

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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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  $\theta$  to the horizontal, where  $\sin \theta = \frac{1}{20}$

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

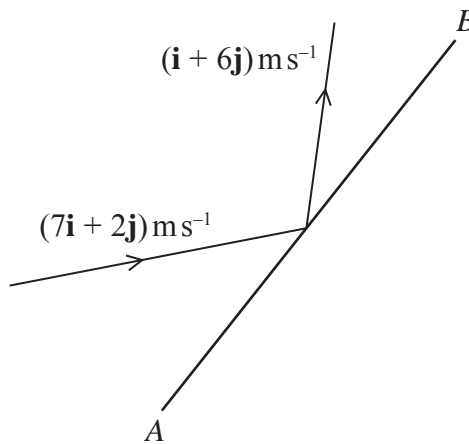


Figure 1

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  $0.5\text{ kg}$  is moving on the floor when it strikes the wall.

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

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

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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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  $(4\mathbf{i} + 2\mathbf{j})\text{ms}^{-1}$  and the velocity of  $Q$  is  $(-3\mathbf{i} + \mathbf{j})\text{ms}^{-1}$ .

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)





**Question 5 continued**

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Question 5 continued

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Question 5 continued

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(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  $\theta$  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)





**Question 6 continued**

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**Question 6 continued**

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



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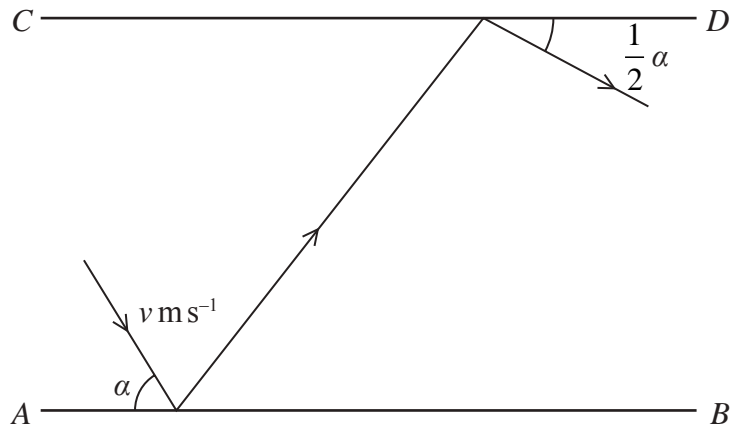
**Figure 2**

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  $\alpha$  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**

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

**TOTAL FOR PAPER IS 75 MARKS**

