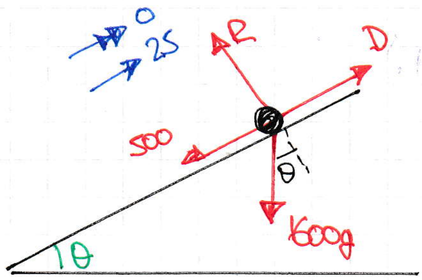
IYGB - FM1 PAPER M - QUESTION 1

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

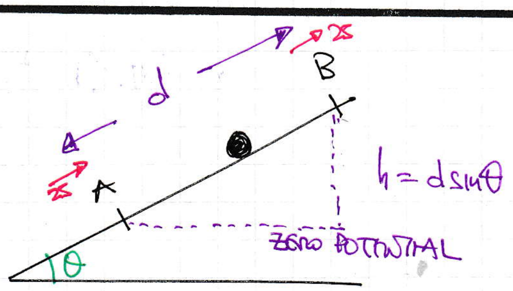
$P = 892 \times 25$

$P = 22300 \text{ W}$

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

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

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



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

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

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

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

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

$\Rightarrow W_{IN} = 892d$

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

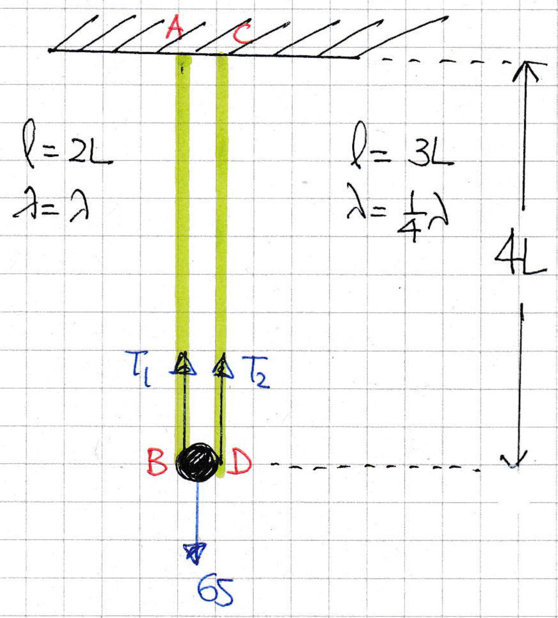
CONSTANT SPEED OF 25 ms^{-1} FOR 20 SECONDS

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

AS BEFORE

IYGB – FM1 PAPER M – QUESTION 2

STARTING WITH A DIAGRAM



FORMING AN EQUATION

$$T_1 + T_2 = 65$$

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

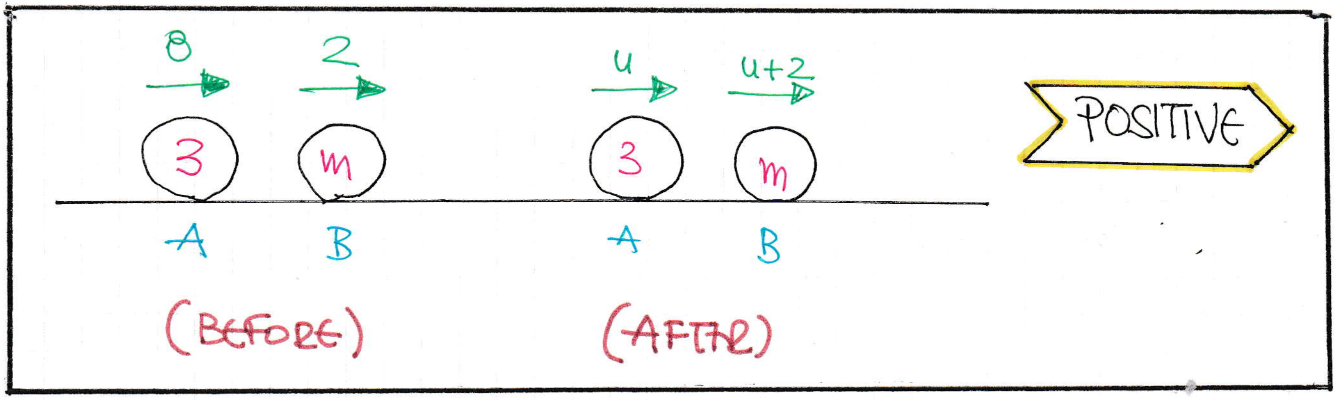
$$\lambda + \frac{1}{12}\lambda = 65$$

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

$$13\lambda = 780$$

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

IYGB - FM1 PAPER M - QUESTION 3



- **BY CONSERVATION OF MOMENTUM**

$$(3\times 8) + (2m) = 3u + m(u+2)$$

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

$$mu + 3u = 24$$

- **BY IMPULSE ON B**

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

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

$$mu = 15$$

- $$15 + 3u = 24$$

$$3u = 9$$

$$u = 3$$

$\therefore\ m = 5\ \text{kg}$

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

IYGB – FM1 PAPER M – QUESTION 4

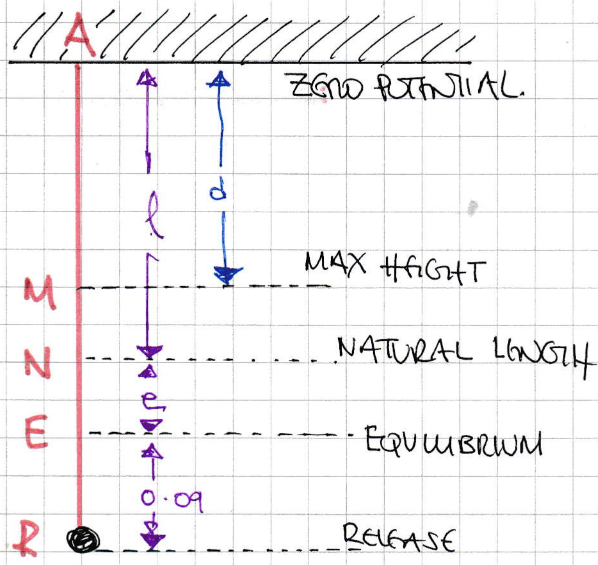
START BY FINDING THE EQUILIBRIUM EXTENSION e

$$mg = \frac{\lambda}{l}e$$

$$e = \frac{mgl}{\lambda}$$

$$e = \frac{3g \times 2}{100g}$$

$$e = \frac{6}{100} = 0.06$$



$\lambda = 100g$ N

$l = 2$ m

$m = 3$ kg

ADDITIONAL EXTENSION

$$2.15 - 2 - 0.06 = 0.09$$

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

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

BY THE QUADRATIC FORMULA

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

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

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

ALTERNATIVE APPROACH

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

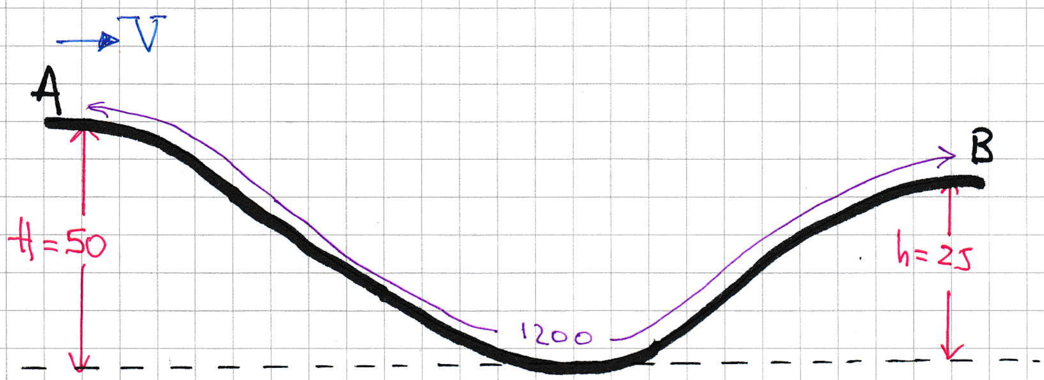
EQUILIBRIUM AT $\quad 2 + 0.06 = 2.06$

$2.15 - 2.06 = 0.09 \leftarrow$ 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

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

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

$$W_{IN} = 4400$$

RETURNING TO THE ENERGY EQUATION

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

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

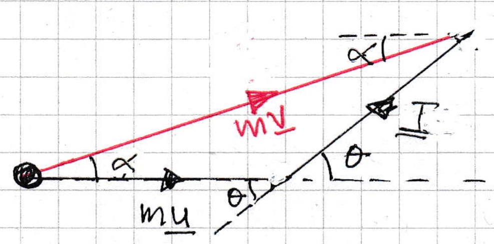
$\Rightarrow KE_A + 19600 = KE_B + 19600$

$\Rightarrow KE_A = KE_B$

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

IYGB - FMI 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

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

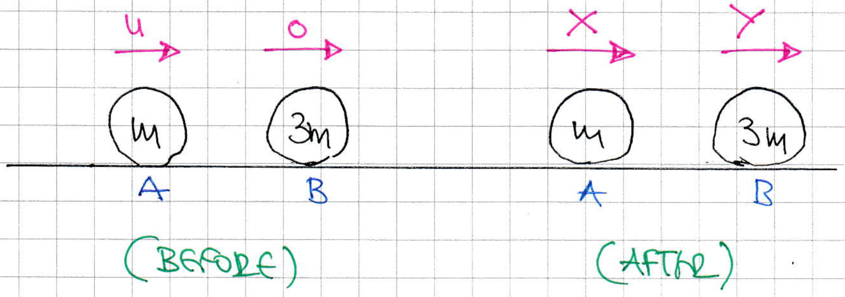
$\Rightarrow \frac{\sin\theta}{4} = \frac{\frac{3}{5}}{\sqrt{7.2}}$

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

$\Rightarrow \theta \simeq 63.4^\circ$

IYGB - FM1 PAPER M - QUESTION 7

LOOKING AT THE COLLISION BETWEEN A & B



$\left(e=\frac{1}{2}\right)$

POSITIVE

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

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

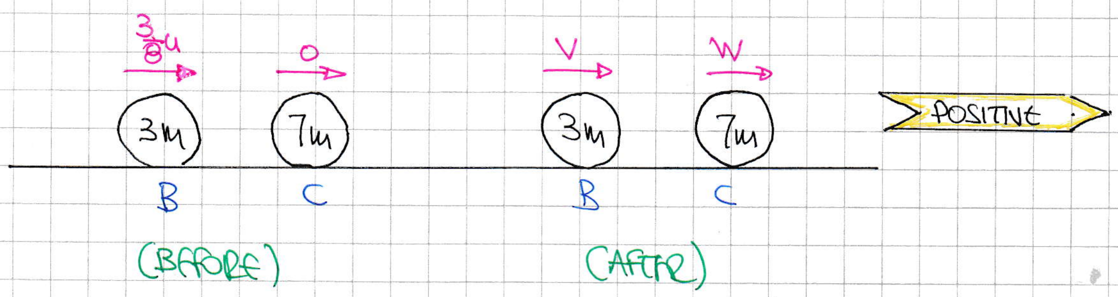
AND USING $X = u - 3Y$

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

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

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

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

BY CONSIDERING RESTITUTION

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

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

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

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

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

ADDING THE EQUATIONS ABOVE (WE ONLY NEED V)

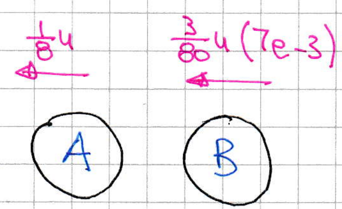
$$\Rightarrow 10V = \frac{9}{8}u - \frac{21}{8}eu$$

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

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

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

FOR A COLLISION BETWEEN B & A



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

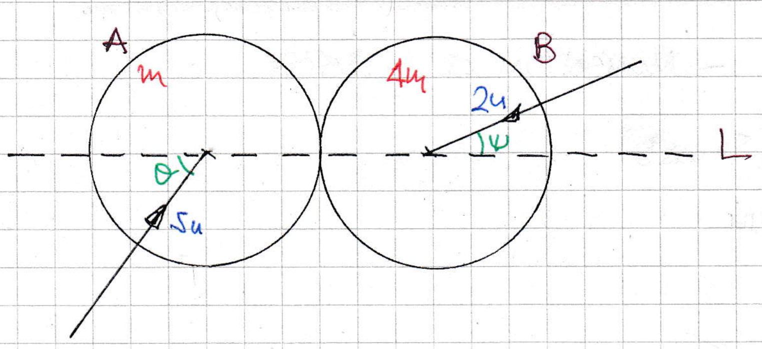
$$\Rightarrow 7e - 3 > \frac{10}{3}$$

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

$$\Rightarrow e > \frac{19}{21} \qquad \text{OR} \qquad \frac{19}{21} < e \leq 1$$

IYGB - FM1 PAPER M - QUESTION 8

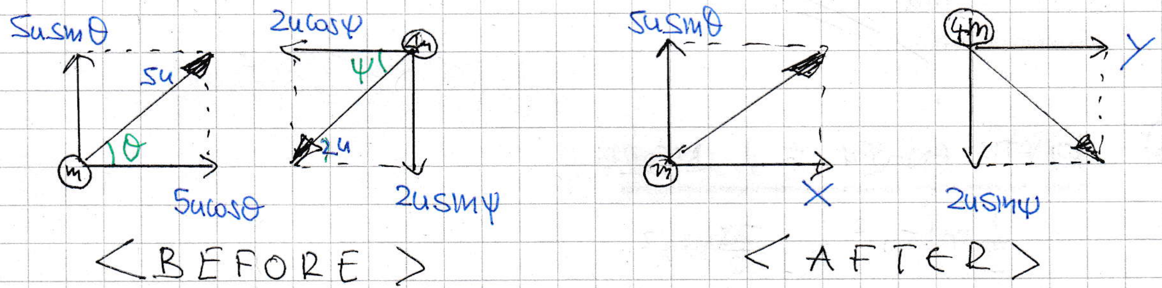
a) STARTING WITH A DIAGRAM



$\cos\theta = \frac{1}{5}$

$\cos\psi = \frac{3}{4}$

$e = \frac{1}{2}$



NO MOMENTUM IS EXCHANGED IN A DIRECTION PERPENDICULAR TO L

- BY CONSERVATION OF LINEAR MOMENTUM ALONG "L"

$\Rightarrow 5\cancel{m}u\cos\theta - 2(4\cancel{m})u\cos\psi = \cancel{m}X + 4\cancel{m}Y$

$\Rightarrow 5u\cos\theta - 8u\cos\psi = X + Y$

$\Rightarrow u - 6u = X + 4Y$

$\Rightarrow \boxed{X + 4Y = -5u}$

- BY RESTITUTION ALONG "L"

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

$\frac{1}{2} = \frac{Y - X}{5u\cos\theta + 2u\cos\psi}$

$\frac{1}{2} = \frac{Y - X}{u + \frac{3}{2}u}$

$\boxed{-X + Y = \frac{5}{4}u}$

ADDING YIELDS

$5Y = -\frac{15}{4}u$

$Y = -\frac{3}{4}u$ (REBOUNDED) & $X = -2u$ (ALSO REBOUNDED)

IYGB - FM1 PAPER M - QUESTION 8

FINALLY THE IMPULSE ON A - JUST ON THE DIRECTION OF L

MOM A AFTER - MOMENTUM OF A BEFORE

$$I = mX - m(5u\cos\theta)$$

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

$$I = -3mu$$

$$|I| = 3mu$$

b) KINETIC ENERGY OF A BEFORE

$$\frac{1}{2}m(5u)^2 = \frac{25}{2}mu^2$$

KINETIC ENERGY OF A AFTER

$$\frac{1}{2}mX^2 + \frac{1}{2}m(5u\sin\theta)^2 = \frac{1}{2}m(-2u)^2 + \frac{1}{2}m(25u^2\sin^2\theta)$$

$$= 2mu^2 + \frac{25}{2}mu^2(1-\cos^2\theta)$$

$$= 2mu^2 + \frac{25}{2}mu^2\left(1-\frac{1}{25}\right)$$

$$= 2mu^2 + \frac{\cancel{25}}{2}\times\frac{24}{\cancel{25}}mu^2$$

$$= 14mu^2$$

KINETIC ENERGY GAIN

$$14mu^2 - \frac{25}{2}mu^2 = \frac{3}{2}mu^2$$

REQUIRED PROPORTION

$$\frac{\frac{3}{\cancel{2}}mu^2}{\frac{25}{\cancel{2}}mu^2} = \frac{3}{25} \text{ OR } 12\%$$