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

The car then accelerates along the road with a constant acceleration of $3.2\,\text{m}\,\text{s}^{-2}$

Find

(a) the speed of the car after 5 s,

**(1)**

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

**(2)**

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**Question 1 continued**

**(Total for Question 1 is 3 marks)**

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**2.**


**Figure 1**

A particle $P$ has mass 5 kg.

The particle is pulled along a rough horizontal plane by a horizontal force of magnitude 28 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 $1.4\,\text{m}\,\text{s}^{-2}$

(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**

**(Total for Question 2 is 4 marks)**

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

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**Question 3 continued**

**(Total for Question 3 is 9 marks)**

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

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

At time $t = 5\,\text{s}$, $P$ passes through the point $B$.

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

(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)**

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**Question 4 continued**

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**Question 4 continued**

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**Question 4 continued**

**(Total for Question 4 is 10 marks)**

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**5.**

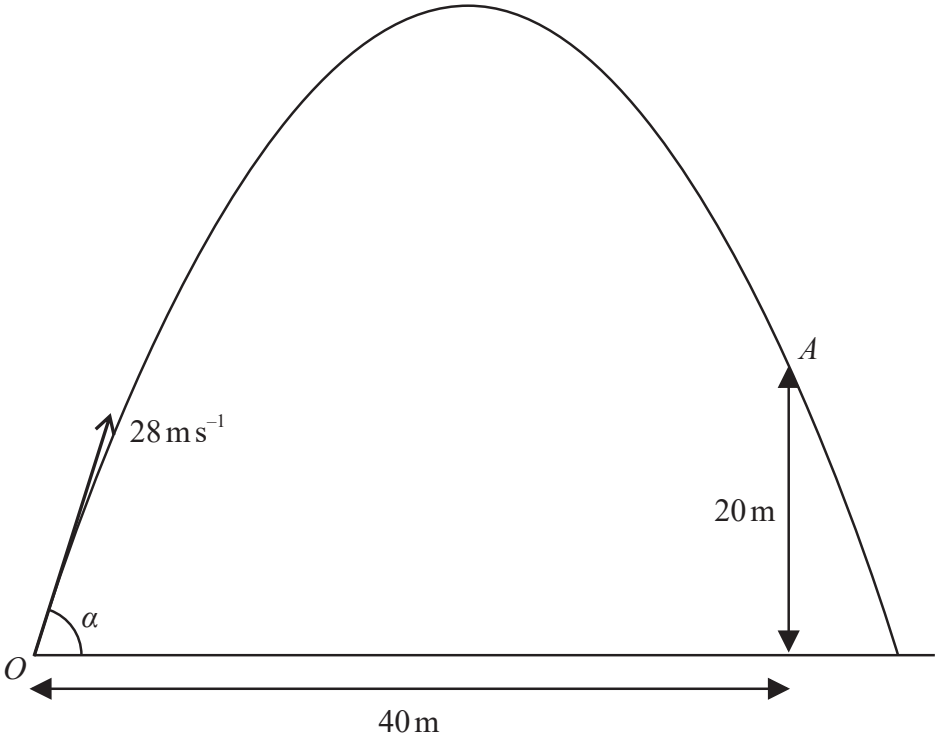


**Figure 2**

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 m horizontally and 20 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 $T = \dfrac{10}{7\cos\alpha}$

**(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)**

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**Question 5 continued**

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**Question 5 continued**

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**Question 5 continued**

**(Total for Question 5 is 11 marks)**

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**6.**

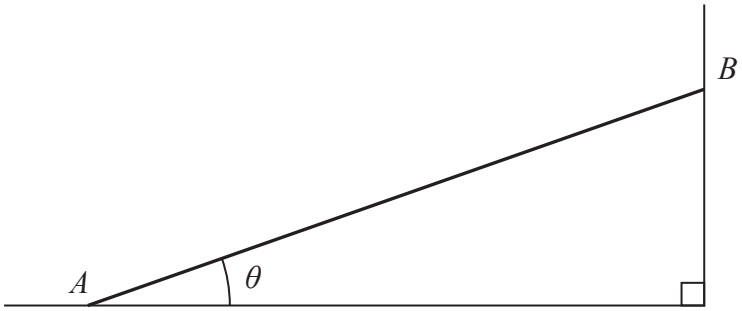


**Figure 3**

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

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

**(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)**

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**Question 6 continued**

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**Question 6 continued**

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**Question 6 continued**

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**Question 6 continued**

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

**TOTAL FOR MECHANICS IS 50 MARKS**

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