

Paper Reference 9MA0/32
Pearson Edexcel Level 3 GCE

Mathematics

Advanced

PAPER 32: Mechanics

Thursday 19 June 2025 – Afternoon

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

Question Paper

Total Marks

**THIS DOCUMENT MUST BE
RETURNED TO PEARSON AT THE END
OF THE EXAMINATION.**

In the boxes below, write your name,
centre number and candidate number.

Surname					
Other names					
Centre Number					
Candidate Number					

YOU MUST HAVE

**Mathematical Formulae and Statistical
Tables (Green), calculator, 9MA0/31**

YOU WILL BE GIVEN

Diagram Booklet

Answer Booklet

**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.**

Turn over

INSTRUCTIONS

Answer ALL questions and ensure that your answers to parts of questions are clearly labelled.

Answer the questions in the Answer Booklet or in the separate Diagram Booklet – 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.

Unless otherwise indicated, whenever a 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.

Turn over

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.

There may be spare copies of some diagrams.

Turn over

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.

Turn over

1. A car moves in a straight line along a horizontal road with constant acceleration 2 m s^{-2}

The car is moving with speed 15 m s^{-1} in the direction of the acceleration when it passes a signpost on the road.

The car is modelled as a particle.

- (a) Use the model to find the speed of the car 4 seconds after passing the signpost.
(2 marks)

(continued on the next page)

Turn over

1. continued.

**Refer to the diagram for Question 1(b)
in the Diagram Booklet.**

**It shows the horizontal forces acting
on the car.**

(continued on the next page)

1. continued.

Given that

- the car has mass **800 kg**
- the driving force of the engine has magnitude **D** newtons
- the resistance to the motion of the car has magnitude **400 newtons**
- the acceleration of the car is **2 m s^{-2}** in the direction of the driving force

(b) use the model to find the value of D
(2 marks)

(Total for Question 1 is 4 marks)

Turn over

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

A small box B of mass 2 kg is dragged in a straight line, along a ROUGH horizontal plane, at a CONSTANT SPEED by a force of magnitude 5 newtons.

(continued on the next page)

2. continued.

The line of action of the force makes an angle α with the plane, where $\sin \alpha = \frac{3}{5}$, as shown in the diagram.

- (a) Show that the magnitude of the normal reaction of the plane on the box is **16.6 newtons**.
(3 marks)

(continued on the next page)

Turn over

2. continued.

At the instant when **B is at the point **O** on the plane, the force of magnitude **5** newtons is removed.**

(b) Describe the motion of the box after the force of magnitude **5 newtons is removed.**

(1 mark)

(c) Find the magnitude of the normal reaction of the plane on the box after the force of magnitude **5 newtons is removed.**

(1 mark)

(continued on the next page)

Turn over

2. continued.

Given that after the force of magnitude 5 newtons is removed

- **the box is modelled as a particle**
- **air resistance is modelled as being negligible**
- **the coefficient of friction between the box and the plane is modelled as 0.2**
- **the speed of the box as it passes through O is 4 m s^{-1}**
- **the box comes to rest at the point X on the plane**

(continued on the next page)

Turn over

2. continued.

**(d) use the model to find the
length OX
(4 marks)**

**(e) State one limitation of the
model, apart from ignoring air
resistance, that could affect your
answer to part (d).
(1 mark)**

(Total for Question 2 is 10 marks)

Turn over

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

A particle **P** of mass 0.5 kg moves with constant acceleration $(2\underline{i} - 2.4\underline{j}) \text{ m s}^{-2}$ on a smooth horizontal plane under the action of a constant horizontal force $\underline{F}$ newtons.

- (a) Find $\underline{F}$ in terms of $\underline{i}$ and $\underline{j}$
(1 mark)

(continued on the next page)

3. continued.

At time $t = 0$, P is moving with velocity

$$(-7\mathbf{i} + 7 \cdot 8\mathbf{j}) \text{ m s}^{-1}$$

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

(2 marks)

(c) Find the direction of motion of P at time $t = 2$ seconds, giving your answer as a bearing in degrees.

(3 marks)

(continued on the next page)

Turn over

3. continued.

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

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

(d) Find $\overrightarrow{OA}$ in terms of $\underline{\underline{i}}$ and $\underline{\underline{j}}$
(2 marks)

(Total for Question 3 is 8 marks)

Turn over

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

At time t seconds, where $t > 0$, the position vector of a particle P is $\underline{r}$ metres where

$$\underline{r} = 4t^{\frac{3}{2}}\underline{i} - t^2\underline{j}$$

- (a) Find the position vector of P at $t = 4$
(1 mark)

(continued on the next page)

Turn over

4. continued.

(b) Find the exact distance of **P** from **O** at $t = 4$
(2 marks)

(c) Find an expression for the velocity of **P** at time t seconds, where $t > 0$, giving your answer in terms of t , $\underline{i}$ and $\underline{j}$
(2 marks)

(continued on the next page)

Turn over

4. continued.

At $t = T$, the acceleration of P is in a direction that is perpendicular to the line with equation

$$y = \frac{1}{3}x$$

(d) Find the value of T
(4 marks)

(Total for Question 4 is 9 marks)

Turn over

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

A small stone is projected with speed 14 m s^{-1} from a point **O** on the top of a cliff.

The point **O** is **H** metres vertically above the point **N**

Point **N** is on horizontal ground.

The stone is projected at an angle θ above the horizontal, where

$$\tan \theta = \frac{1}{2}$$

(continued on the next page)

5. continued.

The stone strikes the horizontal ground at the point A , where $NA = 40$ metres, as shown in the diagram.

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

(continued on the next page)

Turn over

5. continued.

Using this model, find

(a) the value of H

(5 marks)

**(b) the maximum height of the stone
above the horizontal ground.**

(3 marks)

(Total for Question 5 is 8 marks)

Turn over

6. Refer to the diagram for Questions 6(a), 6(b) and 6(c) in the Diagram Booklet.

A uniform rod **AB** has mass **M** and length **2p**

A particle of mass **2M** is attached to the rod at the point **C**, where **AC = 0.5p**

The rod rests with end **A** on rough horizontal ground and end **B** against a vertical wall.

(continued on the next page)

Turn over

6. continued.

The rod lies in a vertical plane which is perpendicular to the wall.

The rod is in equilibrium at an angle α to the wall, as shown in the diagram.

(continued on the next page)

Turn over

6. continued.

In an initial model

- **the vertical wall is modelled as being SMOOTH**
- **the magnitude of the normal reaction of the ground on the rod at A is R**
- **the magnitude of the force exerted on the rod by the wall at B is S**

(continued on the next page)

Turn over

6. continued.

Using the model,

(a) find R in terms of M and g

(1 mark)

(b) show that

$$\mathbf{S = Mg \tan \alpha}$$

(3 marks)

(continued on the next page)

Turn over

6. continued.

In a refined model

- **the vertical wall is modelled as being ROUGH**
- **the magnitude of the normal reaction of the ground on the rod at A is R_1**

**(c) State which is greater, R or R_1 , giving a reason for your answer.
(1 mark)**

(continued on the next page)

Turn over

6. continued.

Refer to the diagram for Question 6(d) in the Diagram Booklet.

A second particle of mass $3M$ is now attached to the rod at **B**

The rod again rests with end **A on rough horizontal ground and end **B** against the vertical wall.**

The rod lies in a vertical plane which is perpendicular to the wall.

(continued on the next page)

Turn over

6. continued.

The rod is now in limiting equilibrium at an angle β to the wall, as shown in the diagram.

The vertical wall is again modelled as being SMOOTH.

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

(continued on the next page)

Turn over

6. continued.

Given that

$$\tan \beta = \frac{1}{2}$$

(d) use the model to show that

$$\mu = \frac{1}{3}$$

(6 marks)

(Total for Question 6 is 11 marks)

TOTAL FOR MECHANICS IS 50 MARKS
END OF PAPER