Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 23 October 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 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

Pearson

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

At time t seconds, $t \geqslant 0$, a particle P is moving with velocity $\mathbf{v}\,\mathrm{m\,s^{-1}}$, where

$$\mathbf{v} = 3(t+2)^2\,\mathbf{i} + 5t(t+2)\,\mathbf{j}$$

Position vectors are given relative to the fixed point O

At time $t = 0$, P is at the point with position vector $(-30\mathbf{i} - 45\mathbf{j})$m.

(a) Find the position vector of P when $t = 3$

(4)

(b) Find the magnitude of the acceleration of P when $t = 3$

(4)

At time T seconds, P is moving in the direction of the vector $2\mathbf{i} + \mathbf{j}$

(c) Find the value of T

(2)

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Question 1 continued

(Total for Question 1 is 10 marks)

2. A particle Q of mass 3 kg is moving on a smooth horizontal surface.

Particle Q is moving with velocity $5\mathbf{i}\ \mathrm{m\,s^{-1}}$ when it receives a horizontal impulse of magnitude $3\sqrt{82}$ N s.

Immediately after receiving the impulse, the velocity of Q is $(x\mathbf{i} + y\mathbf{j})\ \mathrm{m\,s^{-1}}$, where x and y are positive constants.

The kinetic energy **gained** by Q as a result of receiving the impulse is 138 J.

Find, in terms of **i** and **j**, the velocity of Q immediately after receiving the impulse.

(7)

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Question 2 continued

(Total for Question 2 is 7 marks)

P 7 6 1 8 2 A 0 5 2 4

Turn over

3.

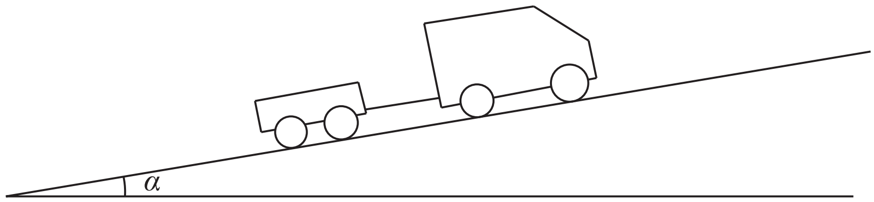

Figure 1

A van of mass 900 kg is moving up a straight road inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{25}$. 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 1.

The resistance to the motion of the van from non-gravitational forces is modelled as a constant force of magnitude 400 N.
The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 240 N.

The towbar is modelled as a light rod.

The engine of the van is working at a constant rate of 15 kW.

(a) Find the acceleration of the van at the instant when the speed of the van is $12\,\mathrm{m\,s^{-1}}$

(5)

At the instant when the speed of the van is $14\,\mathrm{m\,s^{-1}}$, the trailer is passing the point A on the slope and the towbar breaks.

The trailer continues to move up the slope until it comes to rest at the point B.

The resistance to the motion of the trailer from non-gravitational forces is still modelled as a constant force of magnitude 240 N.

(b) Use the work-energy principle to find the distance AB.

(4)

Question 3 continued

Question 3 continued

Question 3 continued

(Total for Question 3 is 9 marks)

4.

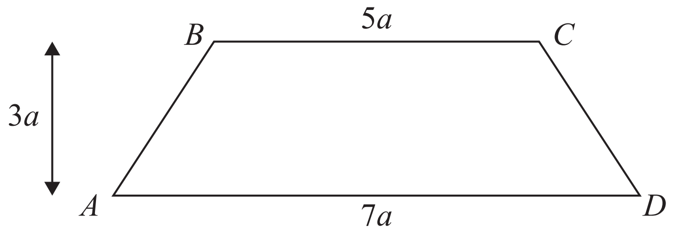

Figure 2

The uniform lamina *ABCD* shown in Figure 2 is in the shape of an isosceles trapezium.

- BC is parallel to AD and angle BAD is equal to angle ADC
- $BC = 5a$ and $AD = 7a$
- the perpendicular distance between BC and AD is $3a$
- the distance of the centre of mass of $ABCD$ from AD is d

(a) Show that $d = \frac{17}{12}a$

(5)

The uniform lamina *PQRS* is a rectangle with $PQ = 5a$ and $QR = 9a$.

The lamina *ABCD* in Figure 2 is used to cut a hole in *PQRS* to form the template shown shaded in Figure 3.

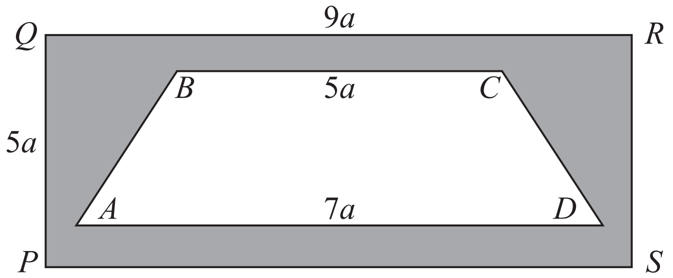

Figure 3

- PS is parallel to AD
- the perpendicular distance between PS and AD is a
- the perpendicular distance of A from PQ is a

The template is freely suspended from P and hangs in equilibrium with PS at an angle of $\theta°$ to the downward vertical.

(b) Find the value of θ

(7)

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Question 4 continued

P 7 6 1 8 2 A 0 1 2 2 4

Question 4 continued

(Total for Question 4 is 12 marks)

5. The fixed points X and Y lie on horizontal ground.

At time $t = 0$, a particle P is projected from X with speed $u\,\text{m s}^{-1}$ at angle θ to the ground.

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

(a) Show that $XY = \dfrac{u^2 \sin 2\theta}{g}$ **(6)**

The points A and B lie on horizontal ground. A vertical pole CD has length 5 m. The end C is fixed to the ground between A and B, where $AC = 12\,\text{m}$.

At time $t = 0$, a particle Q is projected from A with speed $20\ \text{m s}^{-1}$ at 60° to the ground.

Particle Q moves freely under gravity, passes over the pole and first hits the ground at B, as shown in Figure 4.

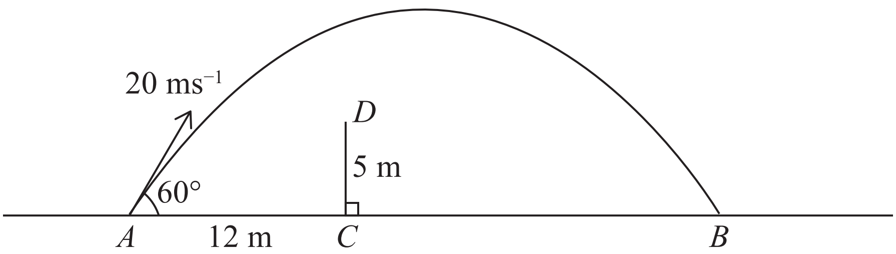

Figure 4

(b) Find the distance CB. **(2)**

(c) Find the height of Q above D at the instant when Q passes over the pole. **(4)**

Question 5 continued

Question 5 continued

Question 5 continued

(Total for Question 5 is 12 marks)

6.

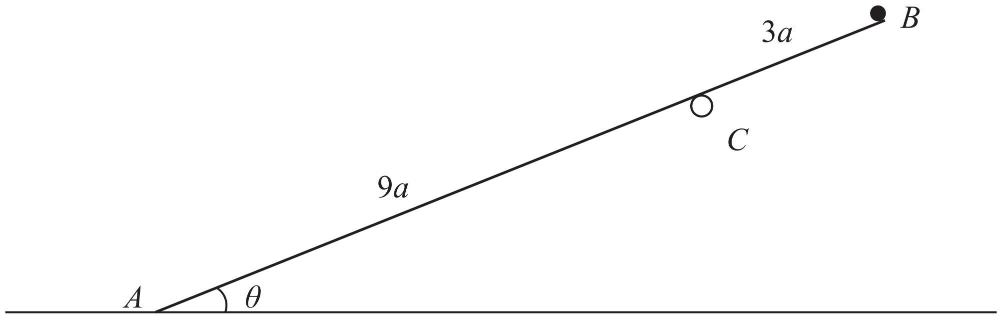

Figure 5

A uniform beam AB, of weight $5W$ and length $12a$, rests with end A on rough horizontal ground.
A package of weight W is attached to the beam at B.
The beam rests in equilibrium on a smooth horizontal peg at C, with $AC = 9a$, as shown in Figure 5.

The beam is inclined at an angle θ to the ground, where $\tan\theta = \frac{5}{12}$

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

The normal reaction between the beam and the peg at C has magnitude kW

Using the model,

(a) show that $k = \frac{56}{13}$

(4)

The coefficient of friction between A and the ground is μ

Given that the beam is resting in limiting equilibrium,

(b) find the value of μ

(6)

Question 6 continued

Question 6 continued

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Question 6 continued

(Total for Question 6 is 10 marks)

7. A particle P has mass $5m$ and a particle Q has mass $2m$.

The particles are moving in opposite directions 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 $2u$ and the speed of Q is $3u$.
Immediately **after** the collision, the speed of P is x and the speed of Q is y.
The direction of motion of Q is **reversed** as a result of the collision.

The coefficient of restitution between P and Q is e.

(a) Find the set of values of e for which the direction of motion of P is **unchanged** as a result of the collision.

(7)

In the collision, Q receives an impulse of magnitude $\frac{60}{7}mu$

(b) Show that $e = \frac{1}{5}$

(5)

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 coefficient of restitution between Q and the wall is $\frac{1}{3}$

(c) Find, in terms of m and u, the magnitude of the impulse received by Q in the second collision between P and Q.

(3)

Question 7 continued

Question 7 continued

(Total for Question 7 is 15 marks)

TOTAL FOR PAPER IS 75 MARKS