IYGB – FM1 PAPER O – QUESTION 1

- BY CONSERVATION OF MOMENTUM

$$\Longrightarrow m\begin{pmatrix}6\\-2\end{pmatrix} + \lambda m\begin{pmatrix}-3\\3\end{pmatrix} = (m+\lambda m)\begin{pmatrix}k\\k\end{pmatrix}$$

- DIVIDING BY m

$$\Longrightarrow \begin{pmatrix}6\\-2\end{pmatrix} + \lambda\begin{pmatrix}-3\\3\end{pmatrix} = (1+\lambda)\begin{pmatrix}k\\k\end{pmatrix}$$

$$\Longrightarrow \begin{pmatrix}6-3\lambda\\-2+3\lambda\end{pmatrix} = \begin{pmatrix}k(1+\lambda)\\k(1+\lambda)\end{pmatrix}$$

- THUS WE HAVE

$$\left.\begin{aligned}6-3\lambda &= k(\lambda+1)\\3\lambda-2 &= k(\lambda+1)\end{aligned}\right\} \Longrightarrow \begin{aligned}6-3\lambda &= 3\lambda-2\\8 &= 6\lambda\\\lambda &= \tfrac{4}{3}\end{aligned}$$

- FINALLY WE HAVE

$$\Longrightarrow 6-3\lambda = k(\lambda+1)$$

$$\Longrightarrow 6-3\left(\tfrac{4}{3}\right) = k\left(\tfrac{4}{3}+1\right)$$

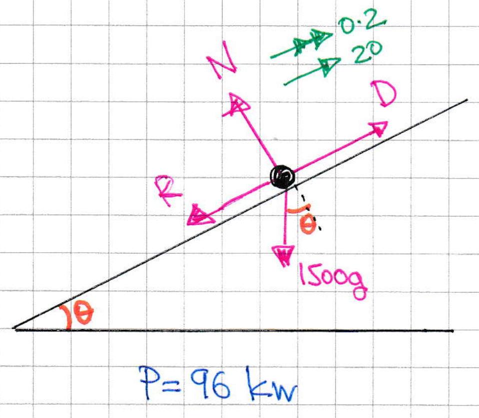
$$\Longrightarrow 6-4 = \tfrac{7}{3}k$$

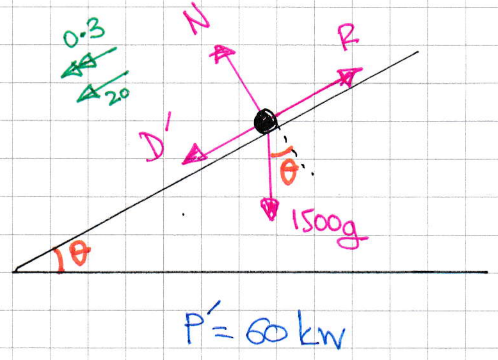
$$\Longrightarrow 2 = \tfrac{7}{3}k$$

$$\Longrightarrow k = \tfrac{6}{7}$$

IYGB - FM1 PAPER O - QUESTION 2

DRAW SEPARATE DIAGRAM FOR THE UPHILL & DOWNHILL MOTION





FIRSTLY CALCULATE THE TRACTIVE (DRIVING) FORCE IN EACH CASE

$\Rightarrow P = Dv$

$\Rightarrow 96000 = D \times 20$

$\Rightarrow D = 4800$

$\Rightarrow P' = D'v'$

$\Rightarrow 60000 = D' \times 20$

$\Rightarrow D' = 3000$

NEXT WRITE THE EQUATION OF MOTION IN EACH CASE

$\Rightarrow D - R - 1500g\sin\theta = ma$

$\Rightarrow 4800 - R - 1500g\sin\theta = 1500 \times 0.2$

$\Rightarrow 4500 = R + 1500g\sin\theta$

$\Rightarrow D' + 1500g\sin\theta - R = ma'$

$\Rightarrow 3000 + 1500g\sin\theta - R = 1500 \times 0.3$

$\Rightarrow 2550 = R - 1500g\sin\theta$

ADDING THE EQUATIONS YIELDS

$7050 = 2R$

$R = 3525 \text{ N}$

SUBTRACTING THE EQUATIONS GIVES

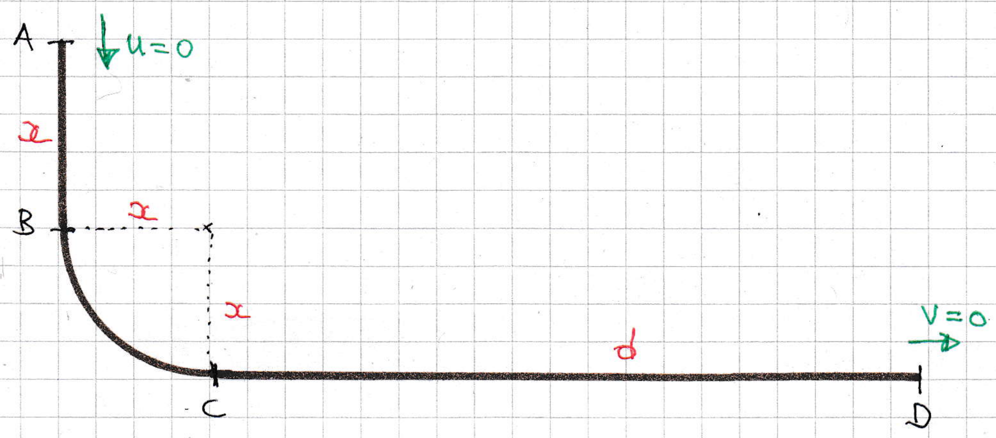
$1950 = 3000g\sin\theta$

$\sin\theta = \frac{13}{196}$

$\theta \approx 3.80°$

IYGB - FM1 PAPER O - QUESTION 3

START BY OBTAINING THE COEFFICIENT OF FRICTION – OR THE CONSTANT FRICTIONAL FORCE



TAKING THE LEVEL OF "CD" AS THE ZERO GRAVITATIONAL POTENTIAL LEVEL

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

$$\Longrightarrow mg(2x) - F \times d = 0$$

$$\Longrightarrow Fd = 2mgx$$

NOW BY ENERGIES AGAIN FROM A TO THE MIDPOINT OF CD

$$\Longrightarrow \cancel{KE_A} + PE_A + \cancel{W_{IN}} - W_{OUT} = KE_M + \cancel{PE_M}$$

$$\Longrightarrow mg(2x) - F \times \frac{1}{2}d = \frac{1}{2}mv^2$$

$$\Longrightarrow 4mgx - Fd = mv^2$$

$$\Longrightarrow 4mgx - 2mgx = mv^2$$

$$\Longrightarrow 2mgx = mv^2$$

$$\Longrightarrow v^2 = 2gx$$

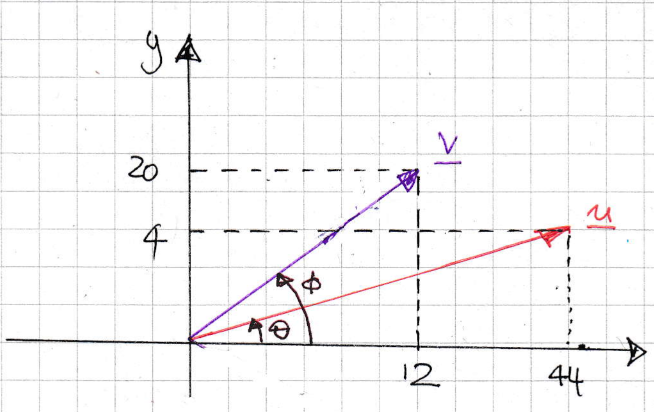
$$\Longrightarrow |v| = \sqrt{2gx}$$

IYGB - FM1 PAPER O - QUESTION 4

a) USING $\underline{I} = m\underline{v} - m\underline{u}$

$$\Rightarrow -8\underline{i} + 4\underline{j} = 0.25(12\underline{i} + 20\underline{j}) - 0.25\underline{u}$$
$$\Rightarrow -32\underline{i} + 16\underline{j} = 12\underline{i} + 20\underline{j} - \underline{u}$$
$$\Rightarrow \underline{u} = 44\underline{i} + 4\underline{j}$$
$$\Rightarrow |\underline{u}| = \sqrt{44^2 + 4^2} = \sqrt{1952}$$
$$\Rightarrow |\underline{u}| \simeq 44.2 \text{ ms}^{-1}$$

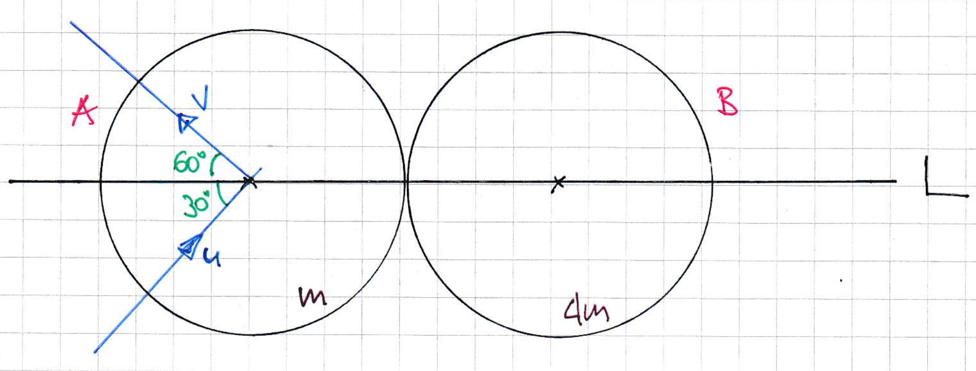
b) LOOKING AT THE DIAGRAM BELOW



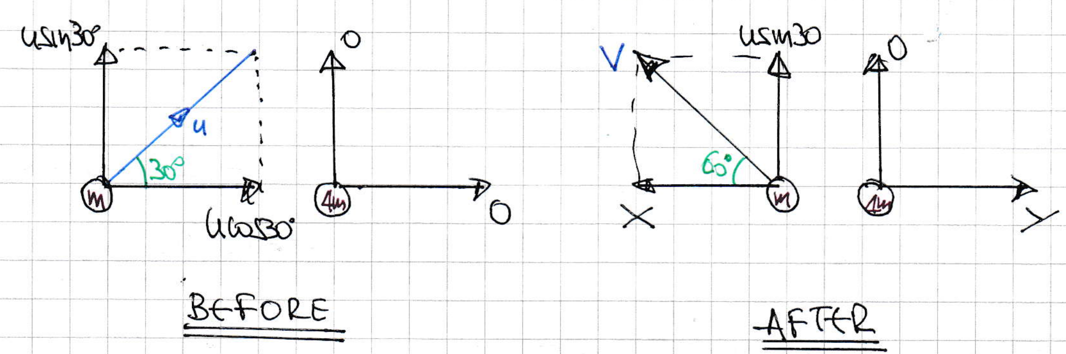
$$\text{deflection angle} = \phi - \theta$$
$$= \arctan\left(\frac{20}{12}\right) - \arctan\left(\frac{4}{44}\right)$$
$$= \arctan\left(\frac{5}{3}\right) - \arctan\left(\frac{1}{11}\right)$$
$$= 59.036...^\circ - 5.1944...^\circ$$
$$\simeq 53.84$$

IYGB - FM1 PAPER O - QUESTION 5

DRAWING A STANDARD OBLIQUE COLLISION DIAGRAM



DRAW BEFORE & AFTER & NOTE THAT THERE IS NO MOMENTUM EXCHANGE IN A DIRECTION PERPENDICULAR TO "L"



BY CONSERVATION OF MOMENTUM ALONG "L"

$$\cancel{m}u\cos 30° + 0 = -\cancel{m}X + 4\cancel{m}Y$$

$$\boxed{-X + 4Y = \frac{\sqrt{3}}{2}u} \quad \text{— (I)}$$

BY RESTITUTION ALONG "L"

$$e = \frac{\text{SEP}}{\text{APP}} \implies e = \frac{X+Y}{u\cos 30°}$$

$$\implies X + Y = eu\cos 30$$

$$\implies \boxed{X + Y = \frac{\sqrt{3}}{2}eu} \quad \text{— (II)}$$

IYGB – FM1 PAPER O – QUESTION 5

AS THERE IS NO MOMENTUM EXCHANGE PERPENDICULAR TO "L"

$$X = V\cos 60$$
$$\boxed{X = \tfrac{1}{2}V} \text{ — (III)}$$

& BY GEOMETRY

$$V\sin 60 = u\sin 30$$
$$\tfrac{\sqrt{3}}{2}V = \tfrac{1}{2}u$$
$$\boxed{u = \sqrt{3}\,V} \text{ — (IV)}$$

SOLVING (I) & (II) FOR X & Y BY ADDING

$$\Rightarrow 5Y = \tfrac{\sqrt{3}}{2}u + \tfrac{\sqrt{3}}{2}eu$$
$$\Rightarrow Y = \tfrac{\sqrt{3}}{10}u + \tfrac{\sqrt{3}}{10}eu$$

$$\Rightarrow X = \tfrac{\sqrt{3}}{2}eu - Y$$
$$\Rightarrow X = \tfrac{\sqrt{3}}{2}eu - \tfrac{\sqrt{3}}{10}u - \tfrac{\sqrt{3}}{10}eu$$
$$\Rightarrow X = \tfrac{2}{5}\sqrt{3}\,eu - \tfrac{\sqrt{3}}{10}u$$

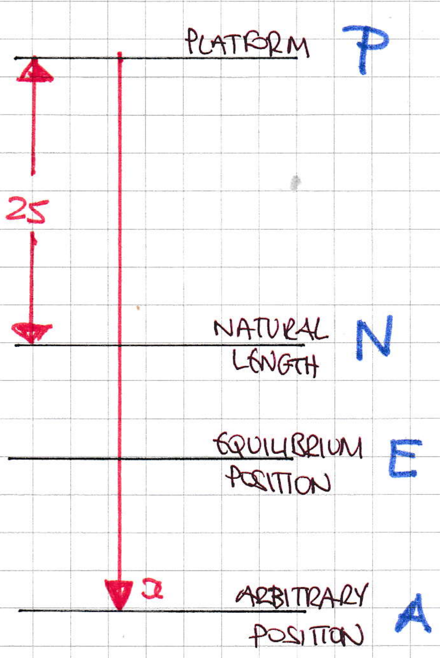
USING THIS X WITH (III) & (IV)

$$\Rightarrow X = \tfrac{1}{2}V$$
$$\Rightarrow 2X = V$$
$$\Rightarrow 2\sqrt{3}\,X = \sqrt{3}\,V$$
$$\Rightarrow 2\sqrt{3}\,X = u$$
$$\Rightarrow 2\sqrt{3}\left[\tfrac{2}{5}\sqrt{3}\,eu - \tfrac{\sqrt{3}}{10}u\right] = u$$
$$\Rightarrow 2\sqrt{3}\left(\tfrac{2}{5}\sqrt{3}\,e - \tfrac{\sqrt{3}}{10}\right) = 1$$
$$\Rightarrow \tfrac{12}{5}e - \tfrac{3}{5} = 1$$
$$\Rightarrow 12e - 3 = 5$$
$$\Rightarrow 12e = 8$$

$$\therefore e = \tfrac{2}{3}$$

IYGB - FM1 PAPER O - QUESTION 6

a) BY CONSIDERING ENERGIES TAKING THE LEVEL OF "P" AS THE ZERO GRAVITATIONAL POTENTIAL WE OBTAIN



$$\Rightarrow \cancel{KE_P} + \cancel{PE_P} + \cancel{EE_P} = KE_A + PE_A + EE_A$$

(IGNORED W_{IN} & W_{OUT} HERE)

$$\Rightarrow 0 = \frac{1}{2}mv^2 - mgx + \frac{\lambda}{2l}(x-l)^2$$

$$\Rightarrow 2mgx - \frac{\lambda}{l}(x-l)^2 = mv^2$$

$$\Rightarrow 1470x - 147(x-25)^2 = 75v^2$$

$$\Rightarrow 1470x - 147(x^2-50x+625) = 75v^2$$

$$\Rightarrow 1470x - 147x^2 + 7350x - 91875 = 75v^2$$

$$\Rightarrow 75v^2 = -147x^2 + 8820x - 91875 \quad \div 3$$

$$\Rightarrow 25v^2 = -49x^2 + 2940x - 30625$$

AS REQUIRED

$m = 75$
$\lambda = 3675$
$l = 25$

NOW MAXIMUM VALUE OF x WILL OCCUR WHEN $v=0$

$$\Rightarrow 0 = -49x^2 + 2940x - 30625$$

$$\Rightarrow 49x^2 - 2940x + 30625 = 0 \quad \div 49$$

$$\Rightarrow x^2 - 60x + 625 = 0$$

$$\Rightarrow (x-30)^2 - 900 + 625 = 0$$

$$\Rightarrow (x-30)^2 = 275$$

$$\Rightarrow x - 30 = \begin{cases} 5\sqrt{11} \\ -5\sqrt{11} \end{cases}$$

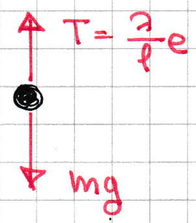
$$\Rightarrow x = \begin{cases} 30 + 5\sqrt{11} \approx 46.58\text{ m} \\ 30 - 5\sqrt{11} \approx \cancel{13.42} \end{cases}$$

(STRING WILL SLACK)

IYGB - FM1 PAPER D - QUESTION 6

b) NOW FOR MAX SPEED $\Rightarrow$ ZERO ACCELERATION

$\Rightarrow$ EQUILIBRIUM

$\Rightarrow$ 

$\Rightarrow \frac{\lambda}{\ell}e = mg$

$\Rightarrow e = \frac{\ell mg}{\lambda}$

$\Rightarrow e = \frac{25 \times 75 \times 9.8}{3675}$

$\Rightarrow e = 5$

$\Rightarrow x = 25 + 5 = 30$

USING THE ENERGY EQUATION WITH $x = 30$

$\Rightarrow 25v^2 = -49x^2 + 2940x - 30625$

$\Rightarrow 25v^2 = -49 \times 30^2 + 2940 \times 30 - 30625$

$\Rightarrow 25v^2 = 13475$

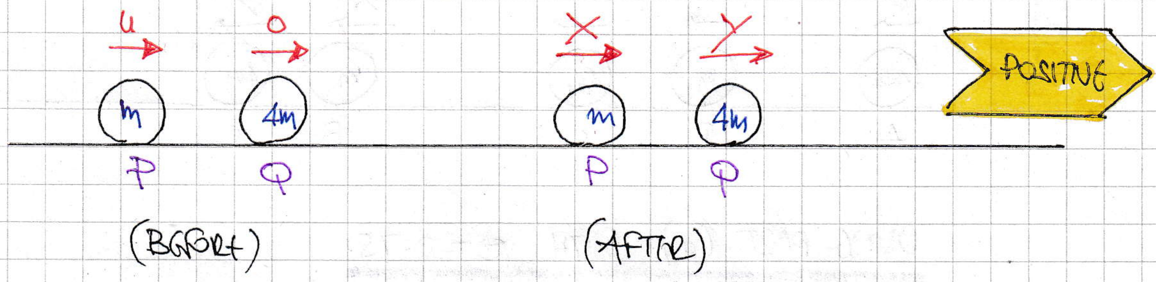
$\Rightarrow v^2 = 539$

$\Rightarrow |v| \approx 23.22 \text{ ms}^{-1}$

$(7\sqrt{11})$

IYGB – FM1 PAPER O – QUESTION 7

a)



BY CONSERVATION OF MOMENTUM

$\Rightarrow mu + 0 = mX + 4mY$

$\Rightarrow X + 4Y = u$

BY RESTITUTION

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

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

$-X + Y = eu$

ADDING THE EQUATIONS GIVES

$5Y = u + eu$

$5Y = u(1+e)$

$Y = \frac{1}{5}u(e+1)$ //

AND $Y = X + eu$

$\frac{1}{5}eu + \frac{1}{5}u = X + eu$

$X = \frac{1}{5}u - \frac{4}{5}eu$

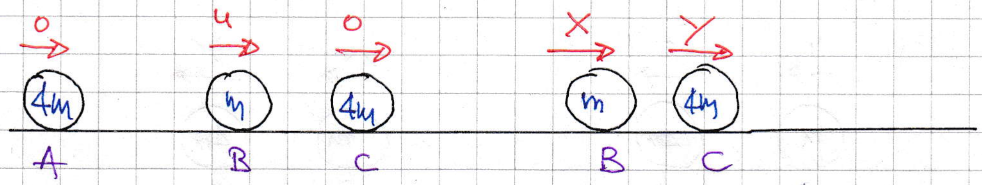
$X = \frac{1}{5}u(1 - 4e)$

$\therefore$ SPEED IS $|X| = \frac{1}{5}u(4e-1)$

"BACKWARDS" //

IYGB - FM1 PAPER O - QUESTION 7

b)

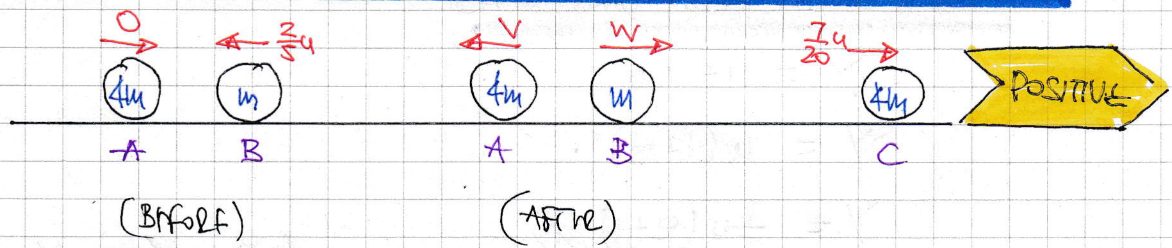


USING PART (a) WITH $e = 0.75$

$$X = \frac{1}{5}u\left(1 - 4(0.75)\right) = -\frac{2}{5}u \quad \text{(BACKWARDS)}$$
$$Y = \frac{1}{5}u\left(1 + 0.75\right) = \frac{7}{20}u$$

$\therefore$ AS B REBOUNDS ANOTHER COLLISION BETWEEN A & B

NOW THE COLLISION BETWEEN A & B AND ITS AFTERMATH



BY CONSERVATION OF MOMENTUM

$$0 - \frac{2}{5}mu = -4mV + mW$$
$$W - 4V = -\frac{2}{5}u$$

BY RESTITUTION

$$e = \frac{SEP}{APP}$$
$$0.75 = \frac{V + W}{\frac{2}{5}u}$$
$$V + W = \frac{3}{10}u$$
$$4V + 4W = \frac{6}{5}u$$

ADDING THE EQUATIONS

$$5W = \frac{4}{5}u$$
$$W = \frac{4}{25}u$$
(TO THE "RIGHT")

AS $\frac{4}{25}w < \frac{7}{20}u$ NO MORE COLLISIONS BETWEEN B & C