Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Friday 31 May 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 ▶

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P 7 5 7 1 9 A 0 1 2 4

Pearson

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

A particle A has mass 2 kg and a particle B has mass 3 kg. The particles are moving on a smooth horizontal plane when they collide.

Immediately before the collision, the velocity of A is $5\mathbf{j}\,\text{m s}^{-1}$ and the velocity of B is $(3\mathbf{i} - \mathbf{j})\,\text{m s}^{-1}$

Immediately after the collision, the velocity of A is $(3\mathbf{i} + 2\mathbf{j})\,\text{m s}^{-1}$

(a) Find the total kinetic energy of the two particles before the collision.

(3)

(b) Find, in terms of **i** and **j**, the impulse received by A in the collision.

(2)

Given that, in the collision, the impulse of A on B is equal and opposite to the impulse of B on A,

(c) find the velocity of B immediately after the collision.

(3)

Question 1 continued

(Total for Question 1 is 8 marks)

2. **In this question you must show all stages of your working.**

Solutions relying on calculator technology are not acceptable.

A particle P is moving in a straight line.

At time t seconds, the speed, $v\,\text{m s}^{-1}$, of P is given by the continuous function

$$v = \begin{cases} \sqrt{2t+1} & 0 \leqslant t \leqslant k \\ \dfrac{3}{4}t & t > k \end{cases}$$

where k is a constant.

(a) Show that $k = 4$, explaining your method carefully.

(3)

(b) Find the acceleration of P when $t = 1.5$

(3)

At time $t = 0$, P passes through the point O

(c) Find the distance of P from O when $t = 8$

(7)

Question 2 continued

(Total for Question 2 is 13 marks)

3.

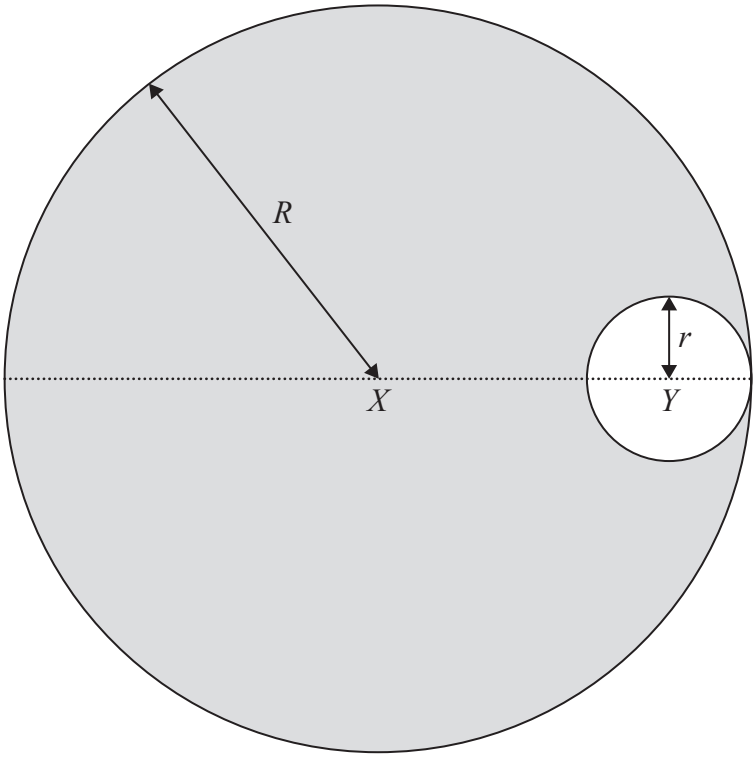

Figure 1

A uniform circular disc C has centre X and radius R.

A disc with centre Y and radius r, where $0 < r < R$ and $XY = R - r$, is removed from C to form the template shown shaded in Figure 1.

The centre of mass of the template is a distance kr from X.

(a) Show that $r = \dfrac{k}{1-k}R$

(4)

(b) Hence find the range of possible values of k.

(2)

The point P is on the outer edge of the template and PX is perpendicular to XY.

The template is freely suspended from P and hangs in equilibrium.

Given that $k = \dfrac{4}{9}$

(c) find the angle that XY makes with the vertical.

(3)

The mass of the template is M.

(d) Find, in terms of M, the mass of the lightest particle that could be attached to the template so that it would hang in equilibrium from P with XY horizontal.

(3)

Question 3 continued

Question 3 continued

Question 3 continued

(Total for Question 3 is 12 marks)

4. A rough plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$

A particle P of mass m is held at rest at a point A on the plane.

The particle is then projected with speed u up a line of greatest slope of the plane and comes to instantaneous rest at the point B.

The coefficient of friction between the particle and the plane is $\frac{1}{7}$

(a) Show that the magnitude of the frictional force acting on the particle, as it moves from A to B, is $\frac{4mg}{35}$

(2)

Given that $u = \sqrt{10ag}$, use the work–energy principle

(b) to find AB in terms of a,

(4)

(c) to find, in terms of a and g, the speed of P when it returns to A.

(4)

Question 4 continued

Question 4 continued

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Question 4 continued

(Total for Question 4 is 10 marks)

5. A particle P of mass m and a particle Q of mass $2m$ are at rest on a smooth horizontal plane.

Particle P is projected with speed u along the plane towards Q and the particles collide. The coefficient of restitution between the particles is e.

As a result of the collision, the direction of motion of P is reversed.

(a) Find, in terms of u and e, the speed of P after the collision.

(6)

After the collision, Q goes on to hit a vertical wall which is fixed at right angles to the direction of motion of Q. The coefficient of restitution between Q and the wall is $\frac{1}{3}$

Given that there is a second collision between P and Q

(b) find the full range of possible values of e.

(5)

Question 5 continued

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Question 5 continued

(Total for Question 5 is 11 marks)

6.

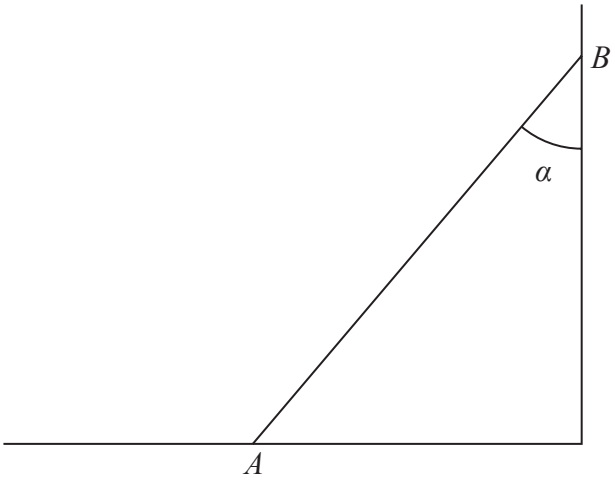

Figure 2

A uniform rod, AB, of mass m and length $2a$, rests in limiting equilibrium with its end A on rough horizontal ground and its end B against a smooth vertical wall.
The vertical plane containing the rod is at right angles to the wall.
The rod is inclined to the wall at an angle α, as shown in Figure 2.

The coefficient of friction between the rod and the ground is $\frac{1}{3}$

(a) Show that $\tan\alpha = \frac{2}{3}$

(6)

With the rod in the same position, a horizontal force of magnitude kmg is applied to the rod at A, towards the wall. The line of action of this force is at right angles to the wall.

The rod remains in equilibrium.

(b) Find the largest possible value of k.

(4)

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Question 6 continued

Question 6 continued

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Question 6 continued

(Total for Question 6 is 10 marks)

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

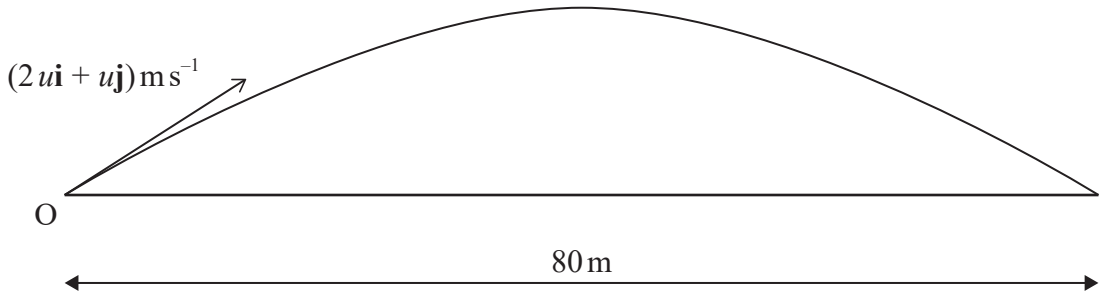

Figure 3

A golf ball is hit from a point O on horizontal ground and is modelled as a particle moving freely under gravity. The initial velocity of the ball is $(2u\mathbf{i} + u\mathbf{j})\,\text{m s}^{-1}$
The ball first hits the horizontal ground at a point which is 80 m from O, as shown in Figure 3.

Use the model to

(a) show that $u = 14$

(6)

(b) find the total time, while the ball is in the air, for which the speed of the ball is greater than $7\sqrt{17}\ \text{m s}^{-1}$

(5)

Question 7 continued

Question 7 continued

(Total for Question 7 is 11 marks)

TOTAL FOR PAPER IS 75 MARKS

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