Paper Reference 9MA0/32
Pearson Edexcel Level 3 GCE

Mathematics

Advanced

PAPER 32: Mechanics

Tuesday 20 June 2023 – Afternoon

Time for 9MA0/31 and 9MA0/32: 2 hours

YOU MUST HAVE
Mathematical Formulae and Statistical Tables (Green), calculator, 9MA0/31

YOU WILL BE GIVEN
Diagram Booklet
Answer Booklet

Y72820A

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.

(continued on the next page)

Instructions continued.

Answer the questions in the Answer Booklet – there may be more space than you need.

Do NOT write on this 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 numerical value of g is required, take $g = 9{\cdot}8\ ms^{-2}$ 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 6 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.

1. A car is initially at rest on a straight horizontal road.

The car then accelerates along the road with a constant acceleration of $3 \cdot 2 \, m \, s^{-2}$

Find

(a) the speed of the car after 5 seconds,
(1 mark)

(continued on the next page)

1. continued.

(b) the distance travelled by the car in the first 5 seconds.

(2 marks)

(Total for Question 1 is 3 marks)

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

A particle P has mass 5 kg

The particle is pulled along a rough horizontal plane by a horizontal force of magnitude 28 newtons.

The only resistance to motion is a frictional force of magnitude F newtons, as shown in the diagram.

(a) Find the magnitude of the normal reaction of the plane on P

(1 mark)

(continued on the next page)

2. continued.

The particle is accelerating along the plane at $1 \cdot 4 \, m s^{-2}$

(b) Find the value of F

(2 marks)

The coefficient of friction between P and the plane is μ

(c) Find the value of μ, giving your answer to 2 significant figures.

(1 mark)

(Total for Question 2 is 4 marks)

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

$$\underline{v} = (t^2 - 3t + 7)\underline{i} + (2t^2 - 3)\underline{j}$$

Find

(a) the speed of P at time $t = 0$

(3 marks)

(b) the value of t when P is moving parallel to $(\underline{i} + \underline{j})$

(2 marks)

(continued on the next page)

3. continued.

(c) the acceleration of $\mathbf{P}$ at time t seconds

(2 marks)

(d) the value of t when the direction of the acceleration of $\mathbf{P}$ is perpendicular to $\mathbf{i}$

(2 marks)

(Total for Question 3 is 9 marks)

4. **[In this question, $\underline{\mathbf{i}}$ and $\underline{\mathbf{j}}$ are horizontal unit vectors and position vectors are given relative to a fixed origin O]**

A particle P is moving on a smooth horizontal plane.

The particle has constant acceleration $(2 \cdot 4\underline{\mathbf{i}} + \underline{\mathbf{j}})\,\mathrm{m\,s^{-2}}$

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

(continued on the next page)

4. continued.

At time $t = 5$ seconds, P passes through the point B

The velocity of P as it passes through A is $(-16\underline{i} - 3\underline{j})\,m\,s^{-1}$

(a) Find the speed of P as it passes through B

(4 marks)

(continued on the next page)

4. continued.

The position vector of A is

$(44\underline{i} - 10\underline{j})$ metres.

At time $t = T$ seconds, where $T > 5$,

P passes through the point C

The position vector of C is

$(4\underline{i} + c\underline{j})$ metres.

(b) Find the value of T

(3 marks)

(continued on the next page)

4. continued.

(c) Find the value of c

(3 marks)

(Total for Question 4 is 10 marks)

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

A small ball is projected with speed $28\,m\,s^{-1}$ from a point O on horizontal ground.

After moving for T seconds, the ball passes through the point A

The point A is 40 metres horizontally and 20 metres vertically from the point O, as shown in the diagram.

(continued on the next page)

5. continued.

The motion of the ball from O to A is modelled as that of a particle moving freely under gravity.

Given that the ball is projected at an angle α to the ground, use the model to

(a) show that $T = \dfrac{10}{7\cos\alpha}$

(2 marks)

(continued on the next page)

5. continued.

(b) show that

$$\tan^2 \alpha - 4 \tan \alpha + 3 = 0$$

(5 marks)

(c) find the greatest possible height, in metres, of the ball above the ground as the ball moves from O to A

(3 marks)

(continued on the next page)

5. continued.

The model does not include air resistance.

(d) State one other limitation of the model.

(1 mark)

(Total for Question 5 is 11 marks)

6. Refer to the diagram for Question 6 in the Diagram Booklet.

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

The rod has its end A on rough horizontal ground and its end B against a smooth vertical wall.

The rod makes an angle θ with the ground, as shown in the diagram.

The rod is at rest in limiting equilibrium.

(continued on the next page)

6. continued.

(a) State the direction (left or right on the diagram in the Diagram Booklet) of the frictional force acting on the rod at **A**

Give a reason for your answer.

(1 mark)

(continued on the next page)

6. continued.

The magnitude of the normal reaction of the wall on the rod at **B** is **S**

In an initial model, the rod is modelled as being UNIFORM.

Use this initial model to answer parts (b), (c) and (d).

(continued on the next page)

6. continued.

(b) By taking moments about **A**, show that

$$S = \frac{1}{2} Mg \cot \theta$$

(3 marks)

(continued on the next page)

6. continued.

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

Given that $\tan\theta = \frac{3}{4}$

(c) find the value of μ

(5 marks)

(d) find, in terms of M and g, the magnitude of the resultant force acting on the rod at A

(3 marks)

(continued on the next page)

6. continued.

In a new model, the rod is modelled as being NON–UNIFORM, with its centre of mass closer to B than it is to A

A new value for S is calculated using this new model, with $\tan\theta = \frac{3}{4}$

(continued on the next page)

6. continued.

(e) State whether this new value for S is larger, smaller or equal to the value that S would take using the initial model.

Give a reason for your answer.

(1 mark)

(Total for Question 6 is 13 marks)

TOTAL FOR MECHANICS IS 50 MARKS

END OF PAPER
