Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Thursday 16 May 2019

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 $g = 9.8\ \mathrm{m\,s^{-2}}$ 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

Pearson

1. A lorry of mass 16 000 kg moves along a straight horizontal road.

The lorry moves at a constant speed of 25 m s^{-1} $\longrightarrow a = 0$

In an initial model for the motion of the lorry, the resistance to the motion of the lorry is modelled as having constant magnitude 16 000 N.

(a) Show that the engine of the lorry is working at a rate of 400 kW.

(4)

The model for the motion of the lorry along the same road is now refined so that when the speed of the lorry along the same road is V m s^{-1}, the resistance to the motion of the lorry is modelled as having magnitude $640V$ newtons.

Assuming that the engine of the lorry is working at the same rate of 400 kW

(b) use the refined model to find the speed of the lorry when it is accelerating at 2.1 m s^{-2}

(6)

(a)

$16000 \longleftarrow \boxed{16000\,kg} \longrightarrow F_D$

<u>using $\Sigma F = ma$:</u> $F_D - 16000 = 0 \quad \therefore F_D = 16000\,N$

<u>using $P = F_D v$:</u> $P = 16000 \times 25 = 400000\,W = 400\,kW$

(b)

$640v \longleftarrow \boxed{16000\,kg} \longrightarrow F_D$

<u>using $P = F_D v$:</u> $400000 = F_D V$

$\therefore F_D = \dfrac{400000}{V}$

<u>using $\Sigma F = ma$:</u> $\dfrac{400000}{v} - 640v = 16000 \times 2.1$

$400000 - 640v^2 = 33600v$

$640v^2 + 33600v - 400000 = 0$ $\quad (\div 320)$

$2v^2 + 105v - 1250 = 0$

Question 1 continued

$$(2v + 125)(v - 10) = 0$$

$$v = -62.5,\ 10$$

but $v > 0$

$\therefore v = 10\ ms^{-1}$

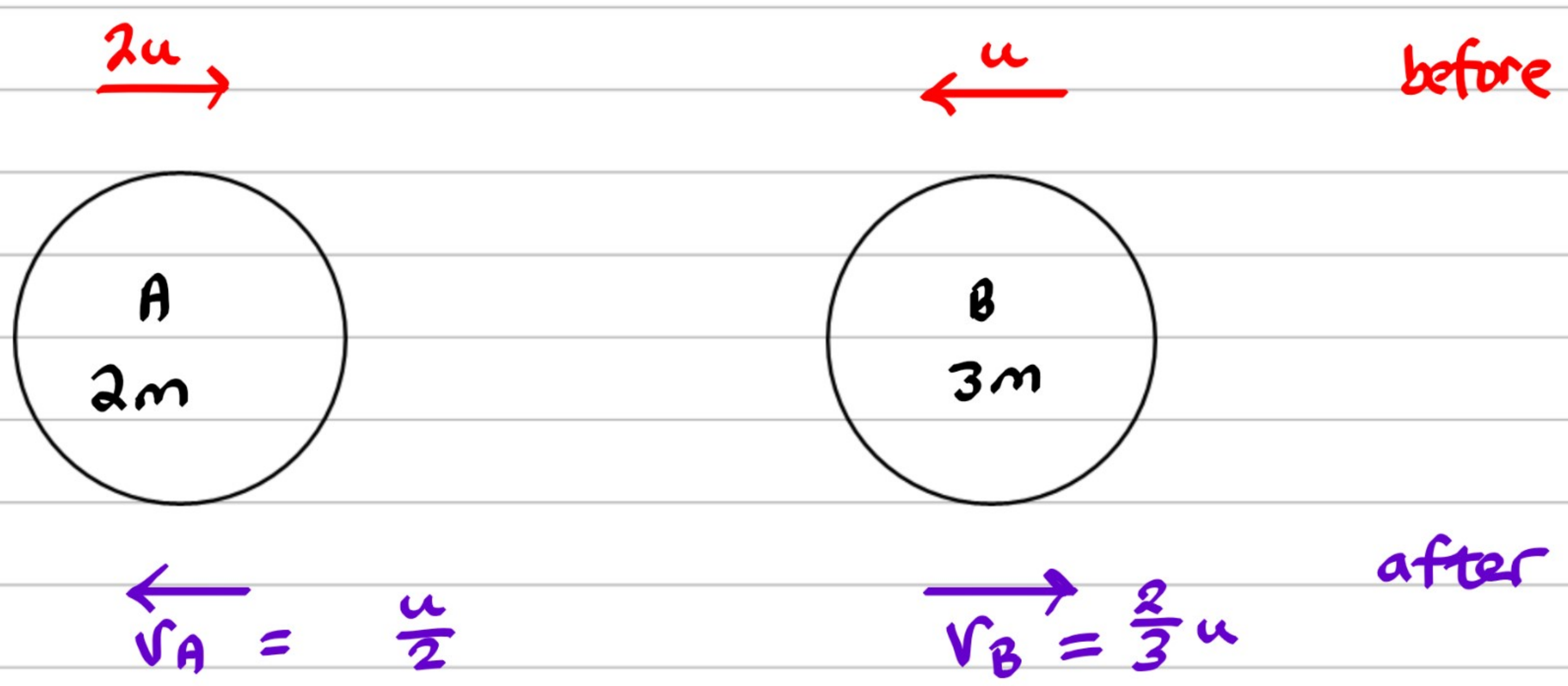
2. Two particles, A and B, of masses $2m$ and $3m$ respectively, are moving on a smooth horizontal plane. The particles are moving in opposite directions towards each other along the same straight line when they collide directly. Immediately before the collision the speed of A is $2u$ and the speed of B is u. In the collision the impulse of A on B has magnitude $5mu$.

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

(9)

(b) Find the total loss in kinetic energy due to the collision.

(4)



we know impulse of A on B has magnitude 5mu, hence using impulse momentum principle for B:

$$5mu = 3m(v_B - -u)$$

$$5u = 3(v_B + u)$$

$$\frac{5u}{3} = v_B + u \quad \therefore v_B = \frac{2u}{3} \text{ ms}^{-1}$$

conservation of momentum:

$$\underbrace{(2u)(2\cancel{m}) + (-u)(3\cancel{m})}_{\text{before}} = \underbrace{(v_A)(2\cancel{m}) + (3\cancel{m})(\tfrac{2}{3}u)}_{\text{after}}$$

$$4u - 3u = 2v_A + 2u$$

$$u = 2v_A + 2u$$

P 6 1 8 6 9 R A 0 6 1 6

Question 2 continued

$-u = 2V_A \therefore V_A = \frac{-u}{2} \ ms^{-1}$

using Newton's law:

$e = \frac{\text{speed of seperation}}{\text{speed of approach}}$

$= \frac{u/2 + 2u/3}{2u + u}$

$= \frac{7u}{6} \Big/ 3u$

$= \frac{7}{18}$

(b) loss of KE = initial KE − final KE

$= \left\{ \underbrace{\frac{1}{2}(2m)(2u)^2}_{A} + \underbrace{\frac{1}{2}(3m)(u)^2}_{B} \right\} - \left\{ \underbrace{\frac{1}{2}(2m)\left(\frac{-u}{2}\right)^2}_{A} + \underbrace{\frac{1}{2}(3m)\left(\frac{2u}{3}\right)^2}_{B} \right\}$

$= 4mu^2 + \frac{3}{2}mu^2 - \frac{1}{4}mu^2 - \frac{2}{3}mu^2$

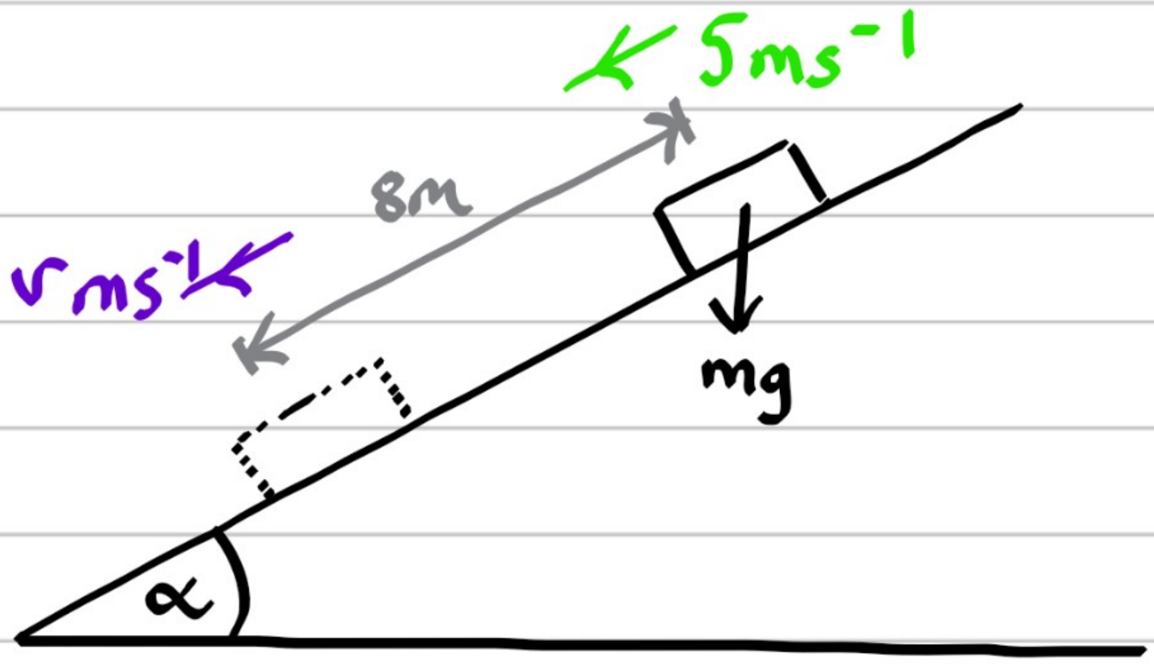
$= \frac{55}{12}mu^2 \quad J$

3. A particle, P, of mass m kg is projected with speed 5 m s^{-1} down a line of greatest slope of a rough plane. The plane is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{3}{5}$

The total resistance to the motion of P is a force of magnitude $\frac{1}{5}mg$

Use the work-energy principle to find the speed of P at the instant when it has moved a distance 8 m down the plane from the point of projection.

(7)



work done against friction = loss in PE − gain in KE

$\frac{1}{5}mg \times 8 = 8mg\sin\alpha - \left(\frac{1}{2}mv^2 - \frac{1}{2}m \times 5^2\right)$

$\frac{8}{5}mg = 8mg \times \frac{3}{5} - \frac{1}{2}mv^2 + \frac{25}{2}m$ $(\times 10)$

$\frac{8}{5}g = \frac{24}{5}g - \frac{1}{2}v^2 + \frac{25}{2}$

$16g = 48g - 5v^2 + 25$

$v^2 = 87.72$

$\therefore v = 9.37$ ms^{-1} (3sf)

4. Three particles, P, Q and R, are at rest on a smooth horizontal plane. The particles lie along a straight line with Q between P and R. The particles Q and R have masses m and km respectively, where k is a constant.

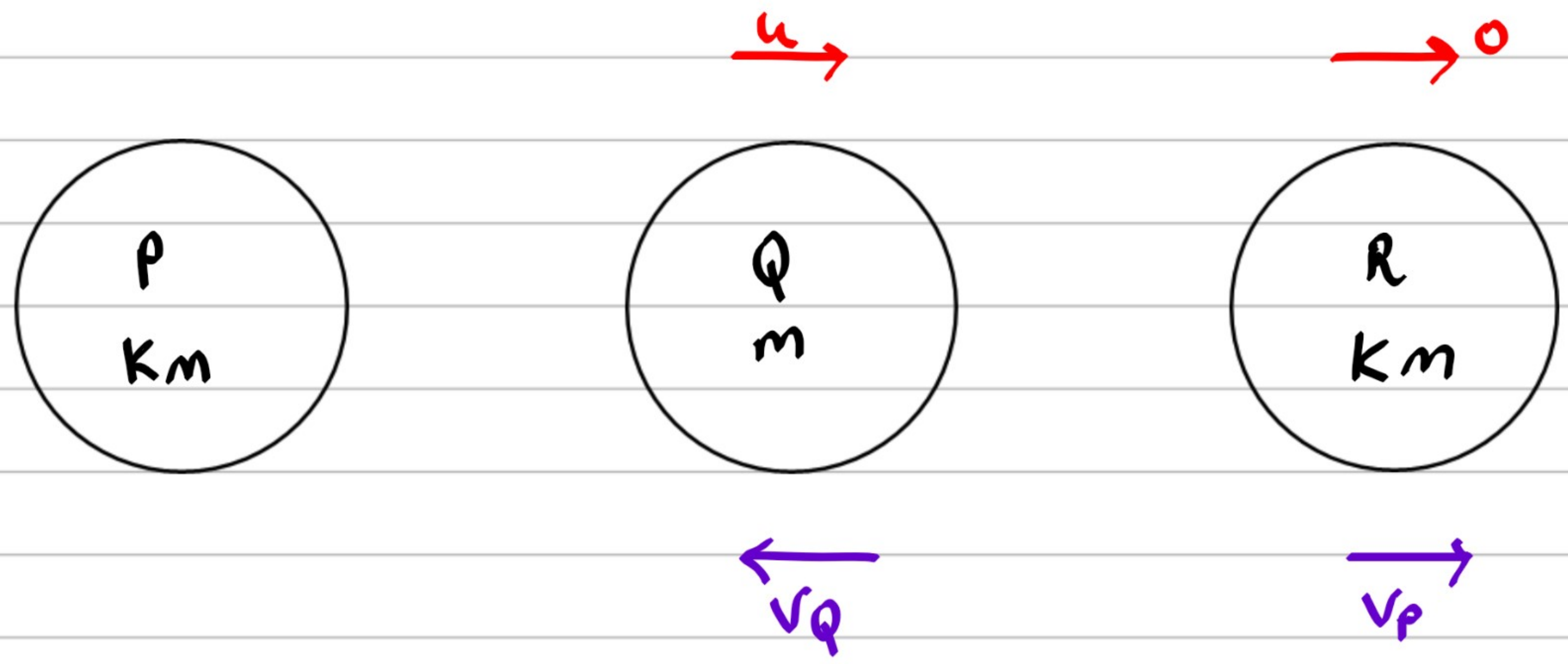
Particle Q is projected towards R with speed u and the particles collide directly.

The coefficient of restitution between each pair of particles is e.

(a) Find, in terms of e, the range of values of k for which there is a second collision.
(9)

Given that the mass of P is km and that there is a second collision,

(b) write down, in terms of u, k and e, the speed of Q after this second collision.
(1)



If a second collision then direction of Q must be reversed

conservation of momentum:

$$mu = -mV_Q + kmV_p$$

$$\therefore\ u = -V_Q + KV_p \quad ①$$

newton's law of restitution:

$$e = \frac{\text{speed of seperation}}{\text{speed of approach}} = \frac{V_Q + V_P}{u}$$

$$\therefore\ eu = V_Q + V_p \quad ②$$

From ①: $$V_P = \frac{u + V_Q}{K} \quad ③$$

Question 4 continued

③ into ②: $eu = v_Q + \dfrac{u + v_Q}{k}$

$keu = kv_Q + u + v_Q$

$keu - u = kv_Q + v_Q$

$u(ke-1) = v_Q(k+1)$

$\therefore v_Q = \dfrac{u(ke-1)}{k+1}$

for second collision, $v_Q > 0$

hence $\dfrac{u(ke-1)}{k+1} > 0$

$ke - 1 > 0 \quad \therefore k > \dfrac{1}{e}$

(b) ratio of masses of particles involved in second collision is identical to that in the first collision

$\therefore$ speed of Q after second collision $= \dfrac{u(ke-1)^2}{(k+1)^2}$

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