

Paper Reference 9FM0/3C
Pearson Edexcel
Level 3 GCE

Further Mathematics
Advanced
PAPER 3C: Further Mechanics 1

Friday 6 June 2025 – Afternoon
Time: 1 hour 30 minutes

Question Paper

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**

YOU WILL BE GIVEN

Diagram Booklet

Answer Booklet

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

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.

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.

There may be spare copies of some diagrams.

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.

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 $20mv$

(continued on the next page)

1. continued.

(a) Find u in terms of v only.

(3 marks)

(b) Find the exact value of k

(3 marks)

(Total for Question 1 is 6 marks)

2. A van of mass **900 kg** is moving along a straight horizontal road.

When the speed of the van is $v \text{ m s}^{-1}$ the resistance to the motion of the van is modelled as a force of magnitude **$50v$** newtons.

The engine of the van is working at a constant rate of **12 kW**

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

Using the model,

- (a) find the value of **V**
(4 marks)

(continued on the next page)

2. continued.

Later on, the van is moving up a straight road that is inclined at an angle α to the horizontal, where

$$\sin \alpha = \frac{1}{12}$$

When the speed of the van is $v \text{ m s}^{-1}$, the resistance to the motion of the van from non-gravitational forces is modelled as a force of magnitude $50v$ newtons.

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

Using the model,

(b) find the value of U
(4 marks)

(Total for Question 2 is 8 marks)

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

The velocity of **P** immediately after it receives the impulse is

$\lambda(2\mathbf{i} + \mathbf{j}) \text{ m s}^{-1}$, where **$\lambda$** is a constant.

Find the two possible values of **λ**

(Total for Question 3 is 6 marks)

4. Refer to the diagram for Question 4 in the Diagram Booklet.

A rough straight ramp is fixed to horizontal ground. The ramp is inclined at an angle θ 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 metres and **B** above **A**, as shown in the diagram.

A package of mass **0.5 kg** is projected up the ramp from **A** with speed **8 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 marks)

4. continued.

The coefficient of friction between the package and the ramp is μ

(b) Find the value of μ
(4 marks)

(Total for Question 4 is 7 marks)

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

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 the diagram.

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 marks)

(continued on the next page)

5. continued.

- (b) Find the coefficient of restitution between **A** and **B**
(3 marks)

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 marks)

(Total for Question 5 is 13 marks)

6. Refer to the diagram for Question 6 in the Diagram Booklet.

A smooth plane is inclined at an angle θ 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 the diagram.

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.

(continued on the next page)

6. continued.

(a) Show that

$$AB = \frac{9}{4}a$$

(4 marks)

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 marks)

(c) Use the principle of conservation of mechanical energy to find the speed of **P** at the instant it passes **B**

(3 marks)

(Total for Question 6 is 10 marks)

7. Refer to the diagram for Question 7 in the Diagram Booklet.

It shows two uniform spheres **P** and **Q** which have equal radii.

The mass of **P** is **0.3 kg** and the mass of **Q** is **0.4 kg**

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

Immediately **BEFORE** the collision,

- **P** is moving with speed 5 m s^{-1} at 30° to the line of centres of the spheres
- **Q** is moving with speed 3 m s^{-1} at 60° to the line of centres of the spheres

Immediately **AFTER** the collision,

- **P** is moving with speed $v \text{ m s}^{-1}$ at 60° to the line of centres of the spheres
- **Q** is moving with speed $w \text{ m s}^{-1}$ at θ° to the line of centres of the spheres

as in the plan view shown in the diagram.

7. continued.

(a) Show that

$$v = \frac{5\sqrt{3}}{3}$$

(3 marks)

(b) Find (i) the value of w

(ii) the value of θ

(7 marks)

(c) Find the coefficient of restitution between
P and **Q**

(3 marks)

(Total for Question 7 is 13 marks)

8. Refer to the diagram for Question 8 in the Diagram Booklet.

It 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 $\underline{i}$

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

A small ball **B** of mass 0.25 kg is projected across the floor towards **RS**

Immediately before the impact with **RS**, the velocity of **B** is $\underline{v} \text{ m s}^{-1}$

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

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

The ball is modelled as a particle.

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Turn over

8. continued.

- (a) Show that the kinetic energy lost by **B** in the impact with **RS** is 4 joules.
(6 marks)

Immediately after the impact with **ST**, the velocity of **B** is W m s⁻¹

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

- (b) find W in terms of i and j
(6 marks)

(Total for Question 8 is 12 marks)

TOTAL FOR PAPER IS 75 MARKS

END OF PAPER