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Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Friday 17 January 2025

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.

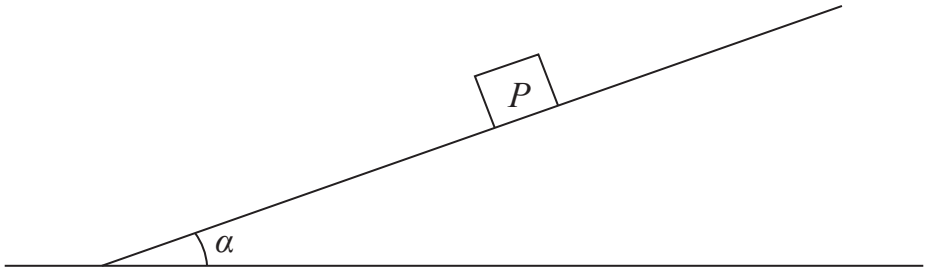


Figure 1

A fixed rough plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{5}{12}$

A package P of mass 2.6 kg is placed on the plane, as shown in Figure 1.
The package is pushed, with **constant speed**, up a line of greatest slope of the plane.
The force pushing P acts parallel to the path of P.

The coefficient of friction between P and the plane is $\frac{1}{5}$

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

Use the model to find the **total** work done in pushing P, at a **constant speed**, a distance of 20 m up the plane.

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Question 1 continued

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2.

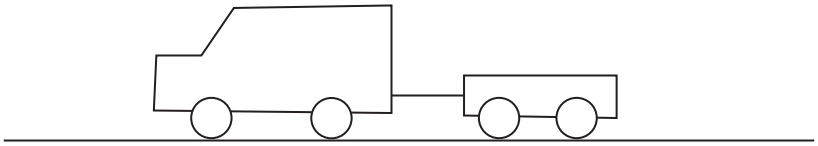


Figure 2

A van of mass 900 kg is moving along a straight horizontal road.
The van is towing a trailer of mass 300 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 2.

The resistance to the motion of the van is modelled as a constant force of magnitude 500 N.
The resistance to the motion of the trailer is modelled as a constant force of magnitude 200 N.
The towbar is modelled as a light rod.

The engine of the van is working at a constant rate of 18 kW.

At the instant when the speed of the van is $12\,\text{m s}^{-1}$, the tension in the towbar has magnitude T newtons.

(a) Find the value of T

(7)

Later, the van is towing the trailer up a straight road inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{15}$
The towbar is still parallel to the direction of motion of the van and the trailer.

The resistance to the motion of the van from non-gravitational forces is modelled as a constant force of magnitude 500 N.
The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 200 N.
The towbar is again modelled as a light rod.

When the van is travelling with a constant speed of $v\,\text{m s}^{-1}$, the engine of the van is working at a constant rate of 18 kW.

(b) Find the value of v

(4)

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Question 2 continued

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Question 2 continued

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

At time $t = 0$, a particle P is at the fixed point O

At time t seconds, $t > 0$, P has position vector **r** metres relative to O, where

$$\mathbf{r} = \left(3t + 2 - 2\sqrt{t+1}\right)\mathbf{i} + \left(t^2 - 6t\right)\mathbf{j}$$

(a) Find the speed of P at the instant when P is moving in the direction of the vector **i**

(5)

(b) Find the magnitude of the acceleration of P when $t = 0.25$

(4)

(c) Show that P never returns to O

(2)

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Question 3 continued

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4. [*In this question* **i** *and* **j** *are unit vectors, with* **i** *horizontal and* **j** *vertically upwards.*]

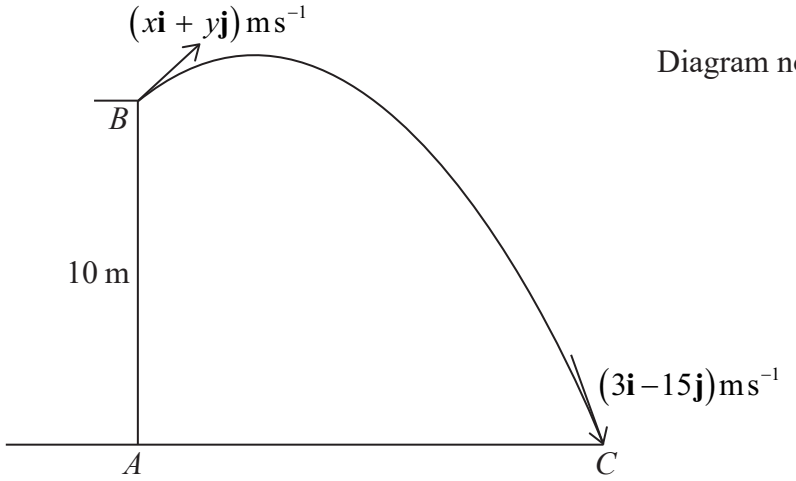


Figure 3

The fixed points A and C lie on horizontal ground.

The point B is vertically above A, with $AB = 10\,\mathrm{m}$.

At time $t = 0$, a particle P is projected from B with velocity $(x\mathbf{i} + y\mathbf{j})\,\mathrm{m\,s^{-1}}$, where x and y are positive.

Particle P moves freely under gravity and hits the ground at C.

At the instant before P hits the ground, the velocity of P is $(3\mathbf{i} - 15\mathbf{j})\,\mathrm{m\,s^{-1}}$, as shown in Figure 3.

(a) Find the value of x and the value of y.

(4)

(b) Find the distance AC.

(4)

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Question 4 continued

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

A particle Q of mass 2 kg is moving on a smooth horizontal surface.

Particle Q is moving with velocity $4\mathbf{i}\ \text{m s}^{-1}$ when it receives a horizontal impulse $\mathbf{I}$ N s.

The magnitude of $\mathbf{I}$ is $4\sqrt{10}$ N s.

Immediately after receiving the impulse, the velocity of Q is $\lambda(\mathbf{i}+\mathbf{j})\ \text{m s}^{-1}$, where λ is a positive constant.

(a) Find the value of λ.

(5)

(b) Find $\mathbf{I}$ in terms of $\mathbf{i}$ and $\mathbf{j}$.

(1)

The angle between the direction of the impulse and the initial direction of motion of Q is $\theta°$

(c) Find the value of θ.

(2)

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Question 5 continued

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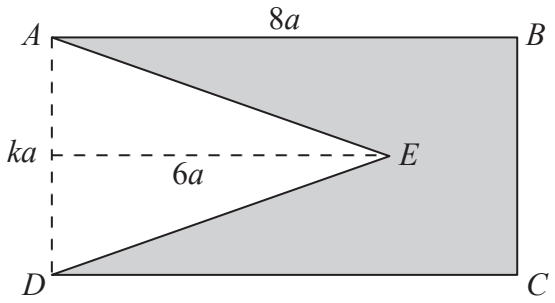


Figure 4

The uniform rectangular lamina $ABCD$ has $AB = 8a$ and $AD = ka$.

The isosceles triangle AED has $AE = DE$ and the perpendicular height of the triangle is $6a$.
The triangle AED is removed from the rectangle to form the template shown shaded in Figure 4.

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

(a) Show that $d = \frac{26}{5}a$.

(5)

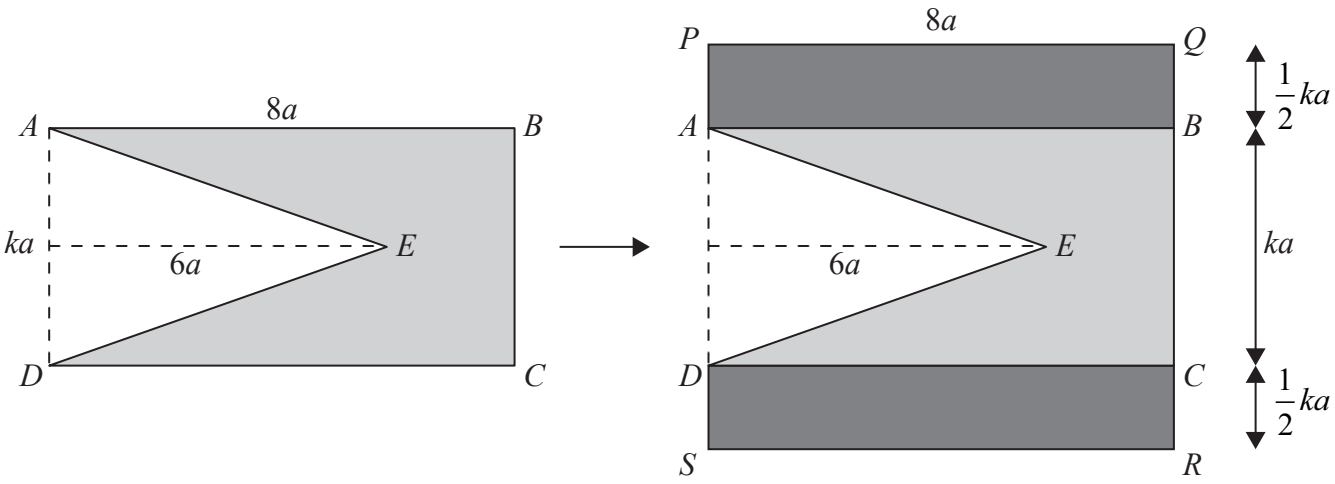


Figure 5

Two identical rectangular laminas, each with length $8a$ and width $\frac{1}{2}ka$, are attached to the template to form the model $PQRSDEA$ shown in Figure 5.

- the two rectangular laminas and the template all lie in the same plane
- the mass per unit area of rectangular lamina $PQBA$ is **three times** the mass per unit area of the template
- the mass per unit area of rectangular lamina $DCRS$ is **three times** the mass per unit area of the template

The model $PQRSDEA$ is freely suspended from P and hangs in equilibrium with PS at an angle of θ to the downward vertical.

(b) Find, in terms of k, the exact value of $\tan\theta$.

(6)

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Question 6 continued

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Question 6 continued

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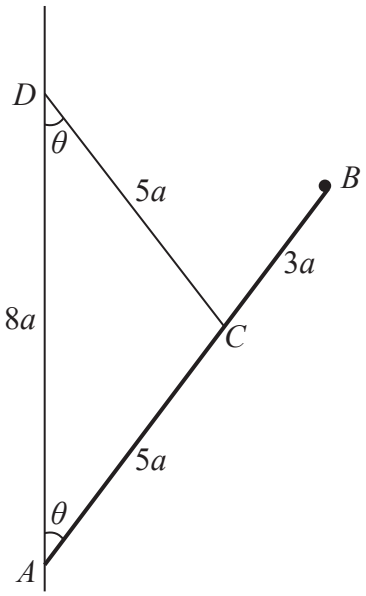


Figure 6

A uniform rod AB has length $8a$ and weight $12W$.
The end A of the rod is freely hinged to a fixed point on a vertical wall.
The rod lies in a vertical plane that is perpendicular to the wall.
A particle of weight W is attached to the rod at B.
A light inextensible string of length $5a$ has one end attached to the rod at the point C, where $AC = 5a$.
The other end of the string is attached to the wall at the point D, where D is above A and $AD = 8a$.
Angle DAC = Angle $ADC = \theta$, as shown in Figure 6.

The rod and the particle rest in equilibrium.

The tension in the string is T.

(a) Show that $T = 7W$.

(4)

The force exerted on the rod by the hinge at A acts at $\alpha°$ above the rod, where $0 < \alpha < 90$

(b) Find the value of α.

(6)

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Question 7 continued

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Question 7 continued

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8. A particle P has mass m and a particle Q has mass km, where k is a constant.

The particles are moving in opposite directions along the same straight line on a smooth horizontal surface.
Particle P collides directly with 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 $2v$ and the speed of Q is $3v$.

As a result of the collision

- the direction of motion of P is unchanged
- the direction of motion of Q is reversed

The coefficient of restitution between P and Q is $\frac{1}{3}$

(a) Find v in terms of u only.

(3)

(b) Find the value of k.

(3)

After the collision, Q hits a smooth fixed vertical wall that is perpendicular to the direction of motion of Q.
Particle Q rebounds and there is a second collision between P and Q.

The first collision between P and Q takes place at a distance d from the wall.

The second collision between P and Q takes place at a distance $\frac{1}{7}d$ from the wall.

The coefficient of restitution between Q and the wall is f

(c) Find the value of f

(5)

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Question 8 continued

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Question 8 continued

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TOTAL FOR PAPER IS 75 MARKS

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