Paper Reference 9MA0/32
Pearson Edexcel
Level 3 GCE

Mathematics
Advanced
PAPER 32: Mechanics

Monday 18 October 2021 – Afternoon

YOU MUST HAVE
Mathematical Formulae and Statistical Tables (Green), calculator

YOU WILL BE GIVEN
Diagram Booklet
Answer Booklet

X68824A

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 spaces provided in the Answer Booklet – 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. A particle P moves with constant acceleration $(2\underline{i} - 3\underline{j})\ ms^{-2}$

At time $t = 0$, P is moving with velocity $4\underline{i}\ ms^{-1}$

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

(2 marks)

At time $t = 0$, the position vector of P relative to a fixed origin O is $(\underline{i} + \underline{j})$ metres.

(b) Find the position vector of P relative to O at time $t = 3$ seconds.

(2 marks)

(Total for Question 1 is 4 marks)

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

A small stone A of mass $3m$ is attached to one end of a string.

A small stone B of mass m is attached to the other end of the string.

Initially A is held at rest on a fixed rough plane.

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

The string passes over a pulley P that is fixed at the top of the plane.

The part of the string from A to P is parallel to a line of greatest slope of the plane.

Stone B hangs freely below P, as shown in the diagram.

(continued on the next page)

2. continued.

The coefficient of friction between A and the plane is $\frac{1}{6}$

Stone A is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before B reaches the pulley,

(a) write down an equation of motion for A

(2 marks)

(continued on the next page)

2. continued.

(b) show that the acceleration of A is $\frac{1}{10}g$

(7 marks)

(c) sketch a velocity–time graph for the motion of B, from the instant when A is released from rest to the instant just before B reaches the pulley, explaining your answer.

There are blank axes on pages 34 – 45 in the Answer Booklet if you wish to use them.

(2 marks)

In reality, the string is not light.

(d) State how this would affect the working in part (b).

(1 mark)

(Total for Question 2 is 12 marks)

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3. Refer to the diagram for Question 3 in the Diagram Booklet.

A beam AB has mass m and length $2a$

The beam rests in equilibrium with A on rough horizontal ground and with B against a smooth vertical wall.

The beam is inclined to the horizontal at an angle θ, as shown in the diagram.

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

The beam is modelled as a uniform rod resting in a vertical plane that is perpendicular to the wall.

Using the model,

(a) show that $\mu \geq \frac{1}{2}\cot\theta$

(5 marks)

(continued on the next page)

3. continued.

A horizontal force of magnitude kmg, where k is a constant, is now applied to the beam at A

This force acts in a direction that is perpendicular to the wall and towards the wall.

Given that $\tan\theta = \frac{5}{4}$, $\mu = \frac{1}{2}$ and the beam is now in limiting equilibrium,

(b) use the model to find the value of k

(5 marks)

(Total for Question 3 is 10 marks)

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

A small stone is projected with speed $65\ ms^{-1}$ from a point O at the top of a vertical cliff.

Point O is 70 metres vertically above the point N

Point N is on horizontal ground.

The stone is projected at an angle α above the horizontal, where $\tan\alpha = \frac{5}{12}$

The stone hits the ground at the point A, as shown in the diagram.

The stone is modelled as a particle moving freely under gravity.

The acceleration due to gravity is modelled as having magnitude $10\ ms^{-2}$

(continued on the next page)

4. continued.

Using the model,

(a) find the time taken for the stone to travel from O to A

(4 marks)

(b) find the speed of the stone at the instant just before it hits the ground at A

(5 marks)

One limitation of the model is that it ignores air resistance.

(c) State one other limitation of the model that could affect the reliability of your answers.

(1 mark)

(Total for Question 4 is 10 marks)

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5. At time t seconds, a particle P has velocity $\underline{v}$ ms^{-1}, where

$$\underline{v} = 3t^{\frac{1}{2}}\underline{i} - 2t\underline{j} \qquad t > 0$$

(a) Find the acceleration of P at time t seconds, where $t > 0$

(2 marks)

(b) Find the value of t at the instant when P is moving in the direction of $\underline{i} - \underline{j}$

(3 marks)

At time t seconds, where $t > 0$, the position vector of P, relative to a fixed origin O, is $\underline{r}$ metres.

When $t = 1$, $\underline{r} = -\underline{j}$

(c) Find an expression for $\underline{r}$ in terms of t

(3 marks)

(continued on the next page)

5. continued.

(d) Find the exact distance of P from O at the instant when P is moving with speed $10\ ms^{-1}$

(6 marks)

(Total for Question 5 is 14 marks)

TOTAL FOR MECHANICS IS 50 MARKS

END OF PAPER
