

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

**Pearson Edexcel Level 3 GCE**

**Tuesday 20 June 2023**

Afternoon

Paper  
reference

**9MA0/32**

**Mathematics**

**Advanced**

**PAPER 32: Mechanics**

**You must have:**

Mathematical Formulae and Statistical Tables (Green), calculator

Total Marks

**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

- 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.
- 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.

### 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.

Turn over ►

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2.



**Figure 1**

A particle  $P$  has mass  $5 \text{ kg}$ .

The particle is pulled along a rough horizontal plane by a horizontal force of magnitude  $28 \text{ N}$ .

The only resistance to motion is a frictional force of magnitude  $F$  newtons, as shown in Figure 1.

- (a) Find the magnitude of the normal reaction of the plane on  $P$  (1)

The particle is accelerating along the plane at  $1.4 \text{ m s}^{-2}$

- (b) Find the value of  $F$  (2)

The coefficient of friction between  $P$  and the plane is  $\mu$

- (c) Find the value of  $\mu$ , giving your answer to 2 significant figures. (1)

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**Question 2 continued**

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(Total for Question 2 is 4 marks)



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

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

Find

- (a) the speed of  $P$  at time  $t = 0$  (3)
- (b) the value of  $t$  when  $P$  is moving parallel to  $(\mathbf{i} + \mathbf{j})$  (2)
- (c) the acceleration of  $P$  at time  $t$  seconds (2)
- (d) the value of  $t$  when the direction of the acceleration of  $P$  is perpendicular to  $\mathbf{i}$  (2)





4. [In this question,  $\mathbf{i}$  and  $\mathbf{j}$  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  $(2.4\mathbf{i} + \mathbf{j})\text{ms}^{-2}$

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

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

The velocity of  $P$  as it passes through  $A$  is  $(-16\mathbf{i} - 3\mathbf{j})\text{ms}^{-1}$

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

(4)

The position vector of  $A$  is  $(44\mathbf{i} - 10\mathbf{j})\text{m}$ .

At time  $t = T$  seconds, where  $T > 5$ ,  $P$  passes through the point  $C$ .

The position vector of  $C$  is  $(4\mathbf{i} + c\mathbf{j})\text{m}$ .

- (b) Find the value of  $T$ .

(3)

- (c) Find the value of  $c$ .

(3)





**Question 4 continued**

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Question 4 continued

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(Total for Question 4 is 10 marks)



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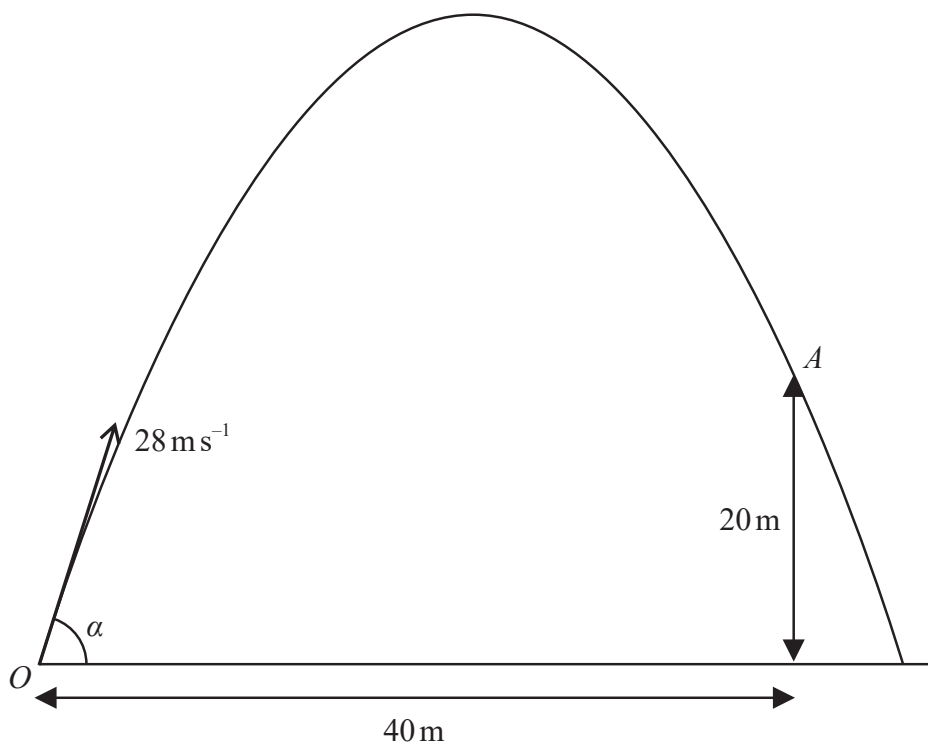


Figure 2

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

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

The point  $A$  is  $40 \text{ m}$  horizontally and  $20 \text{ m}$  vertically from the point  $O$ , as shown in Figure 2.

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  $\alpha$  to the ground, use the model to

(a) show that  $T = \frac{10}{7 \cos \alpha}$  (2)

(b) show that  $\tan^2 \alpha - 4 \tan \alpha + 3 = 0$  (5)

(c) find the greatest possible height, in metres, of the ball above the ground as the ball moves from  $O$  to  $A$ . (3)

The model does not include air resistance.

(d) State one other limitation of the model. (1)





Question 5 continued

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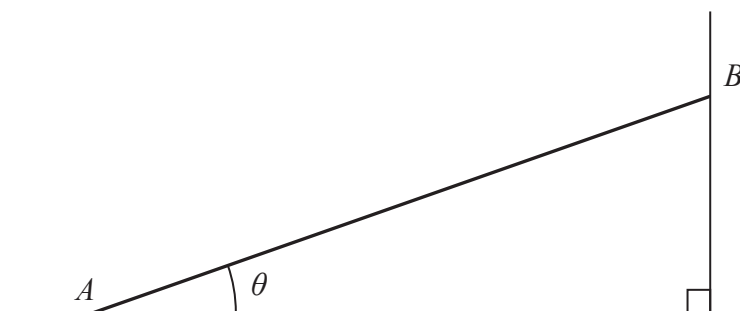


Figure 3

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  $\theta$  with the ground, as shown in Figure 3.

The rod is at rest in limiting equilibrium.

(a) State the direction (left or right on Figure 3 above) of the frictional force acting on the rod at  $A$ . **Give a reason for your answer.**

(1)

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).**

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

$$S = \frac{1}{2} Mg \cot \theta \quad (3)$$

The coefficient of friction between the rod and the ground is  $\mu$

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

(c) find the value of  $\mu$  (5)

(d) find, in terms of  $M$  and  $g$ , the magnitude of the resultant force acting on the rod at  $A$ . (3)

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

(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)





Question 6 continued

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Question 6 continued

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**Question 6 continued**

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**(Total for Question 6 is 13 marks)**

**TOTAL FOR MECHANICS IS 50 MARKS**

