

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

## Pearson Edexcel Level 3 GCE

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 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  $g = 9.8 \text{ m s}^{-2}$  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  $A$  of mass  $3m$  and a particle  $B$  of mass  $m$  are moving along the same straight line on a smooth horizontal surface. The particles are moving in opposite directions towards each other when they collide directly.

Immediately before the collision, the speed of  $A$  is  $ku$  and the speed of  $B$  is  $u$ .  
Immediately after the collision, the speed of  $A$  is  $v$  and the speed of  $B$  is  $2v$ .

The magnitude of the impulse received by  $B$  in the collision is  $\frac{3}{2}mu$ .

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

(3)

- (b) Find the two possible values of  $k$ .

(5)

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Question 1 continued

(Total for Question 1 is 8 marks)

2.

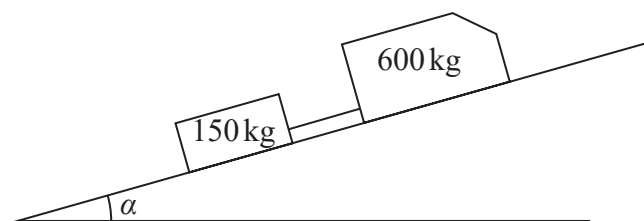


Figure 1

A van of mass 600 kg is moving up a straight road which is inclined at an angle  $\alpha$  to the horizontal, where  $\sin \alpha = \frac{1}{15}$ . The van is towing a trailer of mass 150 kg. The van is attached to the trailer by a towbar which is parallel to the direction of motion of the van and the trailer, as shown in Figure 1.

The resistance to the motion of the van from non-gravitational forces is modelled as a constant force of magnitude 200 N.

The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 100 N.

The towbar is modelled as a light rod.

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

Find the tension in the towbar at the instant when the speed of the van is  $9 \text{ m s}^{-1}$

(8)

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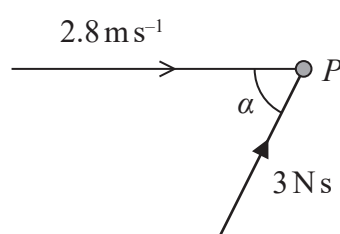
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Question 2 continued

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3.



**Figure 2**

A particle  $P$  of mass  $0.5 \text{ kg}$  is moving in a straight line with speed  $2.8 \text{ ms}^{-1}$  when it receives an impulse of magnitude  $3 \text{ N s}$ .

The angle between the direction of motion of  $P$  immediately before receiving the impulse and the line of action of the impulse is  $\alpha$ , where  $\tan \alpha = \frac{4}{3}$ , as shown in Figure 2.

Find the speed of  $P$  immediately after receiving the impulse.

(5)

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Question 3 continued

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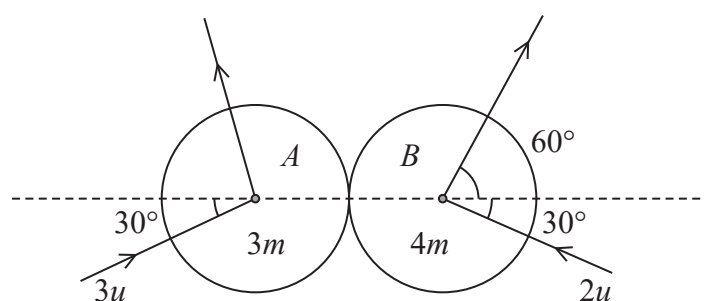


Figure 3

Two smooth uniform spheres,  $A$  and  $B$ , have equal radii. The mass of  $A$  is  $3m$  and the mass of  $B$  is  $4m$ . The spheres are moving on a smooth horizontal plane when they collide obliquely. Immediately before they collide,  $A$  is moving with speed  $3u$  at  $30^\circ$  to the line of centres of the spheres and  $B$  is moving with speed  $2u$  at  $30^\circ$  to the line of centres of the spheres. The direction of motion of  $B$  is turned through an angle of  $90^\circ$  by the collision, as shown in Figure 3.

- (i) Find the size of the angle through which the direction of motion of  $A$  is turned as a result of the collision.
- (ii) Find, in terms of  $m$  and  $u$ , the magnitude of the impulse received by  $B$  in the collision.

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Question 4 continued

(Total for Question 4 is 9 marks)

5. Two particles,  $P$  and  $Q$ , are moving in opposite directions along the same straight line on a smooth horizontal surface when they collide directly.  
The mass of  $P$  is  $3m$  and the mass of  $Q$  is  $4m$ .  
Immediately before the collision the speed of  $P$  is  $2u$  and the speed of  $Q$  is  $u$ .  
The coefficient of restitution between  $P$  and  $Q$  is  $e$ .

(a) Show that the speed of  $Q$  immediately after the collision is  $\frac{u}{7}(9e + 2)$

(6)

After the collision with  $P$ , particle  $Q$  collides directly with a fixed vertical wall and rebounds. The wall is perpendicular to the direction of motion of  $Q$ .

The coefficient of restitution between  $Q$  and the wall is  $\frac{1}{2}$

(b) Find the complete range of possible values of  $e$  for which there is a second collision between  $P$  and  $Q$ .

(4)

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6.

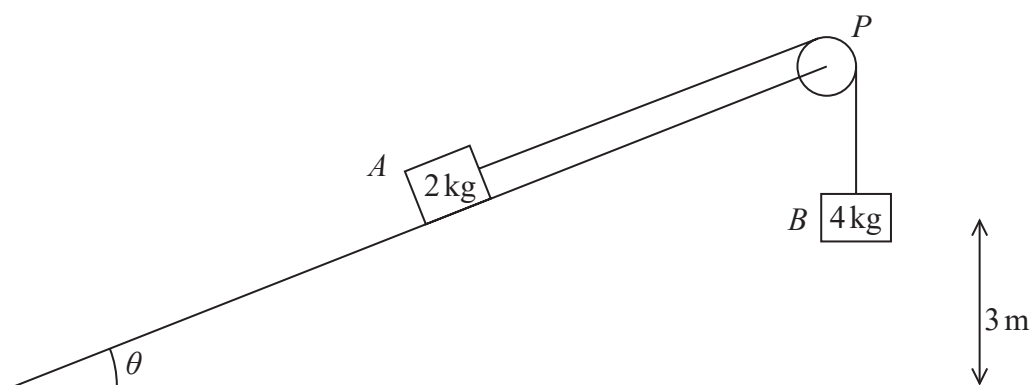


Figure 4

Two blocks,  $A$  and  $B$ , of masses  $2\text{ kg}$  and  $4\text{ kg}$  respectively are attached to the ends of a light inextensible string.

Initially  $A$  is held on a fixed rough plane. The plane is inclined to horizontal ground at an angle  $\theta$ , where  $\tan \theta = \frac{3}{4}$

The string passes over a small smooth light pulley  $P$  that is fixed at the top of the plane. The part of the string from  $A$  to  $P$  is parallel to a line of greatest slope of the plane.

Block  $A$  is held on the plane with the distance  $AP$  greater than  $3\text{ m}$ .

Block  $B$  hangs freely below  $P$  at a distance of  $3\text{ m}$  above the ground, as shown in Figure 4.

The coefficient of friction between  $A$  and the plane is  $\mu$

Block  $A$  is released from rest with the string taut.

By modelling the blocks as particles,

(a) find the potential energy lost by the whole system as a result of  $B$  falling  $3\text{ m}$ .

(3)

Given that the speed of  $B$  at the instant it hits the ground is  $4.5\text{ m s}^{-1}$  and ignoring air resistance,

(b) use the work-energy principle to find the value of  $\mu$

(6)

After  $B$  hits the ground,  $A$  continues to move up the plane but does not reach the pulley in the subsequent motion.

Block  $A$  comes to instantaneous rest after moving a total distance of  $(3 + d)\text{ m}$  from its point of release.

Ignoring air resistance,

(c) use the work-energy principle to find the value of  $d$

(4)

Question 6 continued

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Question 6 continued

(Total for Question 6 is 13 marks)

7. A spring of natural length  $a$  has one end attached to a fixed point  $A$ . The other end of the spring is attached to a package  $P$  of mass  $m$ .  
The package  $P$  is held at rest at the point  $B$ , which is vertically below  $A$  such that  $AB = 3a$ .

After being released from rest at  $B$ , the package  $P$  first comes to instantaneous rest at  $A$ . Air resistance is modelled as being negligible.

By modelling the spring as being light and modelling  $P$  as a particle,

- (a) show that the modulus of elasticity of the spring is  $2mg$  (5)

- (b) (i) Show that  $P$  attains its maximum speed when the extension of the spring is  $\frac{1}{2}a$

- (ii) Use the principle of conservation of mechanical energy to find the maximum speed, giving your answer in terms of  $a$  and  $g$ . (6)

In reality, the spring is not light.

- (c) State one way in which this would affect your energy equation in part (b). (1)

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Question 7 continued

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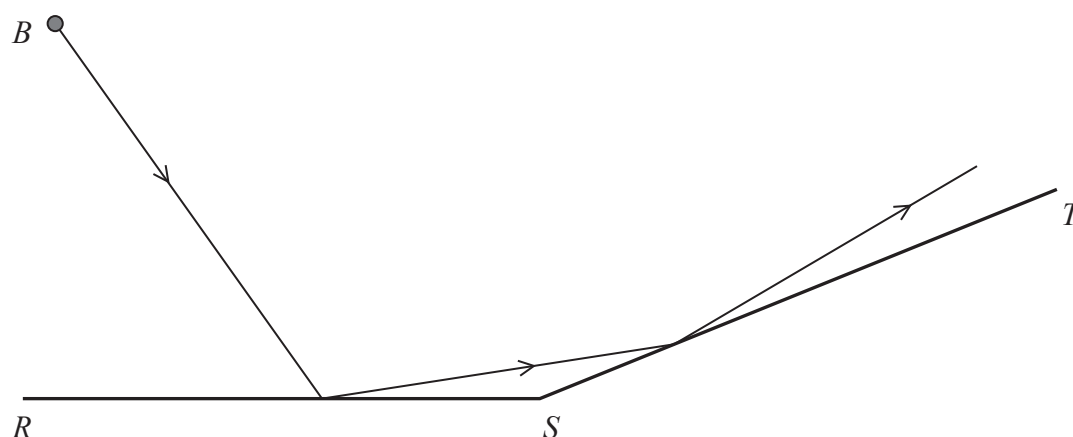


Figure 5

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  $\mathbf{i}$  and the vector  $\overrightarrow{ST}$  is in the direction of  $(2\mathbf{i} + \mathbf{j})$ .

A small ball  $B$  is projected across the floor towards  $RS$ . Immediately before the impact with  $RS$ , the velocity of  $B$  is  $(6\mathbf{i} - 8\mathbf{j})\text{ m s}^{-1}$ . The ball bounces off  $RS$  and then hits  $ST$ .

The ball is modelled as a particle.

Given that the coefficient of restitution between  $B$  and  $RS$  is  $e$ ,

(a) find the full range of possible values of  $e$ .

(3)

It is now given that  $e = \frac{1}{4}$  and that the coefficient of restitution between  $B$  and  $ST$  is  $\frac{1}{2}$

(b) Find, in terms of  $\mathbf{i}$  and  $\mathbf{j}$ , the velocity of  $B$  immediately after its impact with  $ST$ .

(7)

Question 8 continued

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**TOTAL FOR PAPER IS 75 MARKS**