

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel
Level 3 GCE**

Centre Number

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Candidate Number

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Thursday 11 June 2020

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 numerical 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 7 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 P of mass 0.5 kg is moving with velocity $(4\mathbf{i} + 3\mathbf{j}) \text{ m s}^{-1}$ when it receives an impulse \mathbf{J} N s. Immediately after receiving the impulse, P is moving with velocity $(-\mathbf{i} + 6\mathbf{j}) \text{ m s}^{-1}$.

(a) Find the magnitude of \mathbf{J} .

(4)

The angle between the direction of the impulse and the direction of motion of P immediately before receiving the impulse is α°

(b) Find the value of α

(3)



Question 1 continued

(Total for Question 1 is 7 marks)



P 6 6 5 0 7 A 0 3 2 8

2. A truck of mass 1200 kg is moving along a straight horizontal road.

At the instant when the speed of the truck is $v \text{ m s}^{-1}$, the resistance to the motion of the truck is modelled as a force of magnitude $(900 + 9v) \text{ N}$.

The engine of the truck is working at a constant rate of 25 kW.

- (a) Find the deceleration of the truck at the instant when $v = 25$

(4)

Later on, the truck is moving up a straight road that is inclined at an angle θ to the horizontal, where $\sin \theta = \frac{1}{20}$

$$\sin \theta = \frac{1}{20}$$

At the instant when the speed of the truck is $v \text{ m s}^{-1}$, the resistance to the motion of the truck from non-gravitational forces is modelled as a force of magnitude $(900 + 9v) \text{ N}$.

When the engine of the truck is working at a constant rate of 25 kW the truck is moving up the road at a constant speed of $V \text{ m s}^{-1}$.

- (b) Find the value of V .

(5)



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Question 2 continued



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Question 2 continued

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Question 2 continued

(Total for Question 2 is 9 marks)



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3. Two particles, A and B , have masses $3m$ and $4m$ respectively. The particles are moving in the same direction along the same straight line on a smooth horizontal surface when they collide directly. Immediately before the collision the speed of A is $2u$ and the speed of B is u .

The coefficient of restitution between A and B is e .

- (a) Show that the direction of motion of each of the particles is unchanged by the collision.

(8)

After the collision with A , particle B collides directly with a third particle, C , of mass $2m$, which is at rest on the surface.

The coefficient of restitution between B and C is also e .

- (b) Show that there will be a second collision between A and B .

(6)



Question 3 continued



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Question 3 continued

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Question 3 continued

(Total for Question 3 is 14 marks)



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4. [In this question, \mathbf{i} and \mathbf{j} are perpendicular unit vectors in a horizontal plane.]

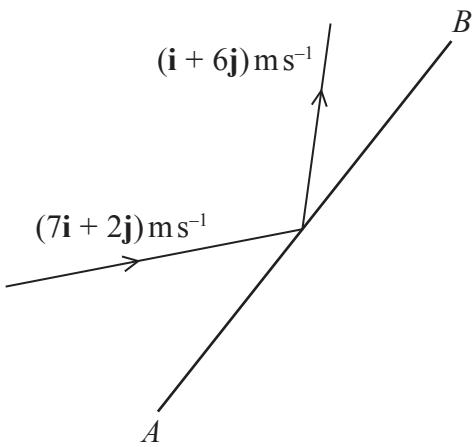


Figure 1

Figure 1 represents the plan view of part of a smooth horizontal floor, where AB represents a fixed smooth vertical wall.

A small ball of mass 0.5 kg is moving on the floor when it strikes the wall.

Immediately before the impact the velocity of the ball is $(7\mathbf{i} + 2\mathbf{j}) \text{ m s}^{-1}$.

Immediately after the impact the velocity of the ball is $(\mathbf{i} + 6\mathbf{j}) \text{ m s}^{-1}$.

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

(a) Show that AB is parallel to $(2\mathbf{i} + 3\mathbf{j})$.

(4)

(b) Find the value of e .

(5)

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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 9 marks)

P 6 6 5 0 7 A 0 1 5 2 8

5. A smooth uniform sphere P has mass 0.3 kg. Another smooth uniform sphere Q , with the same radius as P , has mass 0.2 kg.

The spheres are moving on a smooth horizontal surface when they collide obliquely. Immediately before the collision the velocity of P is $(4\mathbf{i} + 2\mathbf{j}) \text{ m s}^{-1}$ and the velocity of Q is $(-3\mathbf{i} + \mathbf{j}) \text{ m s}^{-1}$.

At the instant of collision, the line joining the centres of the spheres is parallel to \mathbf{i} .

The kinetic energy of Q immediately after the collision is half the kinetic energy of Q immediately before the collision.

(a) Find

- (i) the velocity of P immediately after the collision,
- (ii) the velocity of Q immediately after the collision,
- (iii) the coefficient of restitution between P and Q ,

carefully justifying your answers.

(11)

(b) Find the size of the angle through which the direction of motion of P is deflected by the collision.

(3)



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Question 5 continued

Handwriting practice lines for Question 5.

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Question 5 continued

(20 lines for responses)

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Question 5 continued

(Total for Question 5 is 14 marks)



6. A light elastic string with natural length l and modulus of elasticity kmg has one end attached to a fixed point A on a rough inclined plane. The other end of the string is attached to a package of mass m .

The plane is inclined at an angle θ to the horizontal, where $\tan \theta = \frac{5}{12}$

The package is initially held at A . The package is then projected with speed $\sqrt{6gl}$ up a line of greatest slope of the plane and first comes to rest at the point B , where $AB = 3l$.

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

By modelling the package as a particle,

(a) show that $k = \frac{15}{26}$ (6)

(b) find the acceleration of the package at the instant it starts to move back down the plane from the point B . (5)



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Question 6 continued



Question 6 continued

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Question 6 continued

(Total for Question 6 is 11 marks)



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7.

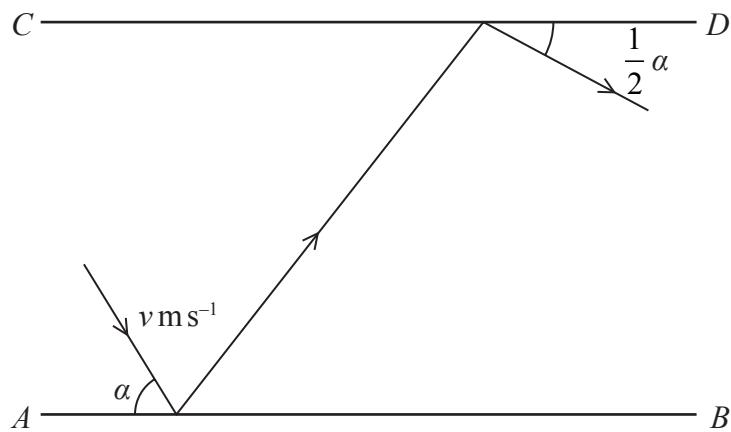
**Figure 2**

Figure 2 represents the plan view of part of a horizontal floor, where AB and CD represent fixed vertical walls, with AB parallel to CD .

A small ball is projected along the floor towards wall AB . Immediately before hitting wall AB , the ball is moving with speed $v \text{ m s}^{-1}$ at an angle α to AB , where $0 < \alpha < \frac{\pi}{2}$

The ball hits wall AB and then hits wall CD .

After the impact with wall CD , the ball is moving at angle $\frac{1}{2}\alpha$ to CD .

The coefficient of restitution between the ball and wall AB is $\frac{2}{3}$

The coefficient of restitution between the ball and wall CD is also $\frac{2}{3}$

The floor and the walls are modelled as being smooth. The ball is modelled as a particle.

(a) Show that $\tan\left(\frac{1}{2}\alpha\right) = \frac{1}{3}$ (7)

(b) Find the percentage of the initial kinetic energy of the ball that is lost as a result of the two impacts. (4)



Question 7 continued



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Question 7 continued

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Question 7 continued



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Question 7 continued

(Total for Question 7 is 11 marks)

TOTAL FOR PAPER IS 75 MARKS

