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**Pearson Edexcel Level 3 GCE**

**Friday 6 June 2025**

Afternoon (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 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.
- 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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1. A particle  $A$  has mass  $4m$  and a particle  $B$  has mass  $3m$ . The particles are moving along the same straight line on a smooth horizontal table. The particles are moving in opposite directions towards each other when they collide directly.

As a result of the collision, the direction of motion of each particle is reversed.

Immediately **before** the collision, the speed of  $A$  is  $u$  and the speed of  $B$  is  $ku$ , where  $k$  is a constant.

Immediately **after** the collision, the speed of  $A$  is  $2v$  and the speed of  $B$  is  $3v$ .

The magnitude of the impulse received by  $A$  in the collision is  $20mv$ .

- (a) Find  $u$  in terms of  $v$  only.

(3)

- (b) Find the exact value of  $k$ .

(3)

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Question 1 continued

(Total for Question 1 is 6 marks)



2. A van of mass  $900\text{ kg}$  is moving along a straight horizontal road.

When the speed of the van is  $v\text{ ms}^{-1}$ , the resistance to the motion of the van is modelled as a force of magnitude  $50v\text{ N}$ .

The engine of the van is working at a constant rate of  $12\text{ kW}$ .

At the instant when the speed of the van is  $V\text{ ms}^{-1}$ , the acceleration of the van is  $0.2\text{ ms}^{-2}$

Using the model,

- (a) find the value of  $V$ .

(4)

Later on, the van is moving up a straight road that is inclined at an angle  $\alpha$  to the horizontal, where  $\sin \alpha = \frac{1}{12}$ . When the speed of the van is  $v\text{ ms}^{-1}$ , the resistance to the motion of the van from non-gravitational forces is modelled as a force of magnitude  $50v\text{ N}$ .

When the van has constant speed  $U\text{ ms}^{-1}$ , the engine of the van is working at a constant rate of  $15\text{ kW}$ .

Using the model,

- (b) find the value of  $U$ .

(4)

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Question 2 continued

(Total for Question 2 is 8 marks)



3. A particle  $P$  of mass  $0.4 \text{ kg}$  is moving with velocity  $7\mathbf{i} \text{ ms}^{-1}$  when it receives an impulse of magnitude  $\sqrt{1.6} \text{ N s}$ .

The velocity of  $P$  immediately after it receives the impulse is  $\lambda(2\mathbf{i} + \mathbf{j}) \text{ ms}^{-1}$ , where  $\lambda$  is a constant.

Find the two possible values of  $\lambda$

(6)

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Question 3 continued

(Total for Question 3 is 6 marks)



4.

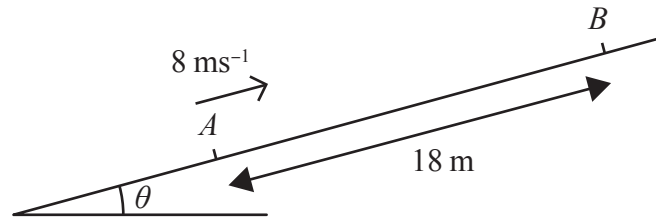


Figure 1

A rough straight ramp is fixed to horizontal ground. The ramp is inclined at an angle  $\theta$  to the horizontal, where  $\sin \theta = \frac{1}{14}$ . The points  $A$  and  $B$  are on a line of greatest slope of the ramp with  $AB = 18$  m and  $B$  above  $A$ , as shown in Figure 1.

A package of mass  $0.5$  kg is projected up the ramp from  $A$  with speed  $8 \text{ m s}^{-1}$  and comes to instantaneous rest at  $B$ .

The work done against friction as the package moves from  $A$  to  $B$  is  $W$  joules.

The package is modelled as a particle and air resistance is ignored.

- (a) Use the work-energy principle to show that  $W = 9.7$  (3)

The coefficient of friction between the package and the ramp is  $\mu$

- (b) Find the value of  $\mu$  (4)

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Question 4 continued



Question 4 continued

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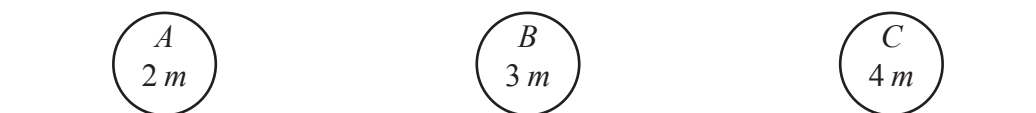
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Question 4 continued

(Total for Question 4 is 7 marks)



5.

**Figure 2**

Three small balls,  $A$ ,  $B$  and  $C$ , have masses  $2m$ ,  $3m$  and  $4m$  respectively.

The balls are initially at rest in a straight line on a smooth horizontal surface, with  $B$  between  $A$  and  $C$ , as shown in Figure 2.

Ball  $A$  is projected towards  $B$  with speed  $5u$  and  $A$  and  $B$  collide directly. Immediately after the collision, the speed of  $B$  is  $3u$

The balls are modelled as uniform spheres with equal radii.

(a) Find, in terms of  $u$ , the speed of  $A$  immediately after the collision with  $B$ . (3)

(b) Find the coefficient of restitution between  $A$  and  $B$ . (3)

After the collision between  $A$  and  $B$ , ball  $C$  is projected towards  $B$  with speed  $u$

Balls  $B$  and  $C$  collide directly.

The coefficient of restitution between  $B$  and  $C$  is  $f$

Given that there is a second direct collision between  $A$  and  $B$

(c) find the complete range of possible values of  $f$  (7)

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Question 5 continued



Question 5 continued

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Question 5 continued

(Total for Question 5 is 13 marks)



6.

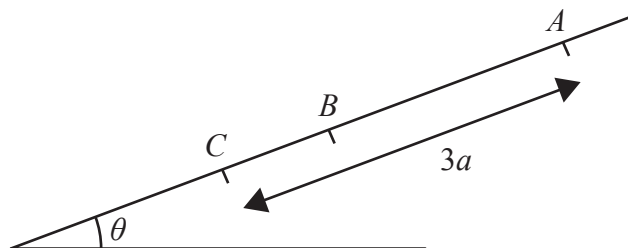


Figure 3

A smooth plane is inclined at an angle  $\theta$  to horizontal ground, where  $\sin \theta = \frac{1}{3}$

The points  $A$ ,  $B$  and  $C$  lie on a line of greatest slope of the plane, with  $B$  between  $A$  and  $C$ , with  $A$  above  $B$  and  $AC = 3a$ , as shown in Figure 3.

A light elastic string of natural length  $2a$  has one end attached to the fixed point  $A$ . The other end of the string is attached to a parcel  $P$  of mass  $m$ .

The modulus of elasticity of the string is  $\frac{8}{3}mg$

The parcel rests in equilibrium on the plane at the point  $B$ .

The parcel is modelled as a particle.

- (a) Show that  $AB = \frac{9}{4}a$  (4)

The parcel is now held at  $C$  and released from rest.

- (b) Find the elastic potential energy lost by the string when  $P$  moves from  $C$  to  $B$ . (3)
- (c) Use the principle of conservation of mechanical energy to find the speed of  $P$  at the instant it passes  $B$ . (3)

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Question 6 continued



Question 6 continued

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Question 6 continued

(Total for Question 6 is 10 marks)



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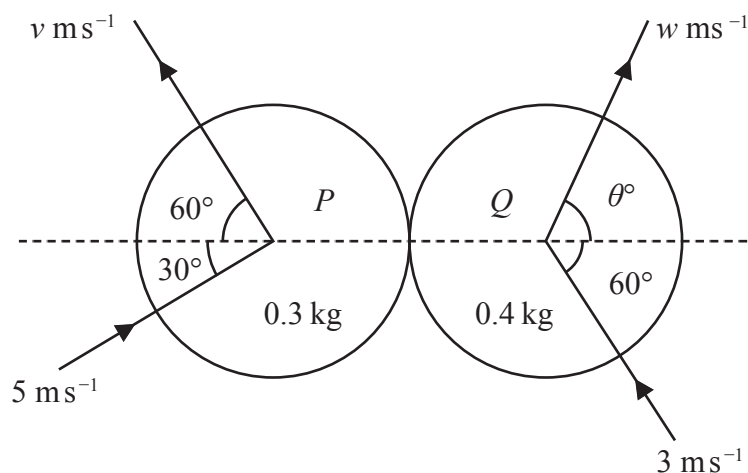


Figure 4

Two uniform spheres  $P$  and  $Q$  have equal radii. The mass of  $P$  is  $0.3 \text{ kg}$  and the mass of  $Q$  is  $0.4 \text{ kg}$ . The spheres are moving on a smooth horizontal plane when they collide obliquely.

Immediately **before** the collision,

- $P$  is moving with speed  $5 \text{ ms}^{-1}$  at  $30^\circ$  to the line of centres of the spheres
- $Q$  is moving with speed  $3 \text{ ms}^{-1}$  at  $60^\circ$  to the line of centres of the spheres

Immediately **after** the collision,

- $P$  is moving with speed  $v \text{ ms}^{-1}$  at  $60^\circ$  to the line of centres of the spheres
- $Q$  is moving with speed  $w \text{ ms}^{-1}$  at  $\theta^\circ$  to the line of centres of the spheres

as in the plan view shown in Figure 4.

(a) Show that  $v = \frac{5\sqrt{3}}{3}$  (3)

(b) Find (i) the value of  $w$   
 (ii) the value of  $\theta$  (7)

(c) Find the coefficient of restitution between  $P$  and  $Q$ . (3)

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Question 7 continued



Question 7 continued

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Question 7 continued

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8.

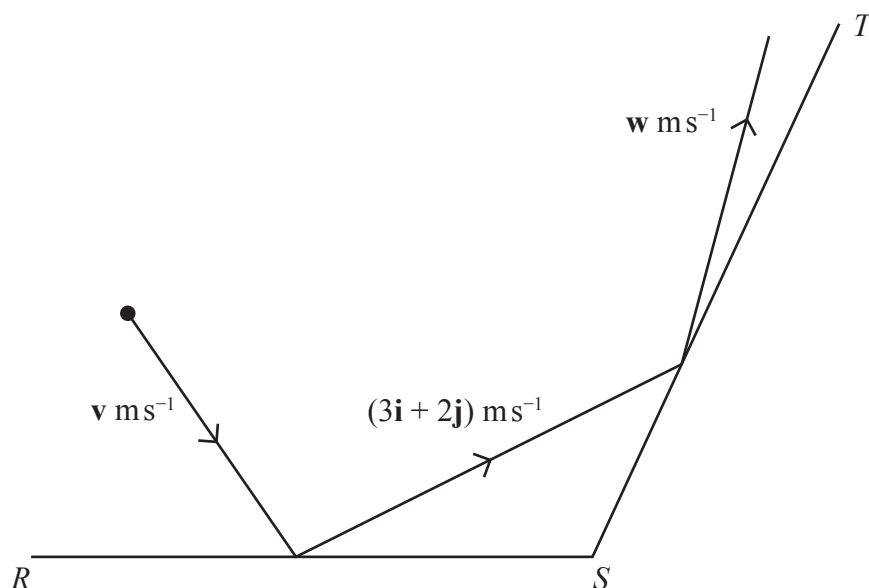


Figure 5

Figure 5 represents the plan view of part of a smooth horizontal floor, where  $RS$  and  $ST$  are smooth fixed vertical walls.

The vector  $\overrightarrow{RS}$  is in the direction of the vector  $\mathbf{i}$ .

The vector  $\overrightarrow{ST}$  is in the direction of the vector  $(3\mathbf{i} + 4\mathbf{j})$ .

A small ball  $B$  of mass  $0.25 \text{ kg}$  is projected across the floor towards  $RS$ .

Immediately before the impact with  $RS$ , the velocity of  $B$  is  $\mathbf{v} \text{ ms}^{-1}$

Immediately after the impact with  $RS$ , the velocity of  $B$  is  $(3\mathbf{i} + 2\mathbf{j}) \text{ ms}^{-1}$

The coefficient of restitution between  $B$  and  $RS$  is  $\frac{1}{3}$

The ball is modelled as a particle.

(a) Show that the kinetic energy lost by  $B$  in the impact with  $RS$  is  $4 \text{ J}$ .

(6)

Immediately after the impact with  $ST$ , the velocity of  $B$  is  $\mathbf{w} \text{ ms}^{-1}$

Given that the coefficient of restitution between  $B$  and  $ST$  is  $\frac{1}{3}$

(b) find  $\mathbf{w}$  in terms of  $\mathbf{i}$  and  $\mathbf{j}$ .

(6)

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Question 8 continued



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Question 8 continued



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**(Total for Question 8 is 12 marks)**

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**TOTAL FOR PAPER IS 75 MARKS**

