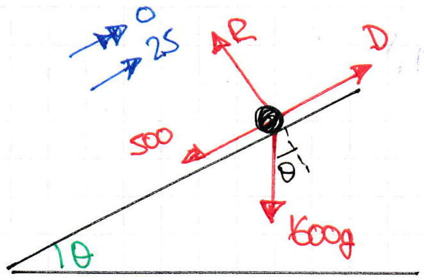
IYGB – FM1 PAPER M – QUESTION 1

- **STARTING WITH A STANDARD DIAGRAM**



$\Rightarrow D = 500 + 1600g\sin\theta$
(NO ACCELERATION)

$\Rightarrow D = 500 + 1600g \times \frac{1}{40}$

$\Rightarrow D = 892\ \text{N}$

- **POWER = TRACTIVE FORCE × SPEED**

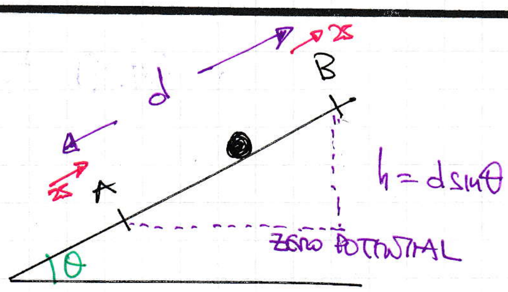
$P = 892 \times 25$

$P = 22300\ \text{W}$

- **BUT POWER** $= \dfrac{\text{WORK IN}}{\text{TIME}}$

$22300 = \dfrac{W_{IN}}{20}$

$W_{IN} = 446\,000\ \text{J}$



$\cancel{KE_A} + \cancel{PE_A} + W_{IN} - W_{OUT} = \cancel{KE_B} + PE_B$

$\Rightarrow W_{IN} - 500d = mgh$

$\Rightarrow W_{IN} = 500d + mgd\sin\theta$

$\Rightarrow W_{IN} = 500d + 1600gd \times \frac{1}{40}$

$\Rightarrow W_{IN} = 500d + 392d$

$\Rightarrow W_{IN} = 892d$

$\Rightarrow W_{IN} = 892 \times (25 \times 20)$

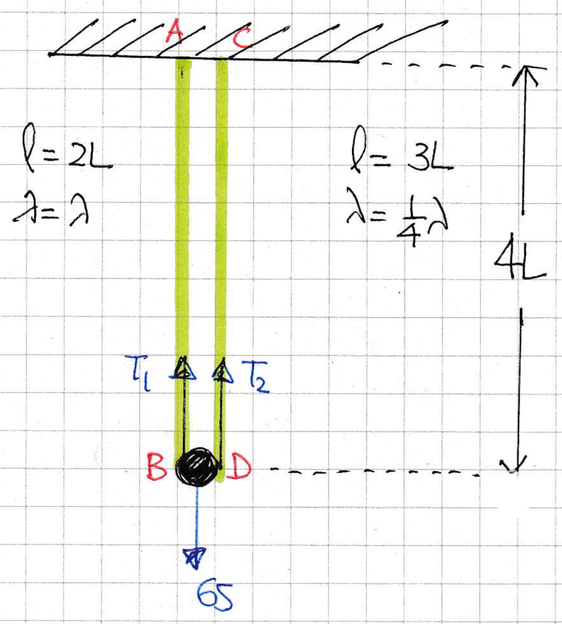
CONSTANT SPEED OF $25\ \text{ms}^{-1}$ FOR 20 SECONDS

$\Rightarrow W_{IN} = 446\,000$

AS BEFORE

IYGB – FM1 PAPER M – QUESTION 2

STARTING WITH A DIAGRAM



FORMING AN EQUATION

$$T_1 + T_2 = 65$$

$$\frac{2L}{2L} \times \lambda + \frac{L}{3L} \times \frac{1}{4}\lambda = 65$$

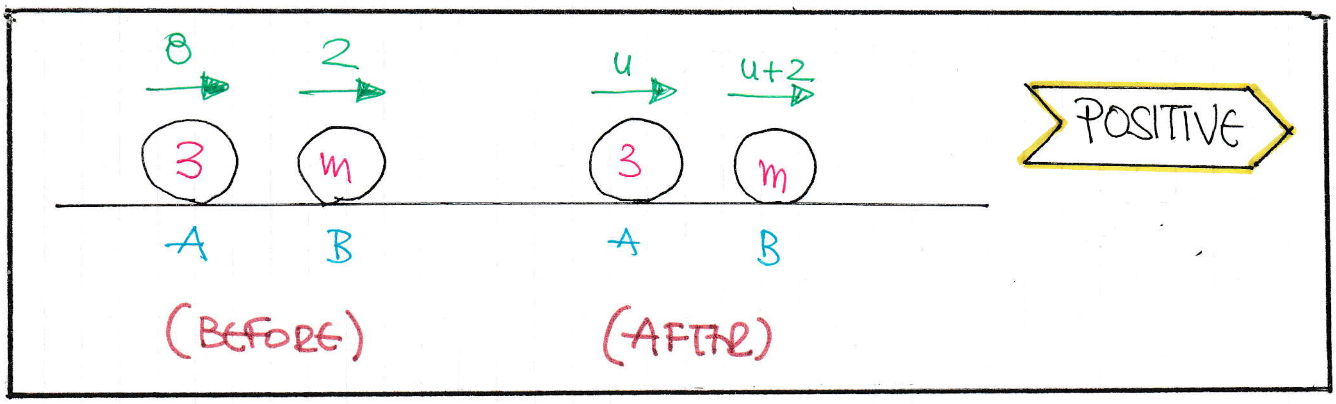
$$\lambda + \frac{1}{12}\lambda = 65$$

$$12\lambda + \lambda = 780$$

$$13\lambda = 780$$

$$\lambda = 60\text{ N}$$

IYGB - FM1 PAPER M - QUESTION 3



- BY CONSERVATION OF MOMENTUM

$$(3\times8)+(2m) = 3u + m(u+2)$$

$$24 + \cancel{2m} = 3u + mu \cancel{+2m}$$

$$mu + 3u = 24$$

- BY IMPULSE ON B

$$m(u+2) - m\times2 = 15$$

$$mu + \cancel{2m} - \cancel{2m} = 15$$

$$mu = 15$$

- $15 + 3u = 24$

$$3u = 9$$

$$u = 3$$

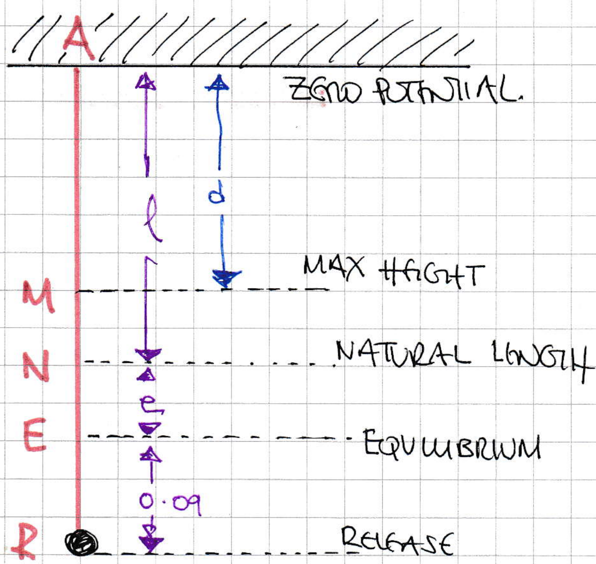
$\therefore$ $m = 5$ kg

$\therefore$ SPEED OF B $= 5\ \mathrm{ms^{-1}}$

IYGB – FM1 PAPER M – QUESTION 4

START BY FINDING THE EQUILIBRIUM EXTENSION e

$$mg = \frac{\lambda}{l}e$$
$$e = \frac{mgl}{\lambda}$$
$$e = \frac{3g \times 2}{100g}$$
$$e = \frac{6}{100} = 0.06$$



ADDITIONAL EXTENSION

$$2.15 - 2 - 0.06 = 0.09$$

$\lambda = 100g$ N
$l = 2$ m
$m = 3$ kg

BY ENERGIES TAKING THE LEVEL OF A, AS THE ZERO POTENTIAL LEVEL

$$\Rightarrow \cancel{KE_R} + PE_R + EE_R = \cancel{KE_M} + PE_M + EE_M$$
$$\Rightarrow -mg(l+e+0.09) + \frac{\lambda}{2l}(e+0.09)^2 = -mgd + \frac{\lambda}{2l}(l-d)^2$$
$$\Rightarrow -m\cancel{g}(2.15) + \frac{100\cancel{g}}{4}(0.15)^2 = -m\cancel{g}d + \frac{100\cancel{g}}{4}(2-d)^2$$
$$\Rightarrow -\frac{129}{20} + \frac{9}{16} = -3d + 25(4 - 4d + d^2)$$
$$\Rightarrow -\frac{471}{80} = -3d + 100 - 100d + 25d^2$$
$$\Rightarrow -471 = -240d + 8000 - 8000d + 2000d^2$$

IYGB - FM1 PAPER M - QUESTION 4

$$\Longrightarrow \quad 0 = 2000d^2 - 8240d + 8471$$

BY THE QUADRATIC FORMULA

$$\Longrightarrow \quad d = \frac{8240 \pm \sqrt{129600}}{2 \times 2000}$$

$$\Longrightarrow \quad d = \frac{8240 \pm 360}{4000}$$

$$\Longrightarrow \quad d = \begin{cases} \cancel{2.15} & \text{RELEASE POINT} \\ 1.97 & \end{cases}$$

ALTERNATIVE APPROACH

- PROVE THE PARTICLE IS MOVING IN S.H.M ABOUT EQUILIBRIUM POSITION
- THEN AS WE HAVE A SPRING THE MOTION IS "FULL S.H.M", SO THE ZERO SPEED POINTS DEFINES THE ENDPOINTS OF THE OSCILLATION
- SYMMETRY THEN YIELDS

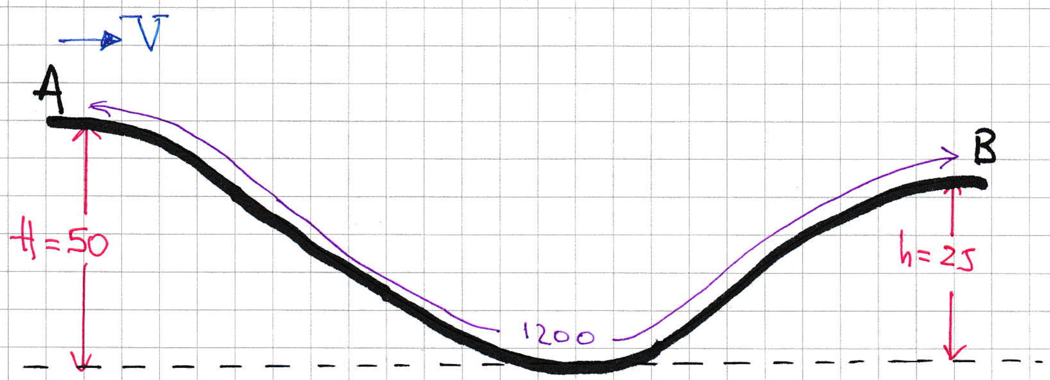
EQUILIBRIUM AT $2 + 0.06 = 2.06$

$2.15 - 2.06 = 0.09$ ← AMPLITUDE

$2.06 - 0.09 = 1.97$

IYGB - FMI PAPER M - QUESTION 5

LOOKING AT THE DIAGRAM BELOW



$$KE_A + PE_A + W_{IN} - W_{OUT} = KE_B + PE_B$$

KE_A: $\frac{1}{2}mV^2$

PE_A: mgH

W_{OUT}: 20×1200

KE_B: TO BE FOUND

PE_B: mgh

W_{IN}:

$$\text{POWER} = \frac{\text{WORK IN}}{\text{TIME}}$$

$$40 = \frac{\text{WORK IN}}{110}$$

$$W_{IN} = 4400$$

RETURNING TO THE ENERGY EQUATION

$\Rightarrow KE_A + 80 \times 9.8 \times 50 + 4400 - 24000 = KE_B + 80 \times 9.8 \times 25$

$\Rightarrow KE_A + 39200 + 4400 - 24000 = KE_B + 19600$

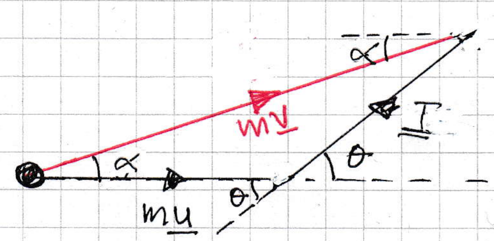
$\Rightarrow KE_A + 19600 = KE_B + 19600$

$\Rightarrow KE_A = KE_B$

$\therefore$ SAME SPEED AS THE KINETIC ENERGY IS UNCHANGED

IYGB - FULL PAPER M - QUESTION 6

STARTING WITH A DIAGRAM: $m\underline{v} = m\underline{u} + \underline{I}$



$\sin\alpha = \frac{3}{5}$

$\cos\alpha = \frac{4}{5}$

$|m\underline{u}| = 0.5 \times 4 = 2$

$|m\underline{v}| = 0.5 \times 8 = 4$

BY THE COSINE RULE

$\Rightarrow |\underline{I}|^2 = |m\underline{u}|^2 + |m\underline{v}|^2 - 2|m\underline{u}||m\underline{v}|\cos\alpha$

$\Rightarrow |\underline{I}|^2 = 2^2 + 4^2 - 2\times2\times4\times\frac{4}{5}$

$\Rightarrow |\underline{I}|^2 = 7.2$

$\Rightarrow |\underline{I}| = \sqrt{7.2} \approx 2.68 \text{ Ns}$

BY THE SINE RULE

$$\Rightarrow \frac{\sin(180-\theta)}{|m\underline{v}|} = \frac{\sin\alpha}{|\underline{I}|}$$

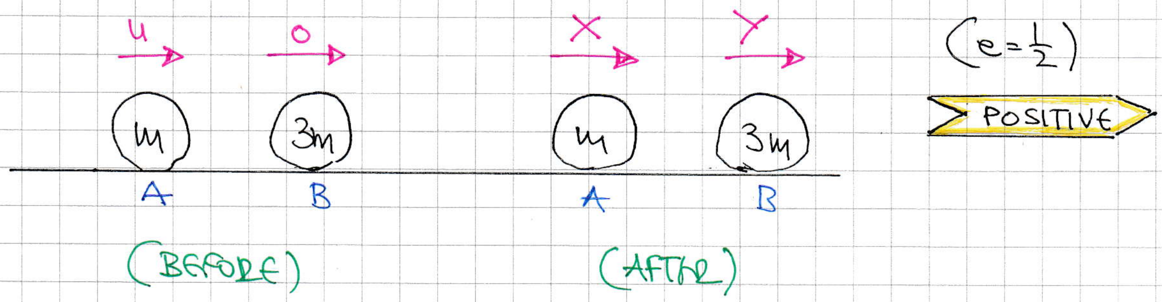
$$\Rightarrow \frac{\sin\theta}{4} = \frac{\frac{3}{5}}{\sqrt{7.2}}$$

$\Rightarrow \sin\theta = 0.894427191\ldots$

$\Rightarrow \theta \simeq 63.4°$

IYGB - FM1 PAPER M - QUESTION 7

LOOKING AT THE COLLISION BETWEEN A & B



BY CONSERVATION OF MOMENTUM

$$\Rightarrow mu + 0 = mX + 3mY$$
$$\Rightarrow u = X + 3Y$$
$$\Rightarrow X + 3Y = u$$

BY CONSIDERING RESTITUTION

$$\Rightarrow e = \frac{\text{SEP}}{\text{APP}}$$
$$\Rightarrow \frac{1}{2} = \frac{Y - X}{u}$$
$$\Rightarrow -X + Y = \frac{1}{2}u$$

ADDING EQNS

$$4Y = \frac{3}{2}u$$
$$Y = \frac{3}{8}u$$

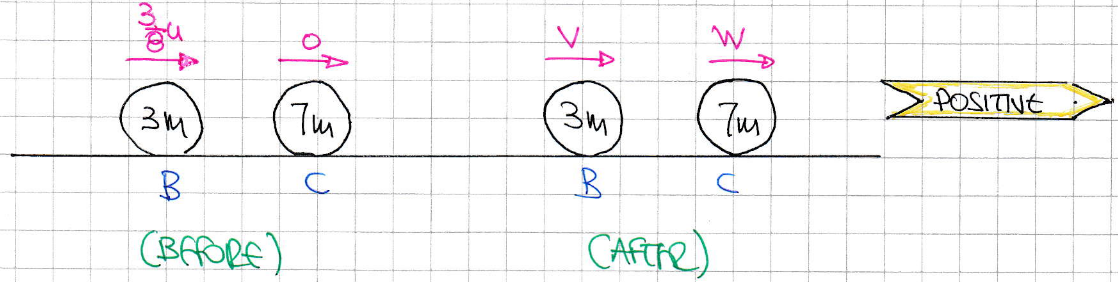
AND USING $X = u - 3Y$

$$X = u - 3\left(\frac{3}{8}u\right)$$
$$X = u - \frac{9}{8}u$$
$$X = -\frac{1}{8}u$$

IE A HAS REBOUNDED (MINUS) WITH SPEED $\frac{1}{8}u$

IYGB - FM1 PAPER M - QUESTION 7

NEXT THE COLLISION BETWEEN B & C



BY CONSERVATION OF MOMENTUM

$$\Rightarrow 3\cancel{m}\left(\tfrac{3}{8}u\right) + 0 = 3\cancel{m}V + 7\cancel{m}W$$

$$\Rightarrow \tfrac{9}{8}u = 3V + 7W$$

BY CONSIDERING RESTITUTION

$$\Rightarrow e = \frac{\text{SEP}}{\text{APP}}$$

$$\Rightarrow e = \frac{W - V}{\frac{3}{8}u}$$

$$\Rightarrow -V + W = \tfrac{3}{8}ue$$

$$\Rightarrow -7V + 7W = \tfrac{21}{8}ue$$

$$\Rightarrow 7V - 7W = -\tfrac{21}{8}ue$$

ADDING THE EQUATIONS ABOVE (WE ONLY NEED V)

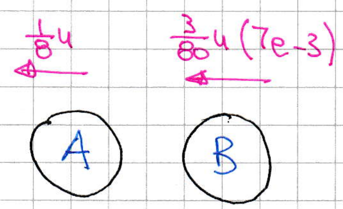
$$\Rightarrow 10V = \tfrac{9}{8}u - \tfrac{21}{8}eu$$

$$\Rightarrow 10V = \tfrac{3}{8}u(3 - 7e)$$

$$\Rightarrow V = \tfrac{3}{80}u(3 - 7e) \quad \leftarrow \text{TO THE "RIGHT"}$$

$$\Rightarrow V = \tfrac{3}{80}u(7e - 3) \quad \leftarrow \text{TO THE "LEFT"}$$

FOR A COLLISION BETWEEN B & A



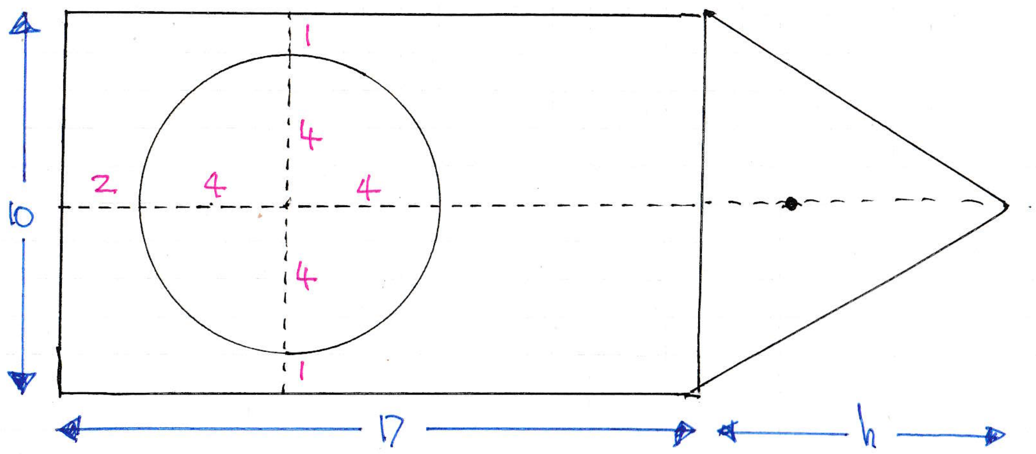
$$\Rightarrow \tfrac{3}{80}\cancel{u}(7e - 3) > \tfrac{1}{8}\cancel{u}$$

$$\Rightarrow 7e - 3 > \tfrac{10}{3}$$

$$\Rightarrow 7e > \tfrac{19}{3}$$

$$\Rightarrow e > \tfrac{19}{21} \qquad \text{OR} \qquad \tfrac{19}{21} < e \leqslant 1$$

IYGB - FMI PAPER M - QUESTION 8



FIRSTLY CONSIDER THE RECTANGLE WITH THE HOLE

MASS RATIO	$170-16\pi$	16π	170
x	$\bar{x}$	6	$17/2$

$$\Rightarrow (170-16\pi)\bar{x} + (6\times 16\pi) = 170\times\frac{17}{2}$$

$$\Rightarrow (170-16\pi)\bar{x} + 96\pi = 1445$$

$$\Rightarrow (170-16\pi)\bar{x} = 1445 - 96\pi$$

$$\Rightarrow \bar{x} = \frac{1445-96\pi}{170-16\pi}$$

NEXT CONSIDER THE WHOLE SHAPE

MASS RATIO	$170-16\pi$	$5h$	$170-16\pi+5h$
x	$\bar{x}$	$17+\frac{1}{3}h$	17

$$\Rightarrow (170-16\pi)\bar{x} + 5h\left(17+\tfrac{1}{3}h\right) = 17(170-16\pi+5h)$$

$$\Rightarrow 1445-96\pi\cancel{+85h}+\frac{5}{3}h^2 = 2890-272\pi\cancel{+85h}$$

$$\Rightarrow \frac{5}{3}h^2 = 1445-176\pi$$

$$\Rightarrow h^2 = \frac{3}{5}(1445-176\pi)$$

$$\Rightarrow h^2 = 535.2478158\ldots$$

$$\Rightarrow h \approx 23.14$$

2 d.p.