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Candidate surname

Other names

Centre Number

Candidate Number

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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 $g = 9.8 \text{ m s}^{-2}$, 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. **In this question you must show all stages of your working.**
Solutions relying entirely on calculator technology are not acceptable.

At time t seconds, $t \geq 0$, a particle P is moving with velocity $\mathbf{v} \text{ ms}^{-1}$, 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 $(-30\mathbf{i} - 45\mathbf{j}) \text{ m}$.

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

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

Immediately after receiving the impulse, the velocity of Q is $(x\mathbf{i} + y\mathbf{j})\text{ ms}^{-1}$, 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 \mathbf{i} and \mathbf{j} , the velocity of Q immediately after receiving the impulse.

(7)

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4.

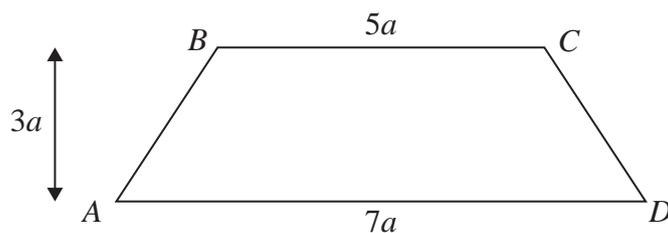


Figure 2

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.

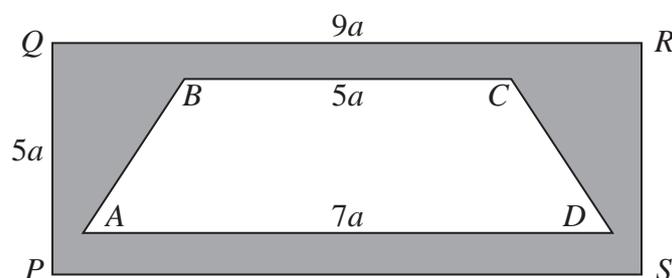


Figure 3

- 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 θ° to the downward vertical.

(b) Find the value of θ (7)



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

6.

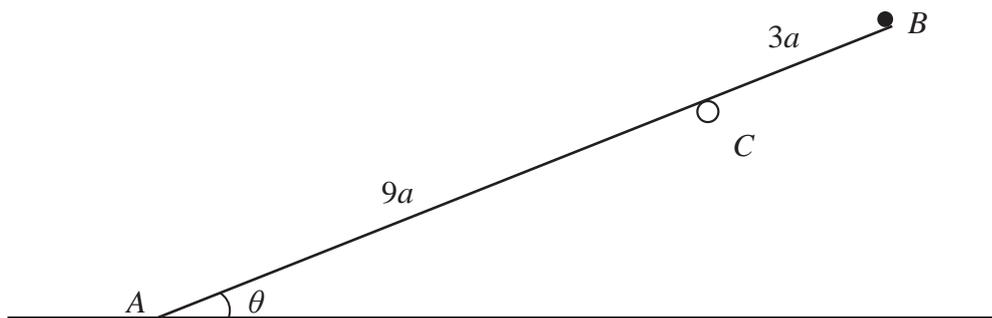


Figure 5

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)

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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)

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