Paper Reference 9MA0/32
Pearson Edexcel
Level 3 GCE

Mathematics

Advanced

PAPER 32: Mechanics

Time: 2 hours

YOU MUST HAVE

Mathematical Formulae and Statistical Tables (Green), calculator

YOU WILL BE GIVEN

Diagram Booklet
Answer Booklet

Y72131A

Pearson

Candidates may use any calculator allowed 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

In the boxes on the Answer Booklet and on the Diagram Booklet, write 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 Answer Booklet or on the separate diagrams – there may be more space than you need.

Do NOT write on the Question Paper.

You should show sufficient working to make your methods clear. Answers without working may not gain full credit.

Unless otherwise indicated, whenever a value of g is required, take $g = 9{\cdot}8\ \text{ms}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

INFORMATION

A booklet 'Mathematical Formulae and Statistical Tables' is provided.

The total mark for this part of the examination is 50
There are 5 questions.

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.

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1. **[In this question, position vectors are given relative to a fixed origin.]**

At time t seconds, where $t > 0$, a particle P has velocity $\underline{v}$ m s^{-1} where

$$\underline{v} = 3t^2\underline{i} - 6t^{\frac{1}{2}}\underline{j}$$

(a) **Find the speed of P at time $t = 2$ seconds.**

(2 marks)

(continued on the next page)

1. continued.

(b) Find an expression, in terms of t, $\underline{i}$ and $\underline{j}$, for the acceleration of P at time t seconds, where $t > 0$

(2 marks)

At time $t = 4$ seconds, the position vector of P is $(\underline{i} - 4\underline{j})$ metres.

(c) Find the position vector of P at time $t = 1$ second.

(4 marks)

(Total for Question 1 is 8 marks)

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2. Refer to the diagram for Question 2 in the Diagram Booklet.

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

A small block B of mass 5 kg is held in equilibrium on the plane by a horizontal force of magnitude X newtons, as shown in the diagram.

The force acts in a vertical plane which contains a line of greatest slope of the inclined plane.

(continued on the next page)

2. continued.

The block B is modelled as a particle.

The magnitude of the normal reaction of the plane on B is $68 \cdot 6$ newtons.

Using the model,

(a) (i) find the magnitude of the frictional force acting on B,
(3 marks)

(ii) state the direction of the frictional force acting on B
(1 mark)

(continued on the next page)

2. continued.

The horizontal force of magnitude X newtons is now removed and B moves down the plane.

Given that the coefficient of friction between B and the plane is $0{\cdot}5$

(b) find the acceleration of B down the plane.

(6 marks)

(Total for Question 2 is 10 marks)

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3. **[In this question, $\underline{i}$ and $\underline{j}$ are horizontal unit vectors.]**

A particle P of mass 4 kg is at rest at the point A on a smooth horizontal plane.

At time $t = 0$, two forces,
$\mathbf{F}_1 = (4\underline{i} - \underline{j})$ newtons and
$\mathbf{F}_2 = (\lambda\underline{i} + \mu\underline{j})$ newtons, where
λ and μ are constants, are applied to P

(continued on the next page)

3. continued.

Given that P moves in the direction of the vector $(3\underline{i} + \underline{j})$

(a) show that

$$\lambda - 3\mu + 7 = 0$$

(4 marks)

(continued on the next page)

3. continued.

At time $t = 4$ seconds, P passes through the point B

Given that $\lambda = 2$

(b) find the length of AB

(5 marks)

(Total for Question 3 is 9 marks)

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4. Refer to the diagram for Question 4 in the Diagram Booklet.

A uniform rod AB has mass M and length $2a$

A particle of mass $2M$ is attached to the rod at the point C, where $AC = 1 \cdot 5a$

The rod rests with its end A on rough horizontal ground.

(continued on the next page)

4. continued.

The rod is held in equilibrium at an angle θ to the ground by a light string that is attached to the end B of the rod.

The string is perpendicular to the rod, as shown in the diagram.

(continued on the next page)

4. continued.

(a) Explain why the frictional force acting on the rod at A acts horizontally to the right on the diagram.

(1 mark)

The tension in the string is T

(b) Show that $T = 2Mg\cos\theta$

(3 marks)

(continued on the next page)

4. continued.

Given that $\cos\theta = \frac{3}{5}$

(c) show that the magnitude of the vertical force exerted by the ground on the rod at A is $\frac{57Mg}{25}$

(3 marks)

(continued on the next page)

4. continued.

The coefficient of friction between the rod and the ground is μ

Given that the rod is in limiting equilibrium,

(d) show that $\mu = \frac{8}{19}$

(4 marks)

(Total for Question 4 is 11 marks)

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5. Refer to the diagram for Question 5 in the Diagram Booklet.

A golf ball is at rest at the point A on horizontal ground.

The ball is hit and initially moves at an angle α to the ground.

The ball first hits the ground at the point B, where $AB = 120$ metres, as shown in the diagram.

The motion of the ball is modelled as that of a particle, moving freely under gravity, whose initial speed is $U\,\text{m s}^{-1}$

(continued on the next page)

5. continued.

Using this model,

(a) show that $U^2 \sin\alpha \cos\alpha = 588$

(6 marks)

The ball reaches a maximum height of 10 metres above the ground.

(b) Show that $U^2 = 1960$

(4 marks)

(continued on the next page)

5. continued.

In a refinement to the model, the effect of air resistance is included.

The motion of the ball, from A to B, is now modelled as that of a particle whose initial speed is $V\,m\,s^{-1}$

This refined model is used to calculate a value for V

(c) State which is greater, U or V, giving a reason for your answer.
(1 mark)

(continued on the next page)

5. continued.

(d) State ONE further refinement to the model that would make the model more realistic.

(1 mark)

(Total for Question 5 is 12 marks)

TOTAL FOR MECHANICS IS 50 MARKS

END OF PAPER
