Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Friday 16 May 2025

Afternoon

Paper reference **8FM0/25**

Further Mathematics

Advanced Subsidiary
Further Mathematics options
25: Further Mechanics 1
(Part of options C, E, H and J)

You must have:
Mathematical Formulae and Statistical Tables (Green), calculator

Total Marks

Candidates may use any calculator allowed 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 $g = 9.8$ 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.
- The total mark for this part of the examination is 40. There are 4 questions.
- 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 car of mass 1000 kg moves along a straight horizontal road at a constant speed U m s^{-1}. The engine of the car is working at a rate of 20 kW.

The total resistance to the motion of the car is modelled as a constant force of magnitude 1600 N.

Using the model,

(a) find the value of U.

(3)

Later on, the car moves down a straight road which is inclined to the horizontal at an angle α, where $\sin \alpha = \frac{1}{49}$

The total resistance to the motion of the car is again modelled as a constant force of magnitude 1600 N.

At the instant when the engine of the car is working at a rate of 20 kW and the speed of the car is 8 m s^{-1}, the acceleration of the car is a m s^{-2}

Using the model,

(b) find the value of a.

(4)

(c) State one improvement to the model that would make it more realistic.

(1)

(a) Driving force $F = \frac{20000}{U}$

Constant speed, so $a = 0$: $F - 1600 = 0$

$\frac{20000}{U} - 1600 = 0 \Rightarrow U = \frac{20000}{1600}$

$U = 12.5$

(b) Driving force $F = \frac{20000}{8} = 2500$ N

N2L down the slope: $F + 1000g \sin\alpha - 1600 = 1000a$

$2500 + 1000 \times 9.8 \times \frac{1}{49} - 1600 = 1000a$

$2500 + 200 - 1600 = 1000a \Rightarrow 1100 = 1000a$

$a = 1.1$

(c) Make the resistance to motion depend on the speed of the car (i.e. model the resistance as variable rather than constant).

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Question 1 continued

Question 1 continued

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Question 1 continued

(Total for Question 1 is 8 marks)

2. A particle Q of mass $3m$ is at rest on a smooth horizontal plane. A particle P of mass m is moving along the plane when it collides directly with Q.

The speed of P immediately before the collision is u.

The direction of motion of P is reversed by the collision.

The coefficient of restitution between P and Q is e.

(a) Show that the speed of P immediately after the collision is $\dfrac{u(3e-1)}{4}$

(6)

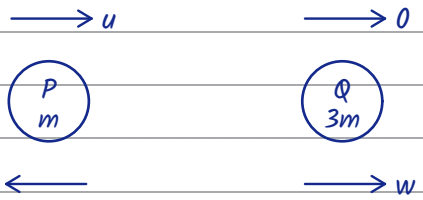
(b) State the full range of possible values of e.

(1)

Given that $e = \dfrac{1}{2}$

(c) find, in terms of m and u, the magnitude of the impulse exerted by P on Q in the collision.

(3)



Taking the initial direction of motion of P as positive.

(a) CLM: $mu = -mv + 3mw \Rightarrow u = -v + 3w$ (1)

NEL: $v + w = eu \Rightarrow w = eu - v$ (2)

Substitute (2) into (1): $u = -v + 3(eu - v)$

$u = -v + 3eu - 3v$

$4v = 3eu - u$

$v = \dfrac{u(3e-1)}{4}$ as required

(b) Direction of P reversed, so $v > 0 \Rightarrow 3e - 1 > 0 \Rightarrow e > 1/3$

Range: $\dfrac{1}{3} < e \leqslant 1$

(c) $e = \dfrac{1}{2}$: $v = \dfrac{u(3/2 - 1)}{4} = \dfrac{u}{8}$, $w = \dfrac{u}{2} - \dfrac{u}{8} = \dfrac{3u}{8}$

Impulse on Q = change in momentum of Q

$I = 3m \times \dfrac{3u}{8} - 0 = \dfrac{9mu}{8}$

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Question 2 continued

(Check with P: $m(v + u) = m\left(\frac{u}{8} + u\right) = \frac{9mu}{8}$)

Magnitude of impulse $= \frac{9mu}{8}$

(Total for Question 2 is 10 marks)

3. A plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{4}{3}$. A small block of mass m is held at a point A on the plane and released from rest.

Initially the block is modelled as a particle, air resistance is modelled as being negligible and the plane is modelled as being **smooth**.

(a) Using the model and the principle of conservation of mechanical energy, find the distance of the block from A at the instant when the speed of the block is $7\,\text{m s}^{-1}$

(3)

In a refined model, the block is again modelled as a particle and air resistance is modelled as being negligible, but the plane is modelled as being **rough** with the coefficient of friction between the block and the plane being $\frac{2}{3}$

Using the refined model,

(b) find, in terms of m and g, the magnitude of the frictional force acting on the block as it slides down the plane,

(3)

(c) find, using the work-energy principle, the distance of the block from A at the instant when the speed of the block is $7\,\text{m s}^{-1}$

(4)

$\tan\alpha = \frac{4}{3} \Rightarrow \sin\alpha = \frac{4}{5}, \cos\alpha = \frac{3}{5}$

(a) Let d m be the distance from A. Height lost $h = d\sin\alpha$

Conservation of mechanical energy: KE gained = PE lost

$\frac{1}{2}m \times 7^2 = mgd\sin\alpha \Rightarrow 24.5 = 9.8 \times \frac{4}{5} \times d$

$d = \frac{24.5}{7.84} = 3.125$

Distance = 3.13 m

(b) Resolve perpendicular to the plane: $R = mg\cos\alpha$

$R = \frac{3}{5}mg$

Block is sliding, so friction is limiting: $F = \frac{2}{3}R$

$F = \frac{2}{3} \times \frac{3}{5}mg$

Frictional force $= \frac{2}{5}mg$

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Question 3 continued

(c) Let x m be the distance from A.

Work done against friction = $Fx = \frac{2}{5}mgx$

Work-energy principle: PE lost − KE gained = WD against friction

$mgx \sin\alpha - \frac{1}{2}m \times 7^2 = \frac{2}{5}mgx$

$\frac{4}{5}gx - \frac{2}{5}gx = 24.5 \Rightarrow \frac{2}{5} \times 9.8x = 24.5$

$x = \frac{24.5}{3.92} = 6.25$

Distance = 6.25 m

Question 3 continued

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Question 3 continued

(Total for Question 3 is 10 marks)

4.



Figure 1

A particle A of mass m is moving on a smooth horizontal plane when it collides directly with a fixed vertical wall which is perpendicular to the direction of motion of A. Immediately **after** the collision, the speed of A is $4u$, directly away from the wall, as shown in Figure 1.

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

Given that the magnitude of the impulse exerted on A by the wall in the collision is $9mu$,

(a) find the value of e.

(5)

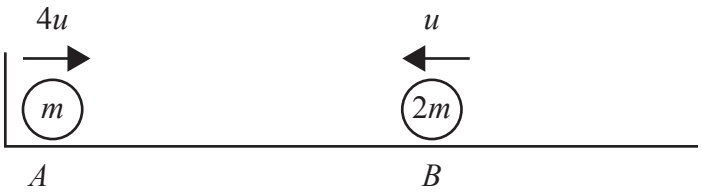


Figure 2

At the instant when A rebounds from the wall, a particle B of mass $2m$ is projected along the plane towards A, as shown in Figure 2.

The particles are moving in opposite directions along the same straight line when they collide directly.
Immediately **before** the collision, the speed of A is $4u$ and the speed of B is u.
Immediately **after** the collision, the total kinetic energy of the two particles is mu^2

(b) Determine, showing your method clearly, whether there are any further collisions between A and the wall.

(7)

(a) Let the speed of A immediately before hitting the wall be v.

Impulse = change in momentum (away from the wall positive):

$9mu = m(4u - (-v)) = m(4u + v)$

$9u = 4u + v \Rightarrow v = 5u$

NEL at the wall: speed after = e × speed before

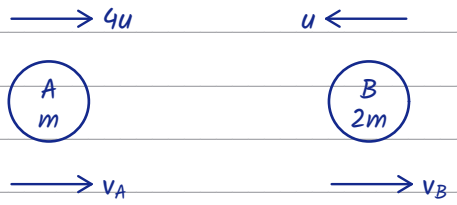
$4u = e \times 5u \Rightarrow e = \frac{4u}{5u}$

$e = \frac{4}{5}$

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Question 4 continued

(b) Away from the wall positive; velocities after: v_A, v_B.



CLM: $4mu - 2mu = mv_A + 2mv_B \Rightarrow v_A = 2u - 2v_B$ (1)

KE: $\frac{1}{2}mv_A^2 + \frac{1}{2} \times 2mv_B^2 = mu^2 \Rightarrow v_A^2 + 2v_B^2 = 2u^2$ (2)

Substitute (1) into (2): $(2u - 2v_B)^2 + 2v_B^2 = 2u^2$

$4u^2 - 8uv_B + 4v_B^2 + 2v_B^2 = 2u^2$

$6v_B^2 - 8uv_B + 2u^2 = 0 \Rightarrow 3v_B^2 - 4uv_B + u^2 = 0$

$(3v_B - u)(v_B - u) = 0$

$v_B = u \Rightarrow v_A = 0$, or $v_B = \frac{u}{3} \Rightarrow v_A = \frac{4u}{3}$

Case $v_A = \frac{4u}{3}$, $v_B = \frac{u}{3}$: A would be moving away from the wall faster than B in the same direction, i.e. A passes through B, (it would need $e < 0$), so this is impossible.

Case $v_A = 0$, $v_B = u$: A is at rest after the collision and B moves away from the wall, so B never meets A again.

In either case A does not move towards the wall after the collision.

∴ There are no further collisions between A and the wall.

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Question 4 continued

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Question 4 continued

Question 4 continued

(Total for Question 4 is 12 marks)

TOTAL FOR FURTHER MECHANICS 1 IS 40 MARKS

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