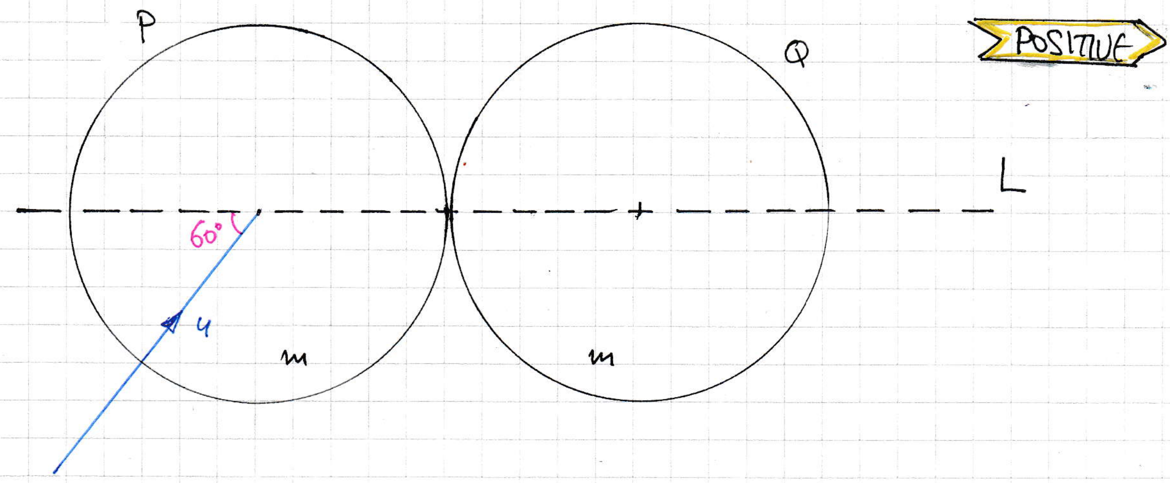
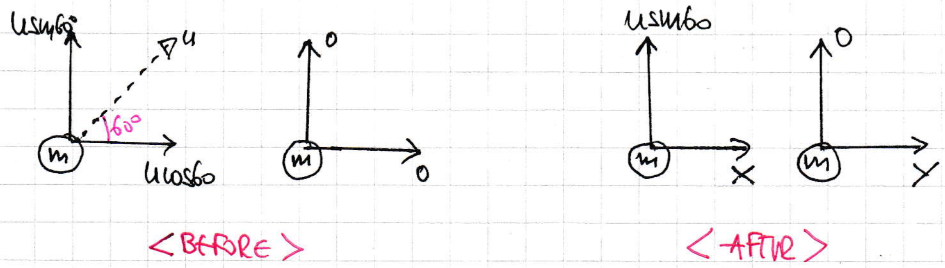
# IYGB - FM1 PAPER R - QUESTION 1

a) STARTING WITH A "BEFORE-AFTER" DIAGRAM




**BY CONSERVATION OF MOMENTUM ALONG L**

$$mu\cos 60 + 0 = mX + mY$$
$$\tfrac{1}{2}u = X + Y$$

**BY RESTITUTION ALONG L**

$$e = \frac{SEP}{APP}$$
$$7 - 4\sqrt{3} = \frac{Y - X}{u\cos 60}$$
$$-X + Y = \tfrac{1}{2}u\left(7 - 4\sqrt{3}\right)$$

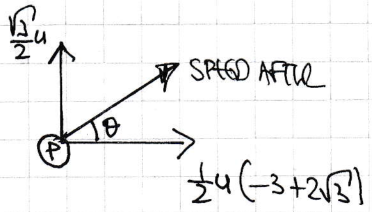
**ELIMINATING Y**

$$\left.\begin{aligned} X + Y &= \tfrac{1}{2}u \\ -X + Y &= \tfrac{1}{2}u\left(7 - 4\sqrt{3}\right) \end{aligned}\right\} \Longrightarrow \quad 2X = \tfrac{1}{2}u - \tfrac{1}{2}\left(7 - 4\sqrt{3}\right)$$

$$2X = \tfrac{1}{2}u\left(1 - 7 + 4\sqrt{3}\right)$$
$$X = \tfrac{1}{4}u\left(-6 + 4\sqrt{3}\right)$$
$$X = \tfrac{1}{2}u\left(-3 + 2\sqrt{3}\right)$$

# IYGB - FM1 PAPER R - QUESTION 1

FINALLY WE HAVE




$$\tan\theta = \frac{\frac{\sqrt{3}}{2}u}{\frac{1}{2}u(-3+2\sqrt{3})} = \frac{\sqrt{3}}{-3+2\sqrt{3}}$$

$$\tan\theta = \frac{\sqrt{3}(-3-2\sqrt{3})}{9-12} = \frac{-3\sqrt{3}-6}{-3}$$

$$\tan\theta = 2-\sqrt{3}$$

$$\theta = 75°$$

AS REQUIRED

b) BY PYTHAGORAS FROM ABOVE DIAGRAM

$$v^2 = \left(\frac{\sqrt{3}}{2}u\right)^2 + \left[\frac{1}{2}u(-3+2\sqrt{3})\right]^2$$

$$v^2 = \frac{3}{4}u^2 + \frac{1}{4}u^2(9-12\sqrt{3}+12)$$

$$v^2 = \frac{1}{4}u^2\left[3+9-12\sqrt{3}+12\right]$$

$$v^2 = \frac{1}{4}u^2(24-12\sqrt{3})$$

$$v^2 = 3u^2(2-\sqrt{3})$$

$$v^2 = 3(6\sqrt{2}+2\sqrt{6})^2(2-\sqrt{3})$$

$$v^2 = 3(2-\sqrt{3})(72+24\sqrt{12}+24)$$

$$v^2 = 3(2-\sqrt{3})(96+48\sqrt{3})$$

$$v^2 = 3(2-\sqrt{3}) \times 48(2+\sqrt{3})$$

$$v^2 = 144 \times (4-1)$$

$$v = 12$$

# IYGB - FM1 PAPER R - QUESTION 1

FIRSTLY WE NEED THE VALUE OF $Y$

$$\left.\begin{aligned} X + Y &= \tfrac{1}{2}u \\ -X + Y &= \tfrac{1}{2}u(7-4\sqrt{3}) \end{aligned}\right\} \Rightarrow \begin{aligned} 2Y &= \tfrac{1}{2}u + \tfrac{1}{2}u(7-4\sqrt{3}) \\ 2Y &= \tfrac{1}{2}u[1+7-4\sqrt{3}] \\ 2Y &= \tfrac{1}{2}u(8-4\sqrt{3}) \\ 2Y &= 2u(2-\sqrt{3}) \\ Y &= u(2-\sqrt{3}) \end{aligned}$$

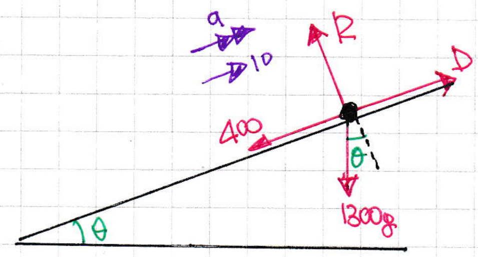
FINALLY WE HAVE

$$\begin{aligned} uV = uY = u^2(2-\sqrt{3}) &= (6\sqrt{2}+2\sqrt{6})^2(2-\sqrt{3}) \\ &= 4(3\sqrt{2}+\sqrt{6})^2(2-\sqrt{3}) \\ &= 4(18+6\sqrt{12}+6)(2-\sqrt{3}) \\ &= 4(24+12\sqrt{3})(2-\sqrt{3}) \\ &= 48(2+\sqrt{3})(2-\sqrt{3}) \\ &= 48 \times 1 \\ &= 48 \\ &= 4U \end{aligned}$$

// AS REQUIRED

# IYGB - FM1 PAPER R - QUESTION 2

a) LOOKING AT THE DIAGRAM WITH THE CAR AT A




$\sin\theta = \frac{1}{10}$

- "POWER = TRACTIVE FORCE × SPEED"

$30000 = D \times 10$

$\underline{\underline{D = 3000\text{ N}}}$

- "F = ma"

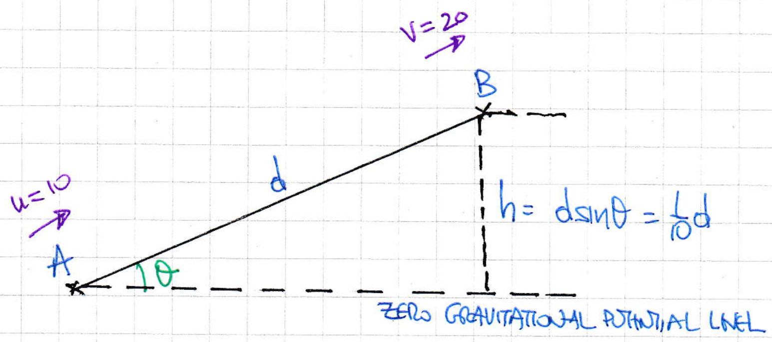
$D - 400 - 1300g\sin\theta = 1300a$

$3000 - 400 - 130g = 1300a$

$1326 = 1300a$

$a = 1.02\text{ ms}^{-2}$

b) NEXT WE LOOK AT AN ENERGY DIAGRAM – NOTE ACCELERATION IS NOT CONSTANT




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

$$30000 = \frac{W_{IN}}{30}$$

$$\underline{\underline{W_{IN} = 900000}}$$

$$K.E_A + \cancel{PE_A} + W_{IN} - W_{OUT} = KE_B + PE_B$$

$$\frac{1}{2}(1300)10^2 + 900{,}000 - 400\times d = \frac{1}{2}(1300)30^2 + 1300g \times \frac{1}{10}d$$

$$65000 + 900\,000 - 400d = 585000 + 1274d$$

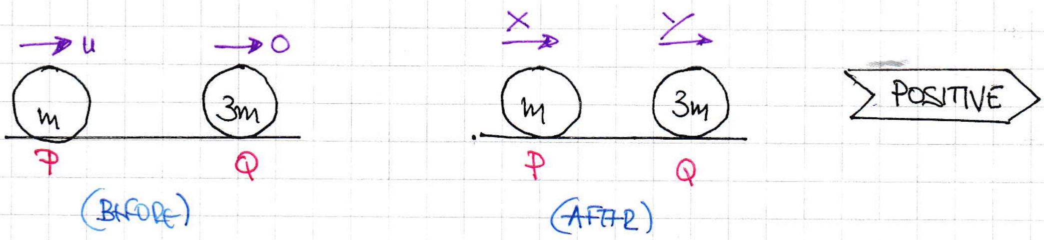
$$380000 = 1674d$$

$$d = 227.0011947\ldots$$

$$d \simeq 227\text{ m}$$

# IYGB – FMI PAPER R – QUESTION 3

a) DRAWING A BEFORE AND AFTER DIAGRAM




BY CONSERVATION OF MOMENTUM

$$mu + 0 = mX + 3mY$$

$$\boxed{X + 3Y = u}$$

BY RESTITUTION

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

$$e = \frac{Y - X}{u}$$

$$\boxed{-X + Y = eu}$$

ADDING

$$4Y = u + eu$$

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

AND USING $X = Y - eu$

$$X = \frac{1}{4}u(e+1) - eu = \frac{1}{4}u\left[(e+1) - 4e\right] = \frac{1}{4}u(1-3e)$$

$$\text{I.E } X = \frac{1}{4}u(1-3e)$$

b) AS X REVERSES DIRECTION $X < 0$, OPPOSITE TO THAT MARKED IN THE DIAGRAM

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

$$\Longrightarrow 1 - 3e < 0$$

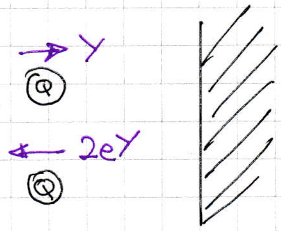
$$\Longrightarrow -3e < -1$$

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

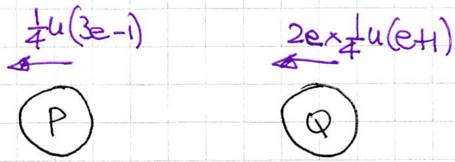
$$\therefore \quad \frac{1}{3} < e \leq 1$$

# IYGB - FM1 PAPER R - QUESTION 3

c) FIRSTLY THE COLLISION WITH THE WALL




HENCE THE CONFIGURATION IS NOW AS FOLLOWS




WE REQUIRE NOW THAT

$$\frac{1}{2}eu(e+1) > \frac{1}{4}u(3e-1)$$
$$2eu(e+1) > u(3e-1)$$
$$2e(e+1) > 3e-1$$
$$2e^2+2e > 3e-1$$
$$2e^2-e+1 > 0$$
$$e^2-\frac{1}{2}e+\frac{1}{2} > 0$$
$$\left(e-\frac{1}{4}\right)^2-\frac{1}{16}+\frac{1}{2} > 0$$
$$\left(e-\frac{1}{4}\right)^2+\frac{7}{16} > 0$$

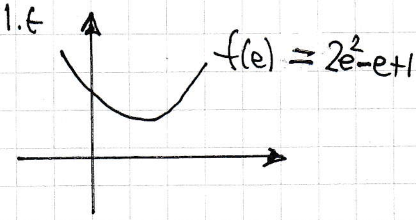
WHICH IS ALWAYS TRUE

$\therefore$ ALWAYS ANOTHER COLLISION

ALTERNATIVE

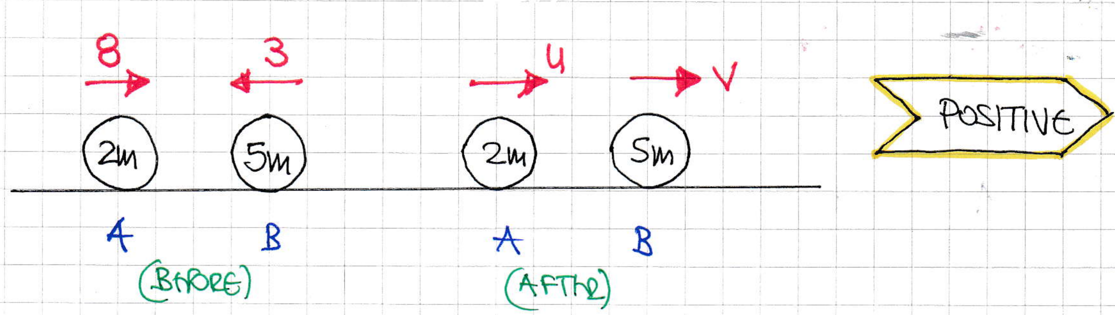
$$b^2-4ac = (-1)^2-4\times2\times1$$
$$= 1-8$$
$$= -7$$

I.E



# IYGB – FM1 PAPER R – QUESTION 4

USING A STANDARD COLLISION DIAGRAM

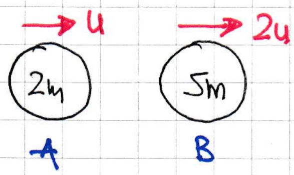



FIRST LET US NOTE THAT B HAS TO MOVE TO THE "RIGHT"

( MOMENTUM BEFORE $= 16m - 15m = +m$ )

HENCE WE HAVE THE FOLLOWING CASES

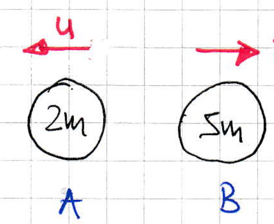
- "BOTH TO THE RIGHT"




$$\Rightarrow \quad 2mu + 10mu = m$$
$$\Rightarrow \quad 12mu = m$$
$$\Rightarrow \quad u = \frac{1}{12}$$

$\therefore$ SPEED OF B $= 2 \times \frac{1}{12} = \frac{1}{6} = 0.167 \text{ ms}^{-1}$

- "BOTH REBOUND, WITH B THE FASTEST"

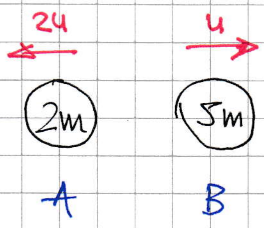



$$\Rightarrow \quad -2mu + 10mu = m$$
$$\Rightarrow \quad 8mu = m$$
$$\Rightarrow \quad u = \frac{1}{8}$$

$\therefore$ SPEED OF B $= 2 \times \frac{1}{8} = \frac{1}{4} = 0.25 \text{ ms}^{-1}$

# IYGB – FM1 PAPER R – QUESTION 4

- "BOTH REBOUND, WITH A THE FASTEST"




$$\Longrightarrow -4mu + 5mu = m$$

$$\Longrightarrow mu = m$$

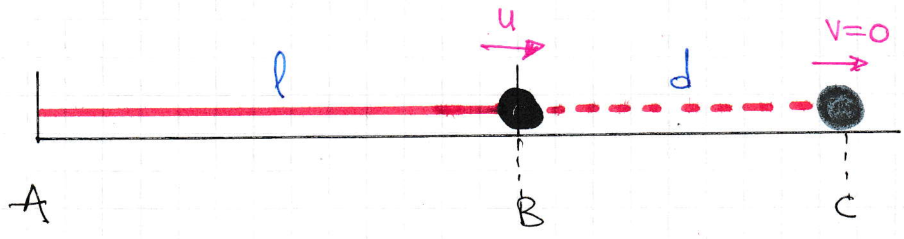
$$\Longrightarrow u = 1$$

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

$\therefore$ THE POSSIBLE SPEEDS OF B ARE 0.167, 0.25, 1

# IYGB - FM1 PAPER R - QUESTION 5

## DRAWING AN ENERGY DIAGRAM




$\mu = 0.8$
$l = 0.5$
$u = 1.4$

$$\Rightarrow KE_B + \cancel{PE_B} + \cancel{EE_B} + \cancel{W_{IN}} - W_{OUT} = \cancel{KE_C} + \cancel{PE_C} + EE_C$$

$$\Rightarrow \frac{1}{2}mu^2 - (\mu mg)d = \frac{\lambda}{2l}d^2$$

$$\Rightarrow \frac{1}{2}\cancel{m}u^2 - \mu \cancel{m}gd = \frac{2\cancel{m}g}{2l}d^2$$

$$\Rightarrow \frac{1}{2}u^2 - \frac{4}{5}gd = 2gd^2$$

$$\Rightarrow 0.98 - 7.84d = 19.6d^2$$

$\times 100$

$$\Rightarrow 98 - 784d = 1960d^2$$

$\div 98$

$$\Rightarrow 1 - 8d = 20d^2$$

$$\Rightarrow 20d^2 + 8d - 1 = 0$$

$$\Rightarrow (2d+1)(10d-1) = 0$$

$$\Rightarrow d = \begin{cases} 1/10 = 0.1 \\ \cancel{-\frac{1}{2}} \end{cases}$$

## FINALLY AT POINT C, $d = 0.1$, IE EXTENSION $0.1$

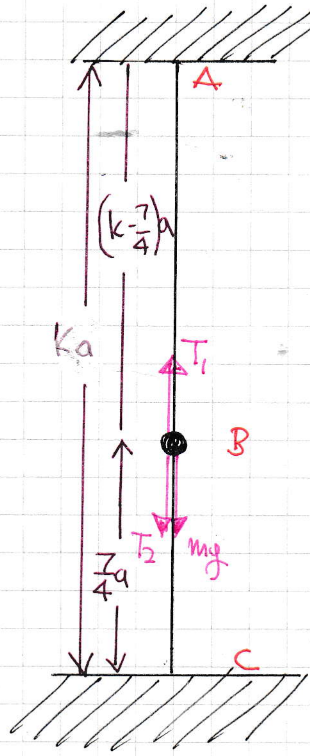
$$\text{TENSION} = \frac{\lambda}{l}x = \frac{2mg}{0.5} \times 0.1 = 0.4mg$$

$$\text{FRICTION} = \mu mg = 0.8mg$$

PERMANENT STOP

# IYGB - FM1 PAPER R - QUESTION 6

STARTING WITH A DIAGRAM




$T_1 = T_2 + mg$

BY HOOKE'S LAW

$$\Longrightarrow \frac{(2mg)\left(k-\frac{7}{4}\right)a}{a} = \frac{(2mg)\left(\frac{7}{4}a\right)}{a} + mg$$

$$\Longrightarrow 2\left(k-\frac{7}{4}\right) = 2\times\frac{7}{4} + 1$$

$$\Longrightarrow 2k - \frac{7}{2} = \frac{7}{2} + 1$$

$$\Longrightarrow 2k = 8$$

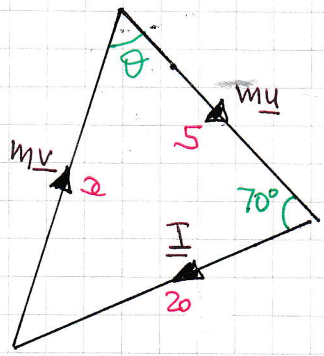
$$\Longrightarrow k = 4$$

# IYGB - FM1 PAPER R - QUESTION 7

LOOKING AT THE VECTOR DIAGRAM

$$\underline{I} = m\underline{v} - m\underline{u}$$

$$m\underline{v} = \underline{I} + m\underline{u}$$




$m = 0.2$

BY THE COSINE RULE

$$\Longrightarrow x^2 = 5^2 + 20^2 - 2 \times 5 \times 20 \cos 70$$

$$\Longrightarrow x^2 = 425 - 200\cos 70$$

$$\Longrightarrow |m\underline{v}|^2 = 425 - 200\cos 70$$

$$\Longrightarrow \frac{1}{25}|\underline{v}|^2 = 25(17 - 8\cos 70)$$

$$\Longrightarrow |\underline{v}|^2 = 625(17 - 8\cos 70)$$

$$\Longrightarrow |\underline{v}| = 25\sqrt{17 - 8\cos 70}$$

$$\Longrightarrow \text{SPEED} \simeq 94.4 \text{ ms}^{-1}$$

BY THE SINE RULE

$$\frac{\sin\theta}{20} = \frac{\sin 70}{x}$$

$$\sin\theta = \frac{20\sin 70}{x} = \frac{20\sin 70}{0.2 \times 94.4\ldots} = 0.995272\ldots$$

$$\theta \simeq 84.4°$$