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Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 11 January 2024

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 (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 $g = 9.8\,\text{m}\,\text{s}^{-2}$, 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 moves along a straight line. The fixed point O is on the line. At time t seconds, $t > 0$, the displacement of P from O is x metres, where

$$x = 2t^3 - 21t^2 + 60t$$

Find

(a) the values of t for which P is instantaneously at rest

(4)

(b) the distance travelled by P in the interval $1 \leqslant t \leqslant 3$

(2)

(c) the magnitude of the acceleration of P at the instant when $t = 3$

(2)

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Question 1 continued

(Total for Question 1 is 8 marks)

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

A particle Q of mass 0.5 kg is moving on a smooth horizontal surface. Particle Q is moving with velocity $(3\mathbf{i} + \mathbf{j})\,\text{m s}^{-1}$ when it receives an impulse of $(2\mathbf{i} + 5\mathbf{j})\,\text{N s}$.

(a) Find the speed of Q immediately after receiving the impulse.

(4)

As a result of receiving the impulse, the direction of motion of Q is turned through an angle $\theta°$

(b) Find the value of θ

(2)

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Question 2 continued

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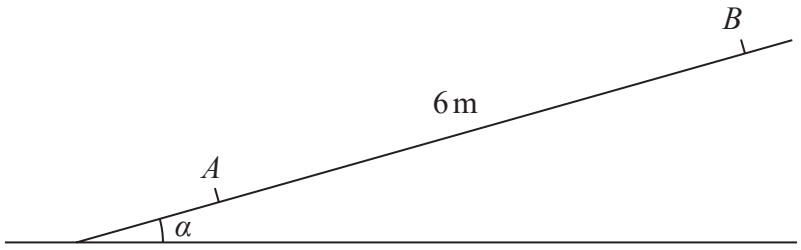


Figure 1

A rough ramp is fixed to horizontal ground.

The ramp is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{3}{7}$

The line AB is a line of greatest slope of the ramp, with B above A and $AB = 6\,\text{m}$, as shown in Figure 1.

A block P of mass 2 kg is pushed, with constant speed, in a straight line up the slope from A to B. The force pushing P acts parallel to AB.

The coefficient of friction between P and the ramp is $\frac{1}{3}$

The block is modelled as a particle and air resistance is negligible.

(a) Use the model to find the **total** work done in pushing the block from A to B.

(5)

The block is now held at B and released from rest.

(b) Use the model and the work-energy principle to find the speed of the block at the instant it reaches A.

(4)

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Question 3 continued

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Question 3 continued

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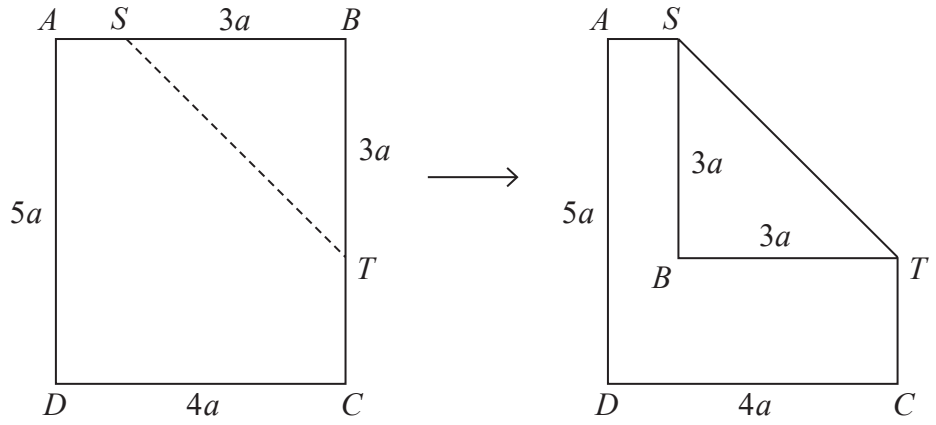


Figure 2 **Figure 3**

The uniform rectangular lamina $ABCD$, shown in Figure 2, has $DC = 4a$ and $AD = 5a$

The points S on AB and T on BC are such that $SB = BT = 3a$

The lamina is folded along ST to form the folded lamina L, shown in Figure 3.

The distance of the centre of mass of L from AD is d.

(a) Show that $d = \frac{71}{40}a$

(5)

The weight of L is $4W$. A particle of weight W is attached to L at C.

The folded lamina L is freely suspended from S.

A force of magnitude F, acting parallel to DC, is applied to L at D so that AD is vertical.

(b) Find F in terms of W

(4)

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Question 4 continued

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Question 4 continued

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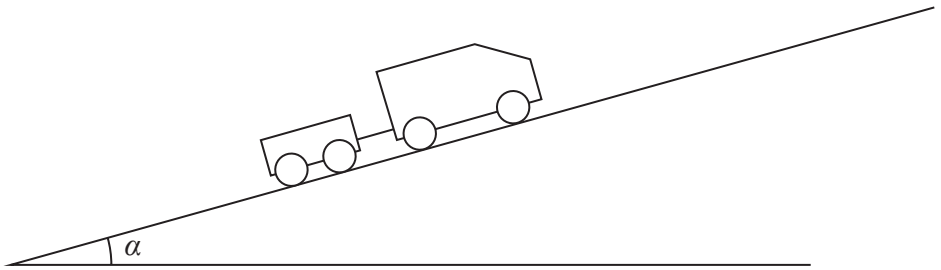


Figure 4

A van of mass 600 kg is moving up a straight road inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{14}$. The van is towing a trailer of mass 200 kg. The trailer is attached to the van by a rigid towbar which is parallel to the direction of motion of the van and the trailer, as shown in Figure 4.

The resistance to the motion of the van from non-gravitational forces is modelled as a constant force of magnitude 250 N.

The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 150 N.

The towbar is modelled as a light rod.

At the instant when the speed of the van is $16\,\text{m}\,\text{s}^{-1}$, the engine of the van is working at a rate of 10 kW.

(a) Find the deceleration of the van at this instant.

(5)

(b) Find the tension in the towbar at this instant.

(4)

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Question 5 continued

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Question 5 continued

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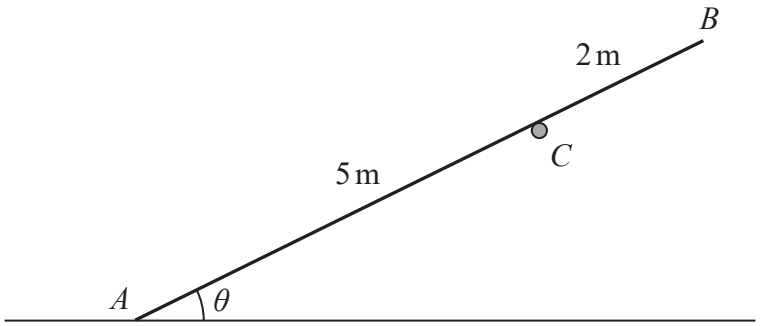


Figure 5

A uniform beam AB, of weight 40 N and length 7 m, rests with end A on rough horizontal ground.

The beam rests on a smooth horizontal peg at C, with $AC = 5$ m, as shown in Figure 5.

The beam is inclined at an angle θ to the ground, where $\sin\theta = \frac{3}{5}$

The beam is modelled as a rod that lies in a vertical plane perpendicular to the peg.

The normal reaction between the beam and the peg at C has magnitude P newtons.

Using the model,

(a) show that $P = 22.4$

(3)

(b) find the magnitude of the resultant force acting on the beam at A.

(6)

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Question 6 continued

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Question 6 continued

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7. Particle P has mass m and particle Q has mass $5m$.

The particles are moving in the same direction along the same straight line on a smooth horizontal surface.

Particle P collides directly with particle Q.

Immediately **before** the collision, the speed of P is $6u$ and the speed of Q is u.

Immediately **after** the collision, the speed of P is x and the speed of Q is y.

The direction of motion of P is reversed as a result of the collision.

The coefficient of restitution between P and Q is e.

(a) Find the complete range of possible values of e.

(7)

Given that $e = \frac{3}{5}$

(b) find the total kinetic energy lost in the collision between P and Q.

(4)

After the collision, Q hits a smooth fixed vertical wall that is perpendicular to the direction of motion of Q.

Particle Q rebounds.

The coefficient of restitution between Q and the wall is f.

Given that there is a second collision between P and Q,

(c) find the complete range of possible values of f.

(3)

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Question 7 continued

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Question 7 continued

(Total for Question 7 is 14 marks)

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8. [*In this question* **i** *and* **j** *are unit vectors, with* **i** *horizontal and* **j** *vertical*.]

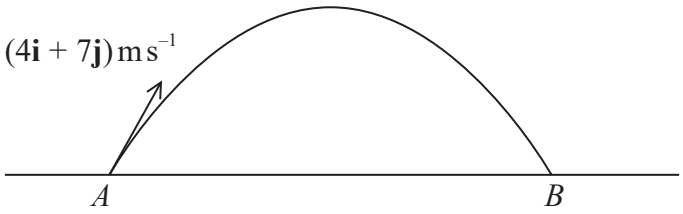


Figure 6

The fixed points A and B lie on horizontal ground.

At time $t = 0$, a particle P is projected from A with velocity $(4\mathbf{i} + 7\mathbf{j})\,\mathrm{m\,s^{-1}}$

Particle P moves freely under gravity and hits the ground at B, as shown in Figure 6.

(a) Find the distance AB.

(4)

The speed of P is less than $5\,\mathrm{m\,s^{-1}}$ for an interval of length T seconds.

(b) Find the value of T

(3)

At the instant when the direction of motion of P is perpendicular to the initial direction of motion of P, the particle is h metres above the ground.

(c) Find the value of h.

(4)

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Question 8 continued

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Question 8 continued

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(Total for Question 8 is 11 marks)

TOTAL FOR PAPER IS 75 MARKS