Write your name here

Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Further Mathematics

Advanced Subsidiary Further Mathematics options

Further Mechanics 1

Sample Assessment Material for first teaching September 2017

Time: 50 minutes

Paper Reference **8FM0/2E**

You must have:
Mathematical Formulae and Statistical Tables, calculator

Total Marks

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for algebraic 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 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.
- Answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 4 questions in this question paper. The total mark for this paper is 40.
- 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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Answer ALL questions. Write your answers in the spaces provided.

Unless otherwise indicated, whenever a numerical 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.

1. A small ball of mass 0.1 kg is dropped from a point which is 2.4 m above a horizontal floor. The ball falls freely under gravity, strikes the floor and bounces to a height of 0.6 m above the floor. The ball is modelled as a particle.

(a) Show that the coefficient of restitution between the ball and the floor is 0.5

(6)

(b) Find the height reached by the ball above the floor after it bounces on the floor for the second time.

(3)

(c) By considering your answer to (b), describe the subsequent motion of the ball.

(1)

a) $v^2 = u^2 + 2as$

$u = 0 \quad a = g \quad s = 2.4$

$v^2 = 0^2 + 2(g)(2.4)$

$v = \sqrt{4.8g}$ (before collision)

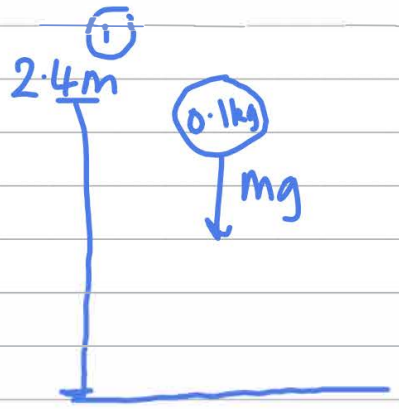
$v = 0 \quad a = -g \quad s = 0.6$

$0^2 = u^2 + 2(-g)(0.6)$

$u = \sqrt{1.2g}$ (after collision)

$e = \dfrac{\sqrt{1.2g}}{\sqrt{4.8g}}$

$= 0.5$



b) $e = \dfrac{u}{\sqrt{1.2g}}$

$u = 0.5 \times \sqrt{1.2g}$

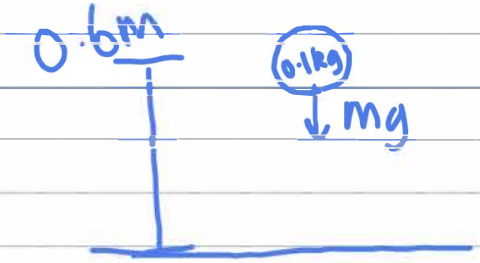
$v = 0, \quad a = -g, \quad h = ?$

$0^2 = (0.5 \times \sqrt{1.2g}) + 2(-g)(h)$

$= 0.25(1.2g) - 2gh$

$2gh = 0.3g$

$h = 0.15\,\text{m}$



c) $2.4 \rightarrow 0.6 \rightarrow 0.15$ The ball will bounce off the floor and the height reached after each bounce is $\frac{1}{4}$ of the previous height.

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Question 1 continued

(Total for Question 1 is 10 marks)

2. A small stone of mass 0.5 kg is thrown vertically upwards from a point A with an initial speed of 25 m s^{-1}. The stone first comes to instantaneous rest at the point B which is 20 m vertically above the point A. As the stone moves it is subject to air resistance. The stone is modelled as a particle.

(a) Find the energy lost due to air resistance by the stone, as it moves from A to B.

(3)

The air resistance is modelled as a constant force of magnitude R newtons.

(b) Find the value of R.

(2)

(c) State how the model for air resistance could be refined to make it more realistic.

(1)

a) energy loss : loss in KE - gain in PE

$= \frac{1}{2} mv^2 - mgh$

$= \frac{1}{2}(0.5)(25^2) - 0.5g(20)$

$= 156.25 - 10g$

$= 58.25$

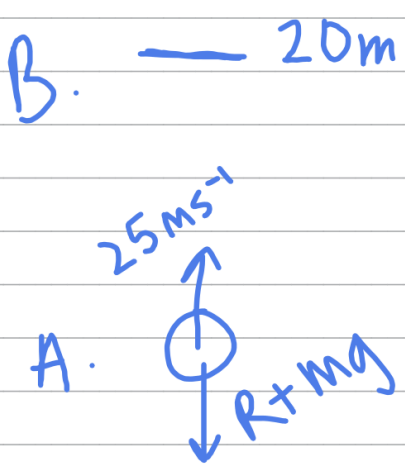
≈ 58.3 J

b) $20 \times R = 58.25$ using work-energy principle

$R = 2.9125$

≈ 2.91 newtons

c) variable air resistance (i.e. dependent on speed)



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Question 2 continued

(Total for Question 2 is 6 marks)

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3. [*In this question use* $g = 10\,m\,s^{-2}$]

A jogger of mass 60 kg runs along a straight horizontal road at a constant speed of $4\,m\,s^{-1}$. The total resistance to the motion of the jogger is modelled as a constant force of magnitude 30 N.

(a) Find the rate at which the jogger is working.

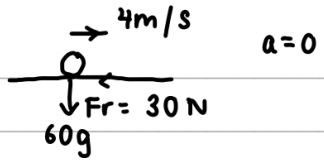
(3)

The jogger now comes to a hill which is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{1}{15}$. Because of the hill, the jogger reduces her speed to $3\,m\,s^{-1}$ and maintains this constant speed as she runs up the hill. The total resistance to the motion of the jogger from non-gravitational forces continues to be modelled as a constant force of magnitude 30 N.

(b) Find the rate at which she has to work in order to run up the hill at $3\,m\,s^{-1}$.

(5)

a)



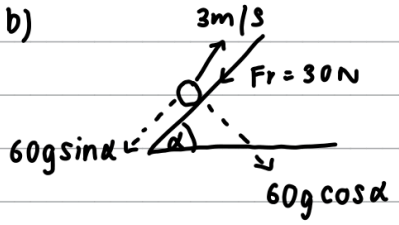
$F = 30\,N$

Power $= F \times V$

$= 30 \times 4$

$= 120\,W$

b)



$\sin\alpha = \frac{1}{15}$

$a = 0$

Resolving parallel to slope : $F - 60g\sin\alpha - 30 = 60(0)$

$F = 30 + 60g\left(\frac{1}{15}\right)$

$= 30 + 4g$ since $g = 10$

$F = 70N$

Power $= F \times V$

$= 70 \times 3$

$= 210\,W$

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Question 3 continued

(Total for Question 3 is 8 marks)

4. A particle P of mass $3m$ is moving in a straight line on a smooth horizontal table. A particle Q of mass m is moving in the opposite direction to P along the same straight line. The particles collide directly. Immediately before the collision the speed of P is u and the speed of Q is $2u$. The velocities of P and Q immediately after the collision, measured in the direction of motion of P before the collision, are v and w respectively. The coefficient of restitution between P and Q is e.

(a) Find an expression for v in terms of u and e.

(6)

Given that the direction of motion of P is changed by the collision,

(b) find the range of possible values of e.

(2)

(c) Show that $w = \frac{u}{4}(1 + 9e)$.

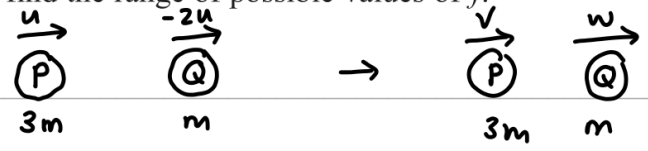
(2)

Following the collision with P, the particle Q then collides with and rebounds from a fixed vertical wall which is perpendicular to the direction of motion of Q. The coefficient of restitution between Q and the wall is f.

Given that $e = \frac{5}{9}$, and that P and Q collide again in the subsequent motion,

(d) find the range of possible values of f.

(6)

a) 

conservation of momentum

$3um - 2um = 3vm + wm$

$u = 3v + w$

$w = u - 3v$

$e = \frac{w-v}{u--2u}$

$= \frac{w-v}{3u}$

$3eu = w - v$

$3eu = u - 3v - v$

$= u - 4v$

$4v = u - 3eu$

$v = \frac{u}{4}(1 - 3e)$

b) $v < 0$

$\frac{u}{4}(1 - 3e) < 0$

$1 - 3e < 0$

$e > \frac{1}{3}$

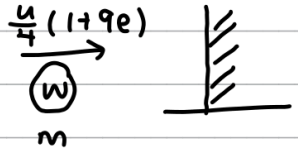
$\therefore \frac{1}{3} < e \leq 1$

c) $w = u - 3v$

$= u - 3\left(\frac{u}{4}\right)(1 - 3e)$

$= u - \frac{3}{4}u + \frac{9}{4}eu$

$= \frac{u}{4}(1 + 9e)$

d) 

when $e = \frac{5}{9}$, $w = \frac{3u}{2}$, $v = -\frac{u}{6}$

$w_1 = \frac{3u}{2} \times f$

$w_1 > |v| : \frac{3}{2}uf > \frac{u}{6}$

$f > \frac{1}{9}$

$\frac{1}{9} < f \leq 1$

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Question 4 continued

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Question 4 continued

(Total for Question 4 is 16 marks)

TOTAL FOR PAPER IS 40 MARKS

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