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 17 May 2024

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 permitted 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 $g = 9.8\,\text{m}\,\text{s}^{-2}$ 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 particle A has mass $2m$ and a particle B has mass $3m$. The particles are moving in opposite directions along the same straight line and collide directly.

Immediately **before** the collision, the speed of A is $2u$ and the speed of B is u.
Immediately **after** the collision, the speed of A is $0.5u$ and the speed of B is w.

Given that the direction of motion of each particle is reversed by the collision,

(a) find w in terms of u

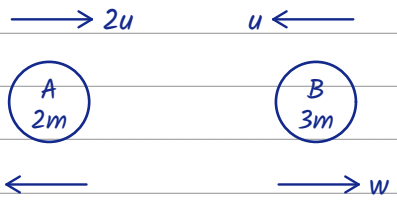
(3)

(b) find the coefficient of restitution between the particles,

(3)

(c) find, in terms of m and u, the magnitude of the impulse received by A in the collision.

(3)



Taking the original direction of motion of A as positive.

(a) CLM: $2m(2u) - 3m(u) = 2m(-0.5u) + 3mw$

$4mu - 3mu = -mu + 3mw$

$2mu = 3mw$

$w = \frac{2u}{3}$

(b) NEL: speed of separation = e × speed of approach

$w + 0.5u = e(2u + u) \Rightarrow \frac{2u}{3} + \frac{u}{2} = 3eu$

$e = \frac{2u/3 + 0.5u}{2u + u} = \frac{7u/6}{3u}$

$e = \frac{7}{18}$

(c) Impulse on A = change in momentum of A

$I = 2m(-0.5u) - 2m(2u)$

$I = -mu - 4mu = -5mu$

Magnitude of impulse received by A = $5mu$

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Question 1 continued

(Total for Question 1 is 9 marks)

2. A lorry has mass 5000 kg.

In all circumstances, when the speed of the lorry is $v\,\text{m s}^{-1}$, the resistance to motion of the lorry from non-gravitational forces is modelled as having magnitude $490v$ newtons.

The lorry moves along a straight horizontal road at $12\,\text{m s}^{-1}$, with its engine working at a constant rate of 84 kW.

Using the model,

(a) find the acceleration of the lorry.

(4)

Another straight road is inclined to the horizontal at an angle α where $\sin\alpha = \frac{1}{14}$

With its engine again working at a constant rate of 84 kW, the lorry can maintain a constant speed of $V\,\text{m s}^{-1}$ up the road.

Using the model,

(b) find the value of V.

(4)

(a) Driving force $F = \frac{P}{v} = \frac{84000}{12} = 7000$ N

Resistance $= 490 \times 12 = 5880$ N

N2L horizontally: $F - 490v = 5000a$

$\frac{84000}{12} - 490 \times 12 = 5000a$

$7000 - 5880 = 5000a \Rightarrow 1120 = 5000a$

$a = \frac{1120}{5000} = \frac{28}{125}$

Acceleration $= 0.224\ \text{m s}^{-2}$

(b) Driving force $D = \frac{84000}{V}$

Constant speed, so $a = 0$. Parallel to the road:

$D - 490V - 5000g \sin\alpha = 0$

$\frac{84000}{V} - 490V - 5000 \times 9.8 \times \frac{1}{14} = 0$

$\frac{84000}{V} - 490V - 3500 = 0$

$84000 - 490V^2 - 3500V = 0$

$\div 70$: $7V^2 + 50V - 1200 = 0$

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Question 2 continued

$(7V + 120)(V - 10) = 0$

$V = 10 \quad (V = -\frac{120}{7}$ rejected, since $V > 0)$

$V = 10$

(Total for Question 2 is 8 marks)

3.

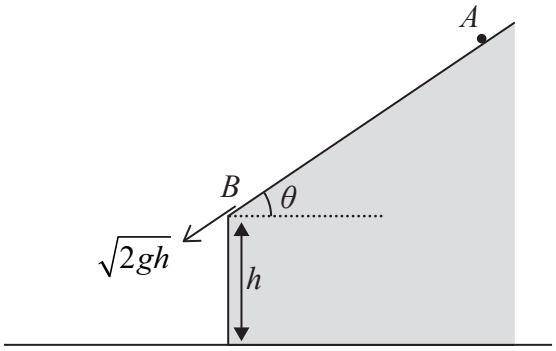


Figure 1

Figure 1 shows part of the end elevation of a building which sits on horizontal ground. The side of the building is vertical and has height h.

A small stone of mass m is at rest on the roof of the building at the point A. The stone slides from rest down a line of greatest slope of the roof and reaches the edge B of the roof with speed $\sqrt{2gh}$

The stone then moves under gravity before hitting the ground with speed W.

In a model of the motion of the stone **from *B* to the ground**

- the stone is modelled as a particle
- air resistance is ignored

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

(a) find W in terms of g and h.

(4)

In a model of the motion of the stone **from *A* to *B***

- the stone is modelled as a particle of mass m
- air resistance is ignored
- the roof of the building is modelled as a rough plane inclined to the horizontal at an angle θ, where $\tan\theta = \frac{3}{4}$
- the coefficient of friction between the stone and the roof is $\frac{1}{3}$
- $AB = d$

Using this model,

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

(3)

(c) use the work–energy principle to find d in terms of h.

(5)

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Question 3 continued

(a) Conservation of mechanical energy, B to the ground:

KE gained = PE lost

$\frac{1}{2}mw^2 - \frac{1}{2}m(\sqrt{(2gh)})^2 = mgh$

$\frac{1}{2}w^2 - gh = gh$

$w^2 = 4gh$

$w = \sqrt{(4gh)} = 2\sqrt{(gh)}$

(b) $\tan\theta = \frac{3}{4} \Rightarrow \sin\theta = \frac{3}{5}, \quad \cos\theta = \frac{4}{5}$

Resolving perpendicular to the roof: $R = mg\cos\theta$

$R = \frac{4}{5}mg$

Friction is limiting (sliding): $F = \mu R = \frac{1}{3}R$

$F = \frac{1}{3} \times \frac{4}{5}mg$

Frictional force $= \frac{4}{15}mg$

(c) Work-energy principle, A to B:

PE lost − KE gained = work done against friction

$mgd\sin\theta - \frac{1}{2}m(\sqrt{(2gh)})^2 = \frac{4}{15}mg \times d$

$\frac{3}{5}mgd - mgh = \frac{4}{15}mgd$

$\frac{3}{5}d - \frac{4}{15}d = h$

$\frac{9}{15}d - \frac{4}{15}d = h \Rightarrow \frac{5}{15}d = h \Rightarrow \frac{1}{3}d = h$

$d = 3h$

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Question 3 continued

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Question 3 continued

(Total for Question 3 is 12 marks)

4.

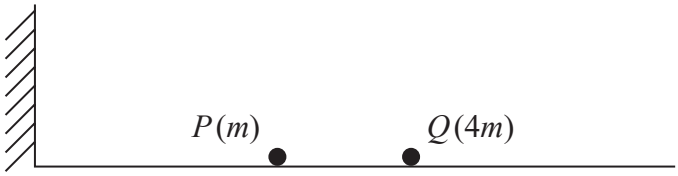


Figure 2

A particle P of mass m and a particle Q of mass $4m$ are at rest on a smooth horizontal plane, as shown in Figure 2.

Particle P is projected with speed u along the plane towards Q and the particles collide.

The coefficient of restitution between the particles is e, where $e > \frac{1}{4}$

As a result of the collision, the direction of motion of P is reversed and P has speed $\frac{u}{5}(4e - 1)$.

(a) Find, in terms of u and e, the speed of Q after the collision.

(3)

After the collision, P goes on to hit a vertical wall which is fixed at right angles to the direction of motion of P.

The coefficient of restitution between P and the wall is f, where $f > 0$

Given that $e = \frac{3}{4}$

(b) find, in terms of m, u and f, the kinetic energy lost by P as a result of its impact with the wall. Give your answer in its simplest form.

(4)

After its impact with the wall, P goes on to collide with Q again.

(c) Find the complete range of possible values of f.

(4)

(a) Direction of motion of P before impact taken as positive.

CLM: $mu = -m \times \frac{u}{5}(4e - 1) + 4mv_Q$

$4v_Q = u + \frac{u}{5}(4e - 1) = \frac{u}{5}(5 + 4e - 1) = \frac{u}{5}(4 + 4e)$

Speed of Q: $v_Q = \frac{u}{5}(e + 1)$

(b) $e = \frac{3}{4}$: speed of P before hitting wall $= \frac{u}{5}(4 \times \frac{3}{4} - 1) = \frac{2u}{5}$

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Question 4 continued

NEL at the wall: speed of P after impact $= f \times \frac{2u}{5} = \frac{2fu}{5}$

KE lost $= \frac{1}{2}m\left(\frac{2u}{5}\right)^2 - \frac{1}{2}m\left(\frac{2fu}{5}\right)^2$

$= \frac{2mu^2}{25} - \frac{2mu^2f^2}{25}$

KE lost $= \frac{2mu^2}{25}(1 - f^2)$

(c) $e = \frac{3}{4}$: $v_Q = \frac{u}{5}\left(\frac{3}{4} + 1\right) = \frac{7u}{20}$ (away from the wall)

After the wall, P moves towards Q with speed $\frac{2fu}{5}$

For P to collide with Q again, P must be faster than Q:

$\frac{2fu}{5} > \frac{7u}{20} \Rightarrow 8f > 7 \Rightarrow f > \frac{7}{8}$

Also $f \leq 1$ (coefficient of restitution)

Range: $\frac{7}{8} < f \leq 1$

Question 4 continued

(Total for Question 4 is 11 marks)

TOTAL FOR FURTHER MECHANICS 1 IS 40 MARKS

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