Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
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**Pearson Edexcel Level 3 GCE**

| Centre Number | Candidate Number |
|---|---|
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**Mock Paper Set 2**

**(Time: 1 hour 30 minutes)** Paper Reference **9FM0 / 3C**

# Further Mathematics

## Advanced

## Paper 3C: Further Mechanics 1

**You must have:**
Mathematical Formulae and Statistical Tables (Green), calculator

Total Marks

**Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for algebraic 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 numerical value of $g$ is required, take $g = 9.8\,\text{m}\,\text{s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

### Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- 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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Pearson

**Answer ALL questions. Write your answers in the spaces provided.**

**1.** A car of mass 700 kg is moving along a straight horizontal road. At the instant when the speed of the car is $v\,\text{m s}^{-1}$, the resistance to the motion of the car is modelled as a force of magnitude $(200 + 10v)\,\text{N}$.

The engine of the car is working at a constant rate of 12 kW.

At the instant when the speed of the car is $w\,\text{m s}^{-1}$, the acceleration of the car is $0.6\,\text{m s}^{-2}$

Find the value of $w$.

**(5)**

**Question 1 continued**

**(Total for Question 1 is 5 marks)**

**2.** A particle $P$ of mass 2 kg is moving in a straight line on a smooth horizontal surface.

When the speed of $P$ is $3\,\text{m s}^{-1}$, $P$ receives an impulse **I** Ns.

Immediately after receiving the impulse, the speed of $P$ is $9\,\text{m s}^{-1}$. As a result of the impulse, the direction of motion of $P$ is deflected through an angle of 45°.

Find (i) the magnitude of **I** Ns,

(ii) the size of the angle between the direction of **I** Ns and the direction of motion of $P$ immediately before $P$ receives the impulse.

**(6)**

**Question 2 continued**

**(Total for Question 2 is 6 marks)**

**3.**

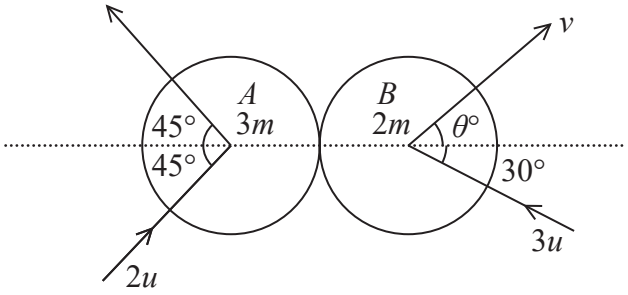


**Figure 1**

A smooth uniform sphere $A$ has mass $3m$. Another smooth uniform sphere $B$, with the same radius as $A$, has mass $2m$.

The spheres are moving on a smooth horizontal surface when they collide obliquely.

Immediately before the collision

- the speed of $A$ is $2u$ and the speed of $B$ is $3u$
- sphere $A$ is moving at 45° to the line of centres
- sphere $B$ is moving at 30° to the line of centres

Immediately after the collision

- the speed of $B$ is $v$
- sphere $B$ is moving at $\theta°$ to the line of centres as shown in Figure 1.

The coefficient of restitution between $A$ and $B$ is $e$.

Given that the direction of motion of $A$ is deflected through 90° by the collision,

(a) find (i) $v$ in terms of $u$

(ii) the value of $\theta$

**(6)**

(b) Find the value of $e$.

**(3)**

**Question 3 continued**

**Question 3 continued**

**Question 3 continued**

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

**4.**

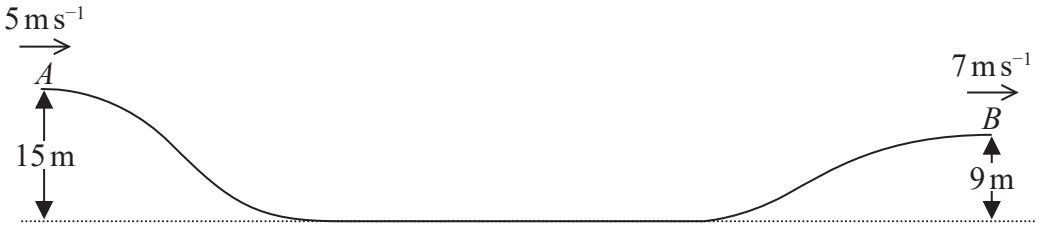


**Figure 2**

A boy cycles along a cycle route. The route passes through two points $A$ and $B$. The boy descends from $A$, cycles along horizontal ground and then ascends to $B$. The point $A$ is 15 m above the horizontal ground and the point $B$ is 9 m above the horizontal ground.

At the instant the boy passes point $A$, his speed is $5\,\text{m s}^{-1}$.

At the instant the boy passes point $B$, his speed is $7\,\text{m s}^{-1}$, as shown in Figure 2.

The distance from $A$ to $B$ along the cycle route is 800 m. The resistance to the motion of the boy and his cycle from non-gravitational forces is modelled as a force of constant magnitude 12 N. The total mass of the boy and his cycle is 75 kg.

(a) Find the work done by the boy as he cycles from $A$ to $B$.

**(5)**

At the instant the boy passes point $B$, he is moving horizontally, working at a rate of 140 W and accelerating at $k\,\text{m s}^{-2}$.

(b) Find the value of $k$.

**(3)**

**Question 4 continued**

**(Total for Question 4 is 8 marks)**

**5.** [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane*.]

A small ball of mass 1.5 kg is moving on a horizontal plane when it strikes a fixed smooth vertical wall. Immediately before the impact the velocity of the ball is $8\mathbf{i}\,\text{m s}^{-1}$. Immediately after the impact the velocity of the ball is $\lambda(\mathbf{i} + 2\mathbf{j})\,\text{m s}^{-1}$, where $\lambda$ is a positive constant.

The coefficient of restitution between the ball and the wall is $e$.

The kinetic energy lost by the ball when it strikes the wall is 33 J.

(a) Find the impulse received by the ball when it strikes the wall.

**(5)**

(b) Find the value of $e$.

**(6)**

**Question 5 continued**

**Question 5 continued**

**Question 5 continued**

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

**6.**

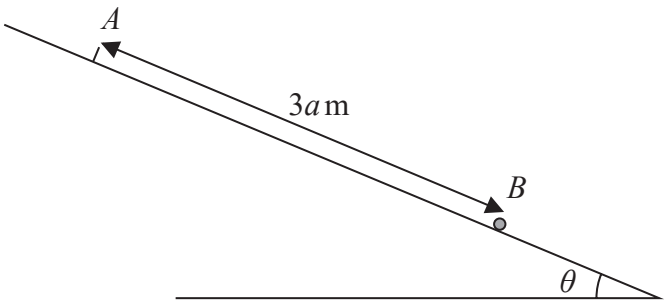


**Figure 3**

[In this question, use $g = 10\,\text{m}\,\text{s}^{-2}$]

A light elastic string has natural length $a$ metres and modulus of elasticity $\lambda$ newtons. A particle $P$ of mass 2 kg is attached to one end of the string. The other end of the string is attached to a fixed point $A$ on a rough inclined plane. The plane is inclined at angle $\theta$ to the horizontal, where $\tan\theta = \frac{3}{4}$

The point $B$ on the plane lies below $A$ on the line of greatest slope of the plane through $A$ and $AB = 3a$ metres, as shown in Figure 3.

The particle $P$ is held at $B$ and then released from rest. The particle first comes to instantaneous rest at $A$.

The coefficient of friction between $P$ and the plane is $\frac{1}{4}$

(a) Show that $\lambda = 24$

**(5)**

(b) Find the magnitude of the acceleration of $P$ at the instant it is released from $B$.

**(5)**

(c) Explain why the answer to part (b) is the greatest value of the magnitude of the acceleration of $P$ as $P$ moves from $B$ to $A$.

**(1)**

**Question 6 continued**

**Question 6 continued**

**Question 6 continued**

**(Total for Question 6 is 11 marks)**

**7.** [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane*.]

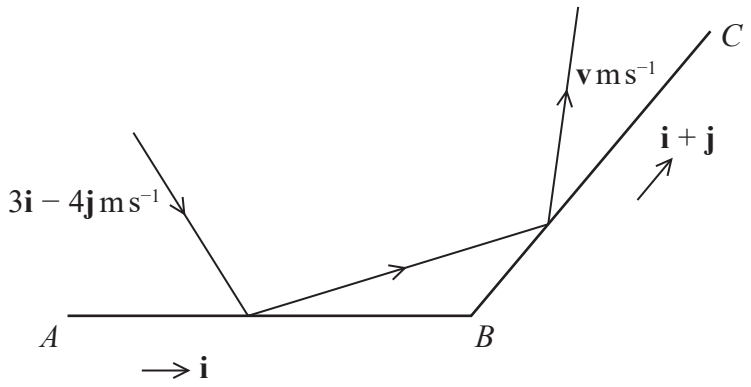


**Figure 4**

Figure 4 represents the plan view of part of a horizontal floor, where $AB$ and $BC$ are fixed vertical walls. The floor and the walls are modelled as being smooth.

The vector $\overrightarrow{AB}$ is in the direction of **i**. The vector $\overrightarrow{BC}$ is in the direction of (**i** + **j**).

A ball is projected along the floor towards the wall $AB$ so that, immediately before hitting the wall $AB$, the velocity of the ball is $(3\mathbf{i} - 4\mathbf{j})\,\text{m s}^{-1}$. The ball hits the wall $AB$ and then hits the wall $BC$. The coefficient of restitution between the ball and each wall is $\frac{1}{4}$

Immediately after hitting the wall $BC$, the velocity of the ball is $\mathbf{v}\,\text{m s}^{-1}$.

By modelling the ball as a particle,

(a) find $\mathbf{v}$ in the form $(a\mathbf{i} + b\mathbf{j})$.

**(8)**

The total angle through which the path of the ball has been deflected as a result of the two collisions is $\theta°$

(b) Find the value of $\theta$ to the nearest whole number.

**(3)**

**Question 7 continued**

**Question 7 continued**

**Question 7 continued**

**(Total for Question 7 is 11 marks)**

**8.** Two particles, $A$ and $B$, have masses $2m$ and $3m$ respectively. The particles are moving in the same direction along the same straight line on a smooth horizontal surface when they collide directly. Immediately after the collision, the speed of $A$ is $u$, the speed of $B$ is $\frac{8}{5}u$ and the particles are both moving in the same direction.

After the collision with $A$, particle $B$ hits a fixed smooth vertical wall which is perpendicular to the direction of motion of $B$. Particle $B$ rebounds from the wall so that there is a second collision between $A$ and $B$.

The first collision between $A$ and $B$ occurs at a distance $d$ from the wall. The second collision between $A$ and $B$ occurs at a distance $x$ from the wall.

Given that the coefficient of restitution between $B$ and the wall is $\frac{1}{2}$

(a) find $x$ in terms of $d$.

**(5)**

Given also that the coefficient of restitution between the particles is $\frac{1}{3}$

(b) show that there will not be a third collision between $A$ and $B$.

**(9)**

**Question 8 continued**

**Question 8 continued**

**Question 8 continued**

**Question 8 continued**

**(Total for Question 8 is 14 marks)**

**TOTAL FOR PAPER IS 75 MARKS**