **WME02/01**

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.
- 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 $g = 9.8$ 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 7 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 0.3 kg is moving with velocity $5\mathbf{i}\ \text{m s}^{-1}$

The particle receives an impulse $\mathbf{I}$ N s.

Immediately after receiving the impulse, the velocity of P is $(7\mathbf{i} + 7\mathbf{j})\ \text{m s}^{-1}$

(a) Find the magnitude of $\mathbf{I}$

(4)

(b) Find the angle between the direction of $\mathbf{I}$ and the direction of motion of P immediately before receiving the impulse.

(3)

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Question 1 continued

(Total for Question 1 = 7 marks)

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2. [*In this question, the perpendicular unit vectors* **i** *and* **j** *are in a horizontal plane.*]

In this question you must show all stages of your working.
Solutions relying on calculator technology are not acceptable.

A particle P is moving on a smooth horizontal plane.

At time t seconds $(t \geqslant 0)$, the position vector of P, relative to a fixed point O, is **r** metres and the velocity of P is $\mathbf{v}\ \text{m s}^{-1}$ where

$$\mathbf{v} = \left(4t^2 - 5t\right)\mathbf{i} + \left(-10t - 12\right)\mathbf{j}$$

When $t = 0$, $\mathbf{r} = 2\mathbf{i} + 6\mathbf{j}$

(a) Find **r** when $t = 2$

(4)

When $t = T$ particle P is moving in the direction of the vector $\mathbf{i} - 2\mathbf{j}$

(b) Find the value of T

(3)

(c) Find the exact magnitude of the acceleration of P when $t = 2.5$

(3)

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Question 2 continued

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Question 2 continued

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3.

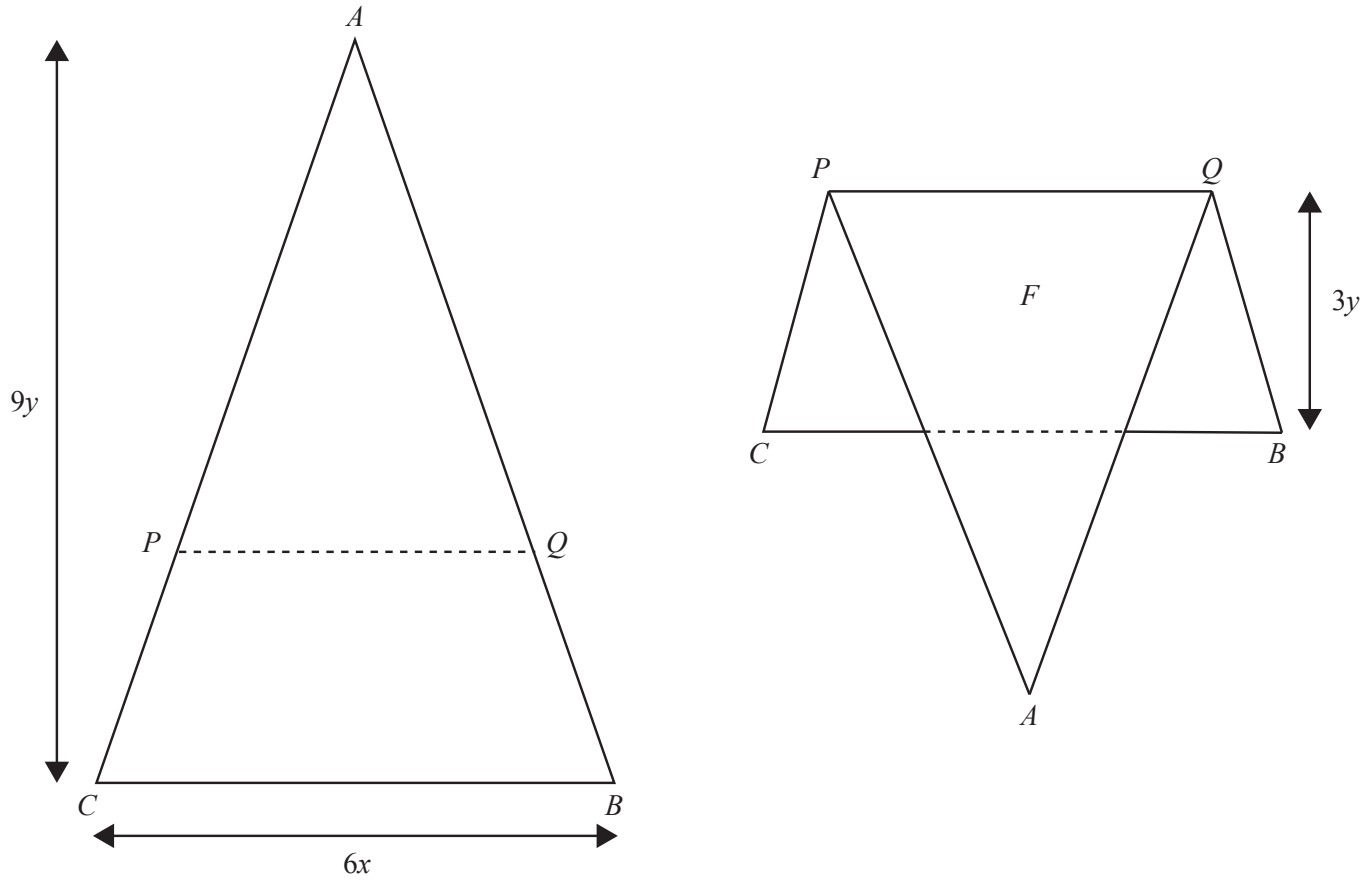

Figure 1

The uniform triangular lamina ABC, shown in Figure 1, has height $9y$, base $BC = 6x$, and $AB = AC$

The points P and Q are such that $AP : PC = AQ : QB = 2 : 1$

The lamina is folded along PQ to form the folded lamina F

The distance of the centre of mass of F from PQ is d

(a) Show that $d = \frac{16}{9}y$

(5)

The folded lamina is suspended from P and hangs freely in equilibrium with PQ at an angle α to the downward vertical.

Given that $\tan\alpha = \frac{64}{81}$

(b) find x in terms of y

(3)

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Question 3 continued

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Question 3 continued

(Total for Question 3 = 8 marks)

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4. A particle P of mass $3m$ and a particle Q of mass $5m$ are moving towards each other along the same straight line on a smooth horizontal surface. The particles collide directly.

Immediately **before** the collision, the speed of P is u and the speed of Q is ku.

Immediately **after** the collision, the speed of P is $2v$ and the speed of Q is v.

The direction of motion of each particle is reversed by the collision.

In the collision, P receives an impulse of magnitude $15mv$.

(a) Show that $u = 3v$.

(3)

(b) Find the value of k.

(3)

The coefficient of restitution between P and Q is e.

(c) Find the value of e.

(3)

The total kinetic energy lost in the collision is λmv^2

(d) Find the value of λ.

(3)

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Question 4 continued

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Question 4 continued

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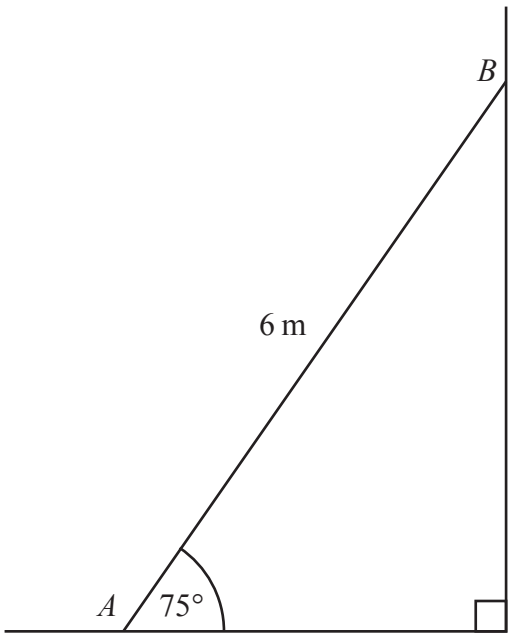

Figure 2

A uniform beam AB, of mass 15 kg and length 6 m, rests with end A on rough horizontal ground. The end B of the beam rests against a rough vertical wall.

The beam is inclined at 75° to the ground, as shown in Figure 2.

The coefficient of friction between the beam and the wall is 0.2

The coefficient of friction between the beam and the ground is μ

The beam is modelled as a uniform rod which lies in a vertical plane perpendicular to the wall.

The beam rests in limiting equilibrium.

(a) Find the magnitude of the normal reaction between the beam and the wall at B.

(5)

(b) Find the value of μ

(6)

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Question 5 continued

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Question 5 continued

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6. A van of mass 900 kg is moving along a straight horizontal road.

The resistance to the motion of the van is modelled as a constant force of magnitude 600 N.

The engine of the van is working at a constant rate of 24 kW.

At the instant when the speed of the van is $V\ \text{m s}^{-1}$, the acceleration of the van is $2\,\text{m s}^{-2}$

(a) Find the value of V

(4)

Later on, the van is towing a trailer of mass 700 kg up a straight road inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{14}$

The trailer is attached to the van by a towbar, as shown in Figure 3.

The towbar is parallel to the direction of motion of the van and the trailer.

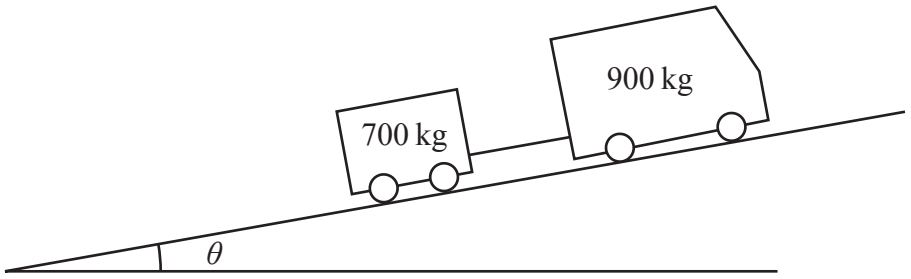

Figure 3

The resistance to the motion of the van from non-gravitational forces is modelled as a constant force of magnitude 600 N.

The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 550 N.

The towbar is modelled as a light rod.

The engine of the van is working at a constant rate of 24 kW.

(b) Find the acceleration of the van at the instant when the van and the trailer are moving with speed $8\,\text{m s}^{-1}$

(4)

At the instant when the van and the trailer are moving up the road at $9\,\text{m s}^{-1}$, the towbar breaks. The trailer continues to move in a straight line up the road until it comes to instantaneous rest.

The distance moved by the trailer as it slows from a speed of $9\,\text{m s}^{-1}$ to instantaneous rest is d metres.

(c) Use the work-energy principle to find the value of d.

(4)

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Question 6 continued

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Question 6 continued

(Total for Question 6 = 12 marks)

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7. [*In this question, the perpendicular unit vectors* **i** *and* **j** *are in a vertical plane with* **i** *being horizontal and* **j** *being vertically upwards.*]

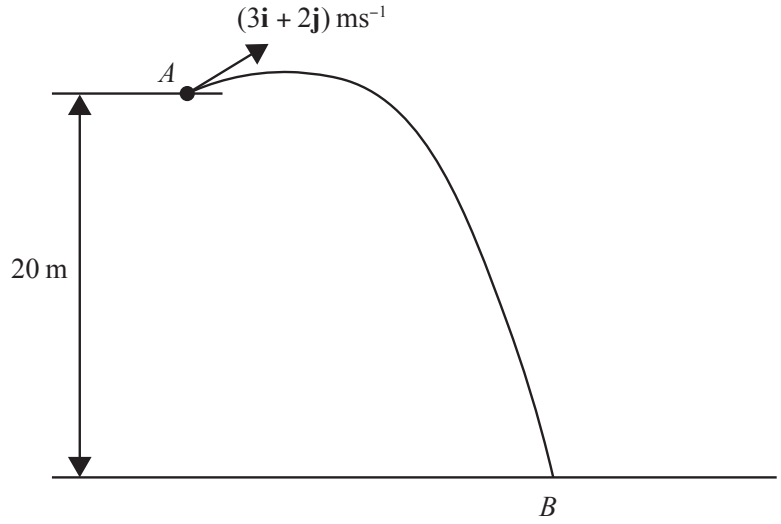

Figure 4

A small ball is projected with velocity $(3\mathbf{i} + 2\mathbf{j})\,\text{m s}^{-1}$ from the fixed point A.

The point A is 20 m above horizontal ground.

The ball hits the ground at the point B, as shown in Figure 4.

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

(a) By considering energy, find the speed of the ball at the instant immediately before it hits the ground.

(3)

(b) Find the direction of motion of the ball at the instant immediately before it hits the ground.

(3)

(c) Find the time taken for the ball to travel from A to B.

(3)

At the instant when the direction of motion of the ball is perpendicular to $(3\mathbf{i} + 2\mathbf{j})$ the ball is h metres above the ground.

(d) Find the value of h.

(6)

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Question 7 continued

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Question 7 continued

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Question 7 continued

(Total for Question 7 = 15 marks)

TOTAL FOR PAPER IS 75 MARKS

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