

Please check the examination details below before entering your candidate information

Candidate surname					Other names										
Pearson Edexcel Level 3 GCE					Centre Number					Candidate Number					
					<input type="text"/>					<input type="text"/>					
										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			
												<input type="text"/>			

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. 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 $g = 9.8 \text{ m s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- 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.
- Good luck with your examination.

Turn over ►



1.

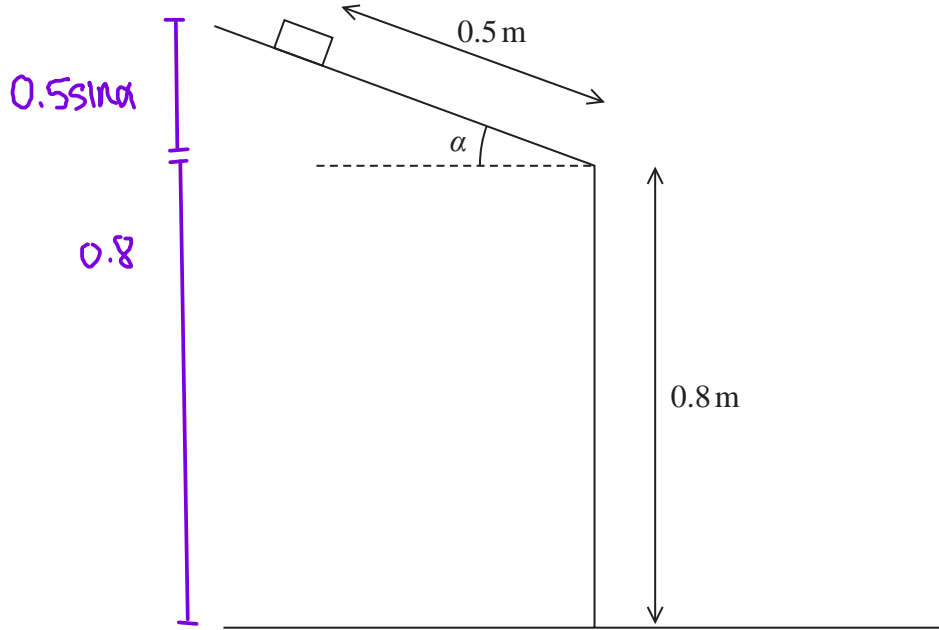


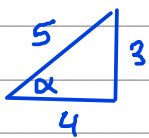
Figure 1

A small book of mass m is held on a rough straight desk lid which is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. The book is released from rest at a distance of 0.5 m from the edge of the desk lid, as shown in Figure 1. The book slides down the desk lid and then hits the floor that is 0.8 m below the edge of the desk lid. The coefficient of friction between the book and the desk lid is 0.4 $\mu = 0.4$

The book is modelled as a particle which, after leaving the desk lid, is assumed to move freely under gravity.

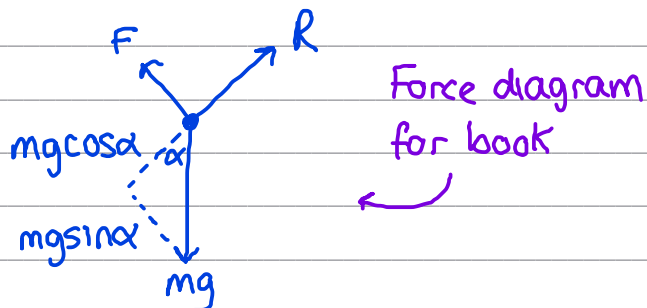
- (a) Find, in terms of m and g , the magnitude of the normal reaction on the book as it slides down the desk lid. (2)
- (b) Use the work-energy principle to find the speed of the book as it hits the floor. (5)

a) $\tan \alpha = 3/4$



$\sin \alpha = 3/5$

$\cos \alpha = 4/5$



Resolve (\nearrow): $R = mg \cos \alpha \Rightarrow R = \frac{4mg}{5}$



Question 1 continued

b) considering motion from release until hitting floor:

KE before + GPE before = KE after + GPE after + w.d. against friction

$$0 + \overset{mgh}{mg(0.8 + 0.5 \sin \alpha)} = \frac{1}{2}mv^2 + 0 + 0.5\mu R \quad (1)$$

$$\frac{11}{10}mg = \frac{1}{2}mv^2 + \frac{4}{25}mg \quad (1) \quad \mu = 0.4, \quad R = \frac{4mg}{5}$$

$$\frac{1}{2}v^2 = \frac{47}{50}g$$

$$v = \sqrt{18.424}$$

$$v = 4.3 \text{ (2sf)} \quad (1)$$



Question 1 continued

Lined writing area for the answer to Question 1.

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2.

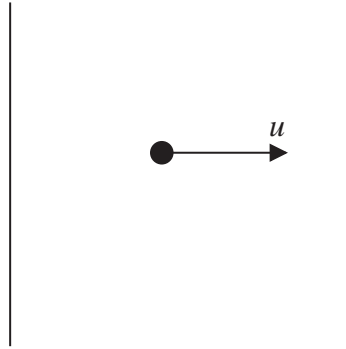


Figure 2

A particle of mass m is at rest on a smooth horizontal plane between two smooth fixed parallel vertical walls, as shown in the plan view in Figure 2. The particle is projected along the plane with speed u towards one of the walls and strikes the wall at right angles. The coefficient of restitution between the particle and each wall is e and air resistance is modelled as being negligible.

Using the model,

- (a) find, in terms of m , u and e , an expression for the total loss in the kinetic energy of the particle as a result of the first two impacts. (3)

Given that e can vary such that $0 < e < 1$ and using the model,

- (b) find the value of e for which the total loss in the kinetic energy of the particle as a result of the first two impacts is a maximum, (4)
- (c) describe the subsequent motion of the particle. (2)

a) speed after first impact: eu
 speed after second impact: e^2u ①

$$\text{KE loss} = \text{KE before} - \text{KE after}$$

$$= \frac{1}{2}emu^2 - \frac{1}{2}em(e^2u)^2 \quad \text{①}$$

$$= \frac{1}{2}mu^2(e - e^5) \quad \text{①}$$



Question 2 continued

b) Maximum $K = \frac{1}{2} mu^2 (e - e^5)$ by varying e

$$\frac{dK}{de} = \frac{1}{2} mu^2 (1 - 5e^4)$$

want maximum so $\frac{dK}{de} = 0$

$$\frac{1}{2} mu^2 (1 - 5e^4) = 0$$

$$1 - 5e^4 = 0$$

$$e^4 = \frac{1}{5}$$

$$e = 5^{-1/4} = 0.67 \text{ (2sf)}$$

c) the particle continues bouncing off the two walls, and its speed decreases with each bounce.



Question 2 continued

Lined writing area for question 2.

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3. The total mass of a cyclist and his bicycle is 100 kg.

In all circumstances, the magnitude of the resistance to the motion of the cyclist from non-gravitational forces is modelled as being kv^2 N, where $v \text{ m s}^{-1}$ is the speed of the cyclist.

The cyclist can freewheel, without pedalling, down a slope that is inclined to the horizontal at an angle α , where $\sin \alpha = \frac{1}{35}$, at a constant speed of $V \text{ m s}^{-1}$

When he is pedalling up a slope that is inclined to the horizontal at an angle β , where $\sin \beta = \frac{1}{70}$, and he is moving at the same constant speed $V \text{ m s}^{-1}$, he is working at a constant rate of P watts.

- (a) Find P in terms of V .

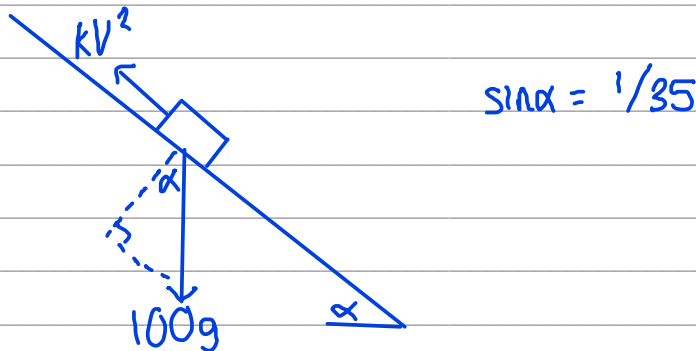
(7)

If he pedals and works at a rate of $35V$ watts on a horizontal road, he moves at a constant speed of $U \text{ m s}^{-1}$

- (b) Find U in terms of V .

(4)

a) considering downhill slope:



Resolve (\searrow): constant speed so forces balanced

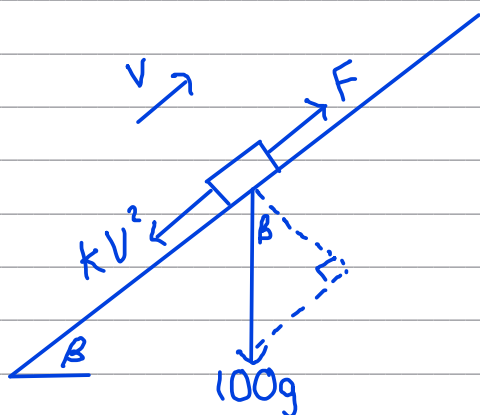
$$100g \sin \alpha = kV^2 \quad (1)$$

$$kV^2 = \frac{100g}{35} \quad (1)$$



Question 3 continued

considering uphill slope:



$$\sin\beta = 1/70$$

$$P = FV$$

$$\Rightarrow F = P/V$$

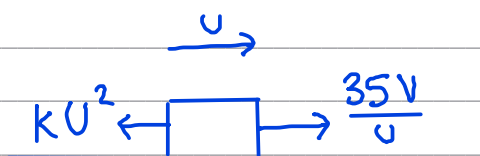
Resolve (\nearrow): constant speed so forces balanced:

$$F = 100g \sin\beta + kV^2 \quad \text{sub in } kV^2 = \frac{100g}{35} \quad (1)$$

$$\frac{P}{V} = \frac{100g}{70} + \frac{100g}{35} = 42 \quad (1)$$

$$P = 42V \quad (1)$$

b)



$$P = 35V \quad \text{and} \quad P = FU$$

$$FU = 35V$$

$$F = \frac{35V}{U}$$

Resolve (\rightarrow): constant speed so forces equal

$$\frac{35V}{U} = kU^2 \quad (1) \quad (1)$$

$$\text{from (a), } kV^2 = \frac{100g}{35} \Rightarrow k = \frac{100g}{35V^2} \quad (2)$$



Question 3 continued

substitute ② into ①:

$$\frac{35V}{U} = \frac{100gU^2}{35V^2} \quad \text{①}$$

$$1225V^3 = 100gU^3$$

$$U^3 = \frac{1225V^3}{100g}$$

$$U = 1.1V \quad \text{①}$$

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4. Two particles, P and Q , have masses m and em respectively. The particles are moving on a smooth horizontal plane in the same direction along the same straight line when they collide directly. The coefficient of restitution between P and Q is e , where $0 < e < 1$

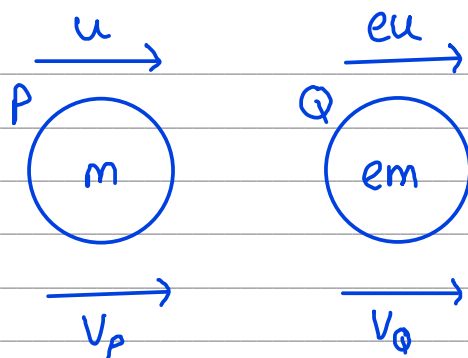
Immediately before the collision the speed of P is u and the speed of Q is eu .

- (a) Show that the speed of Q immediately after the collision is u . (6)

- (b) Show that the direction of motion of P is unchanged by the collision. (3)

The magnitude of the impulse on Q in the collision is $\frac{2}{9}mu$

- (c) Find the possible values of e . (4)



$e < 1$ so Q is slower than P , so P must be moving towards Q .

conservation of momentum: (\rightarrow +) ①

$$mu + e^2mu = mV_p + emV_q \quad \text{cancel } m \quad \text{①}$$

$$V_p + eV_q = u + e^2u \quad \text{①}$$

Newton's Law of Restitution ①

$$e = \frac{V_q - V_p}{u - eu}$$

$$V_q - V_p = eu - e^2u \quad \text{②} \quad \text{①}$$

$$\text{①} + \text{②}: eV_q + V_q = u + e^2u + eu - e^2u$$

$$V_q(e+1) = u(e+1) \quad \text{①}$$

$$V_q = u \quad \text{①}$$



Question 4 continued

b) sub $V_p = u$ into ①:

$$V_p + eu = u + e^2u$$

$$V_p = u(e^2 - e + 1) \quad \text{①}$$

$u > 0$ as u is a speed

$$\begin{aligned} e^2 - e + 1 &= \left(e - \frac{1}{2}\right)^2 - \frac{1}{4} + 1 \\ &= \left(e - \frac{1}{2}\right)^2 + \frac{3}{4} > 0 \quad \text{①} \end{aligned}$$

$$\therefore V_p > 0$$

so P continues to move in the same direction. ①

c) $I = \frac{2}{9}mu$

$$\frac{2}{9}mu = em(u - eu) \quad \text{①}$$

$$I = m(v - u)$$

$$\frac{2}{9}mu = em(u - eu)$$

$$\frac{2}{9} = e - e^2$$

$$9e^2 - 9e + 2 = 0$$

$$(3e - 1)(3e - 2) = 0 \quad \text{①}$$

$$e = \frac{1}{3} \text{ or } e = \frac{2}{3} \quad \text{①}$$



Question 4 continued

Lined area for student response.

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(Total for Question 4 is 13 marks)

TOTAL FOR FURTHER MECHANICS 1 IS 40 MARKS

