Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
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Centre Number | Candidate Number

# Pearson Edexcel Level 3 GCE

**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 $g = 9.8\,\text{m s}^{-2}$ 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.

*Turn over* ▶

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Q:1/1/

P 7 2 0 9 1 A 0 1 1 6

Pearson

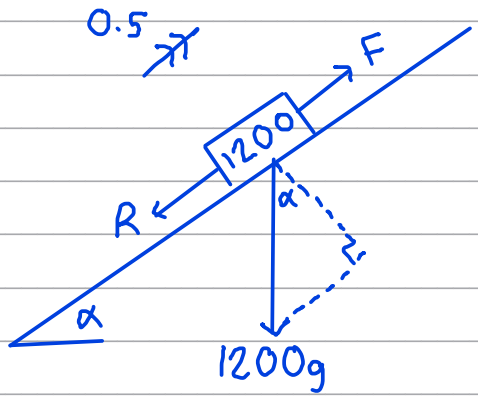
**1.** A car of mass 1200 kg moves up a straight road that is inclined to the horizontal at an angle $\alpha$, where $\sin\alpha = \frac{1}{15}$

The total resistance to the motion of the car from non-gravitational forces is modelled as a constant force of magnitude $R$ newtons.

At the instant when the engine of the car is working at a rate of 32 kW and the speed of the car is $20\,\text{m s}^{-1}$, the acceleration of the car is $0.5\,\text{m s}^{-2}$

Find the value of $R$

**(5)**




$\sin\alpha = 1/15$

using $P=Fv$ where $F$ = driving force

$P = 32{,}000 = 20F$

$F = \frac{32000}{20}$ (1)

$F = 1600$

(1) using $F=ma$ where $F$ = resultant force

$R(\nearrow)$: $F - 1200g\sin\alpha - R = 1200 \times 0.5$ (1)

$R = 1600 - 1200 \times 9.8 \times 1/15 - 1200 \times 0.5$ (1)

$= 220$ N (2sf) (1)

**Question 1 continued**

**(Total for Question 1 is 5 marks)**

**2.** Two particles, $A$ and $B$, have masses $m$ and $3m$ respectively. The particles are moving in opposite directions along the same straight line on a smooth horizontal plane when they collide directly.

Immediately before they collide, $A$ is moving with speed $2u$ and $B$ is moving with speed $u$.

The direction of motion of each particle is reversed by the collision.

In the collision, the magnitude of the impulse exerted on $A$ by $B$ is $\frac{9mu}{2}$

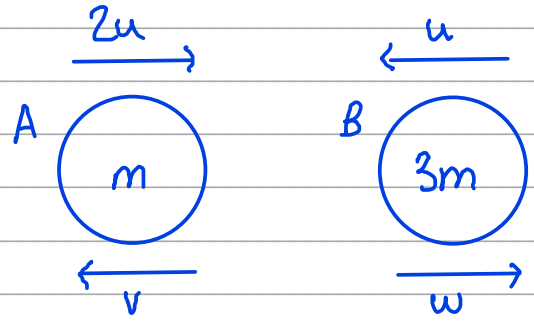
(a) Find the value of the coefficient of restitution between $A$ and $B$.

**(7)**

(b) Hence, write down the total loss in kinetic energy due to the collision, giving a reason for your answer.

**(1)**

a)




considering impulse on B:

$\frac{9mu}{2} = 3m(w - -u)$ (1) (1)

$9u = 6(w+u)$

$6w = 3u$

$w = \frac{1}{2}u$

considering impulse on A:

$\frac{9mu}{2} = m(v - -2u)$ (1) (1)

$9u = 2(v+2u)$

$2v = 5u$

$v = \frac{5}{2}u$ (1)

$e = \frac{v+w}{2u+u} = \frac{\frac{5}{2}u + \frac{1}{2}u}{3u} = 1$ (1) (1)

b) since $e = 1$, the collision is perfectly elastic, so there is no loss in kinetic energy. (1)

**Question 2 continued**

**Question 2 continued**

**Question 2 continued**

**(Total for Question 2 is 8 marks)**

**3.** A plane is inclined to the horizontal at an angle $\alpha$, where $\tan\alpha = \frac{3}{4}$

A particle $P$ is held at rest at a point $A$ on the plane.

The particle $P$ is then projected with speed $25\,\text{m s}^{-1}$ from $A$, up a line of greatest slope of the plane.

In an initial model, the plane is modelled as being smooth and air resistance is modelled as being negligible.

Using this model and the principle of conservation of mechanical energy,

(a) find the speed of $P$ at the instant when it has travelled a distance $\frac{25}{6}$ m up the plane from $A$.

**(4)**

In a refined model, the plane is now modelled as being rough, with the coefficient of friction between $P$ and the plane being $\frac{3}{5}$ $\mu = \frac{3}{5}$

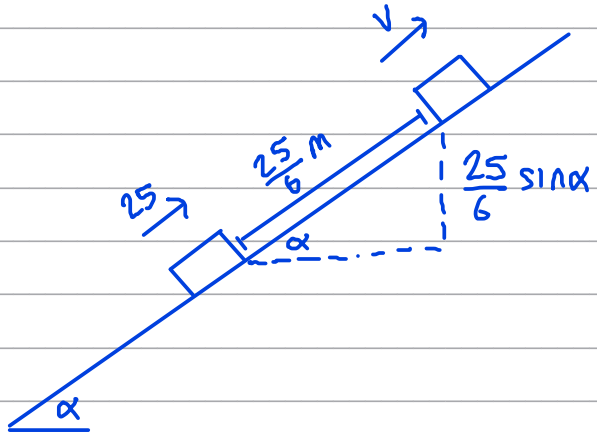
Air resistance is still modelled as being negligible.

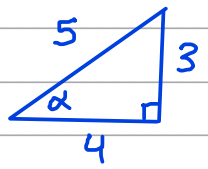
Using this refined model and the work-energy principle,

(b) find the speed of $P$ at the instant when it has travelled a distance $\frac{25}{6}$ m up the plane from $A$.

**(8)**

a)




$\tan\alpha = 3/4$

$\sin\alpha = 3/5$

$\cos\alpha = 4/5$

KE before + GPE before = KE after + GPE after

$\frac{1}{2}m(25)^2 + 0 = \frac{1}{2}mv^2 + mg\left(\frac{25}{6}\sin\alpha\right)$ (1)

(1) (1)

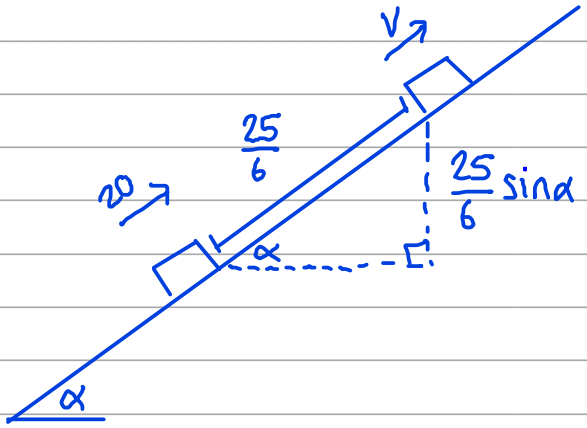
$625 = v^2 + 49$

**Question 3 continued**

$v^2 = 576$

$v = 24\ ms^{-1}$ (1)

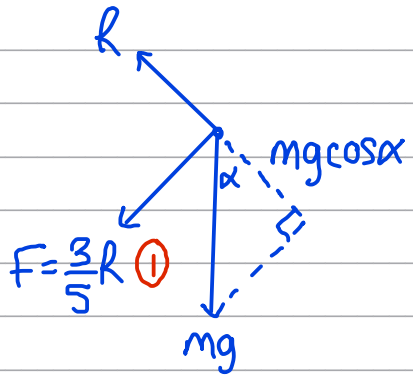
b)




$\sin\alpha = 3/5$

$\cos\alpha = 4/5$

Force diagram for P:




Resolve (↖): forces balanced

$R = mg\cos\alpha$ (1)

$R = \frac{4}{5}mg$ (1)

KE before + GPE before = KE after + GPE after + w.d. against friction ($\mu Rd$)

$\frac{1}{2}m(25)^2 + 0 = \frac{1}{2}mv^2 + mg\left(\frac{25}{6}\sin\alpha\right) + \frac{3}{5}\left(\frac{4}{5}mg\right)\left(\frac{25}{6}\right)$ (1) (1) (1) (1)

$312.5 = 0.5v^2 + 24.5 + 19.6$

$0.5v^2 = 268.4$

$v = 23\ ms^{-1}$ (2sf) (1)

**Question 3 continued**

**Question 3 continued**

**(Total for Question 3 is 12 marks)**

**4.** A particle $P$ of mass $2m$ kg is moving with speed $2u$ m s$^{-1}$ on a smooth horizontal plane. Particle $P$ collides with a particle $Q$ of mass $3m$ kg which is at rest on the plane. The coefficient of restitution between $P$ and $Q$ is $e$. Immediately after the collision the speed of $Q$ is $v$ m s$^{-1}$

(a) Show that $v = \dfrac{4u(1+e)}{5}$

**(6)**

(b) Show that $\dfrac{4u}{5} \leqslant v \leqslant \dfrac{8u}{5}$

**(2)**

Given that the direction of motion of $P$ is reversed by the collision,

(c) find, in terms of $u$ and $e$, the speed of $P$ immediately after the collision.

**(2)**

After the collision, $Q$ hits a wall, that is fixed at right angles to the direction of motion of $Q$, and rebounds.

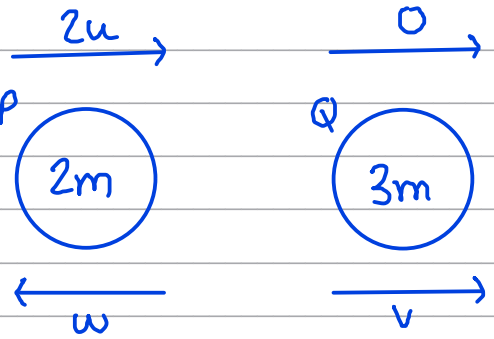
The coefficient of restitution between $Q$ and the wall is $\dfrac{1}{6}$

Given that $P$ and $Q$ collide again,

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

**(5)**

a)




conservation of linear momentum: (→ +)

$4mu + 0 = -2mw + 3mv$ ①

$3v - 2w = 4u$ ①

Newton's law of restitution:

$e = \dfrac{w+v}{2u}$ ① $\Rightarrow v + w = 2eu$ ① $\times 2$

$2v + 2w = 4eu$ ②

**Question 4 continued**

① + ②: $3v + 2v = 4u + 4eu$ (1)

$5v = 4u(1+e)$

$v = \frac{4u(1+e)}{5}$ as required. (1)

b) since $0 \leq e \leq 1$,

$\frac{4u(1+0)}{5} \leq v \leq \frac{4u(1+1)}{5}$ (1)

$\frac{4u}{5} \leq v \leq \frac{8u}{5}$ (1)

c) $w = 2eu - v$ and given that $w > 0$

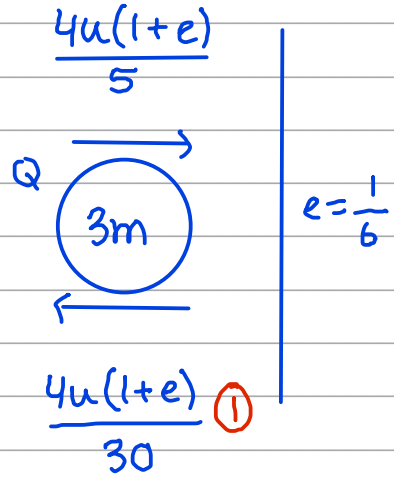
$w = 2eu - \frac{4u}{5} - \frac{4eu}{5}$ (1)

$w = \frac{6}{5}eu - \frac{4}{5}u$

$w = \frac{2u(3e-2)}{5}$ (1) $w > 0 \Rightarrow 3e - 2 > 0$

$e > \frac{2}{3}$

d)




(1)

**Question 4 continued**

P and Q collide again so

$$\frac{4u(1+e)}{30} > \frac{2u(3e-2)}{5} \quad (2)$$

$$20(1+e) > 60(3e-2)$$

$$20 + 20e > 180e - 120$$

$$140 > 160e$$

$$\frac{7}{8} > e \quad (1)$$

$$\frac{2}{3} < e < \frac{7}{8} \quad (1)$$

**Question 4 continued**

**Question 4 continued**

**(Total for Question 4 is 15 marks)**

**TOTAL FOR FURTHER MECHANICS 1 IS 40 MARKS**