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**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)

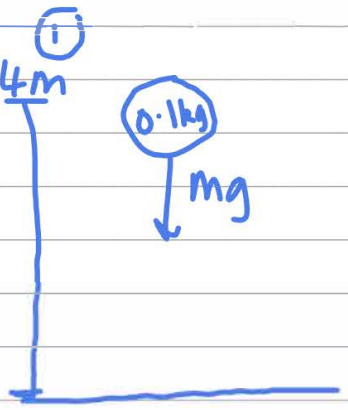
$v = 0 \quad a = -g \quad s = 0.6$

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

$u = \sqrt{1.2g}$ (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.

**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

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

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

$= 156.25 - 10g$

$= 58.25$

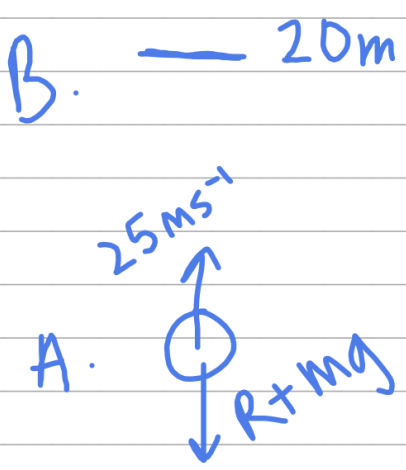
$\simeq 58.3$ J

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

$R = 2.9125$

$\simeq 2.91$ newtons

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



**Question 2 continued**

**(Total for Question 2 is 6 marks)**

**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.

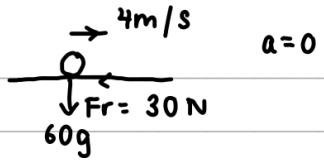
**(3)**

The jogger now comes to a hill which is inclined to the horizontal at an angle $\alpha$, 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)



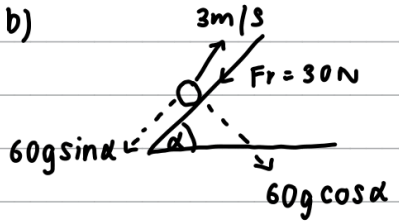

$F = 30\,N$

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) $v < 0$

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

$1 - 3e < 0$

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

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

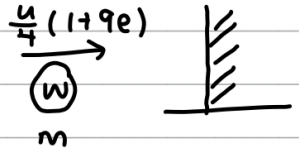
c) $w = u - 3v$

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

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

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

d)




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

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

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

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

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

**Question 4 continued**

**Question 4 continued**

**Question 4 continued**

**(Total for Question 4 is 16 marks)**

**TOTAL FOR PAPER IS 40 MARKS**