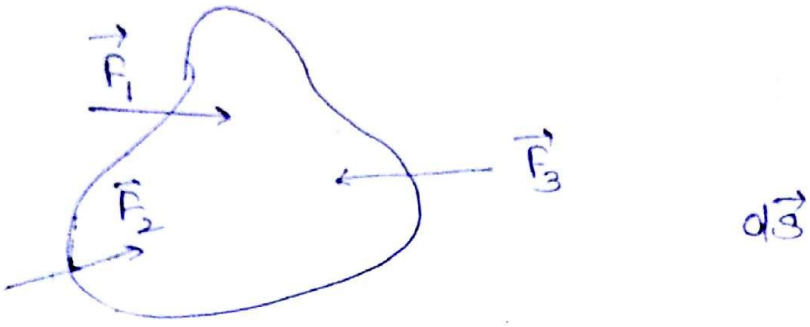
Work Done

It is a scalar quantity and define as

$$\vec{F} \cdot d\vec{s} = W$$



$$W_{F_1} = \vec{F}_1 \cdot d\vec{s}$$

$$W_{F_2} = \vec{F}_2 \cdot d\vec{s}$$

$$W_{F_3} = \vec{F}_3 \cdot d\vec{s}$$

Total work done

$$TWD = W_{F_1} + W_{F_2} + W_{F_3}$$

$$= \left[\vec{F}_1 + \vec{F}_2 + \vec{F}_3\right] \cdot d\vec{s}$$

$$TWD = \vec{F}_R \cdot d\vec{s}$$

if body is in equ^m

$$TWD = 0 \quad \left[\because \vec{F}_R = 0\right]$$

Principle of Virtual Work (POVW)

(imaginary)

It states if a system (single rigid body or No. of interconnected rigid bodies) is in equ^{m} then the sum of virtual work by all the forces will be zero.

Virtual work = Force (virtual displacement)

Note →

1. using POVW we can find forces necessary to keep a system in equ^{m}.
2. If using eqn of equ^{m} is difficult then use POVW to find the unknowns easily

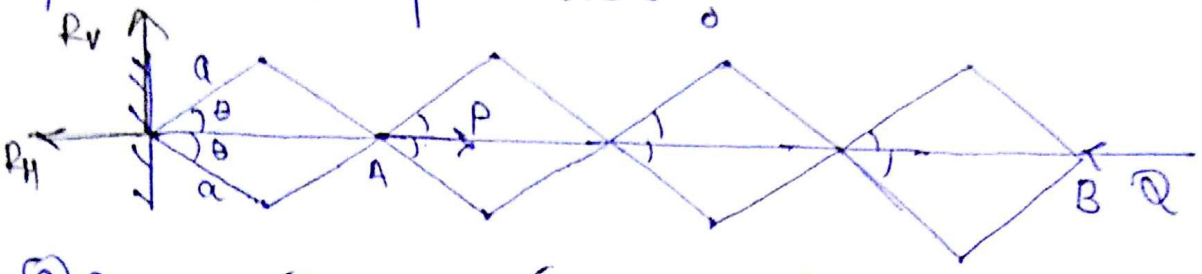
Procedure –

1. Take any fixed point in question as origin, fix coordinate axis and find the co-ordinates of all the points where forces are acting.
2. Find virtual displacement
3. Use POVW to find the unknowns.

Sign Convention:-

1. Sign Conv. for the coordinates is choosen based on the quardent in which they are lying
2. If any force is acting along +ve x-axis or +ve y-axis then take that force +ve and vise-verca.

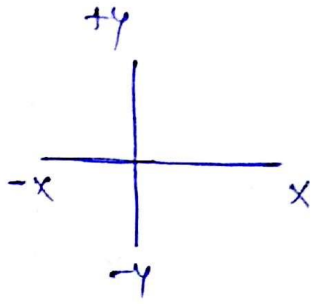
Qu:- For the lazy tong mechanism as shown in fig the relationship b/w P & Q to keep this system in equm is. ?



(a) $P = Q$ (b) $P = 2Q$ (c) $P = 3Q$ (d) $P = 4Q$

$$\Sigma \vec{F}_H = 0 \qquad R_H + Q = P$$

$$\Sigma \vec{F}_V = 0 \qquad R_V = 0$$



apply POV W

1. $x_A = 2a \cos\theta$

$x_B = 8a \cos\theta$

2. $\partial x_A = -2a \sin\theta \, \partial\theta$

$\partial x_B = -8a \sin\theta \, \partial\theta$

} Virtual displacement

3. $(V.W)_P + (V.W)_Q = 0$

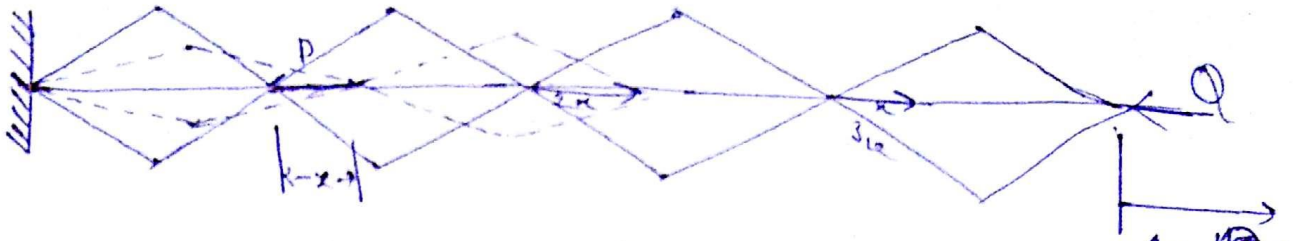
$(+P)(-2a \sin\theta \partial\theta) + (-Q)(-8a \sin\theta \partial\theta) = 0$

$2P = 8Q$

$\boxed{P = 4Q}$

$R_H + Q = P = 4Q$

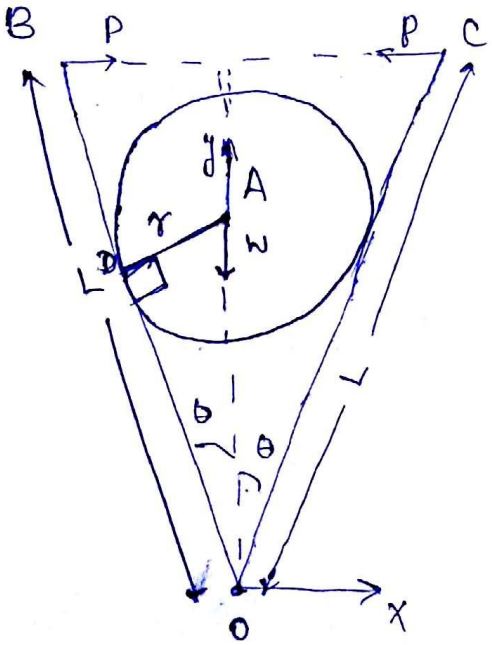
$R_H = 3Q$



$$P(x) + (-Q4x) = 0$$

$$P = 4Q$$

Ques. A sphere of weight W ~~at various~~ and radius R is supported by 2 Rods of length l as shown in fig. The value of P to keep the system in equ^m is



Soln $\therefore y_A = + l \operatorname{Cosec} \theta$

$x_B = - L \sin\theta$

$x_C = + L \sin\theta$

In $\triangle AOD$

$$\sin\theta = \frac{r}{y_A}$$

$$y_A = \frac{r}{\sin\theta}$$

virtual displacements

2. $\partial y_A = -r \operatorname{Cosec}\theta \cot\theta \, \partial\theta$

$\partial x_B = -L \cos\theta \, d\theta$

$\partial x_c = +L \cos\theta \, \partial\theta$

3. $(-w)(\partial y)_A + (P)(\partial x)_B + (-P)(\partial x_c) = 0$

$(-w)(-r \operatorname{Cosec}\theta \cot\theta \partial\theta) + P(-L\cos\theta \, \partial\theta)$

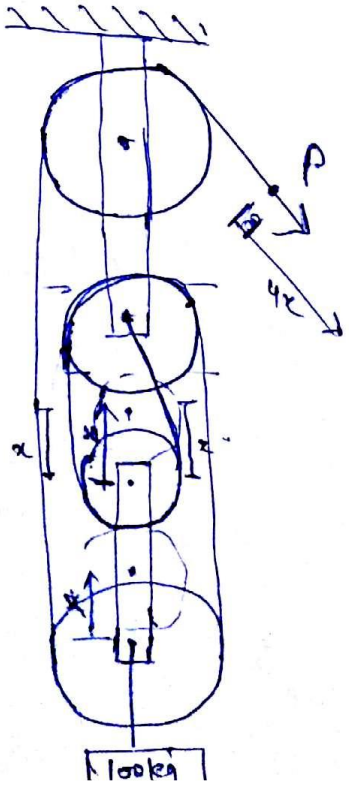
$+ (-P)(L\cos\theta \, \partial\theta) = 0$

$wr \times \frac{1}{\sin\theta} \times \frac{\cos\theta}{\sin\theta} = 2PL\cos\theta$

$$P = \frac{wr}{2L\sin^2\theta}$$

7.10

2.g. 103

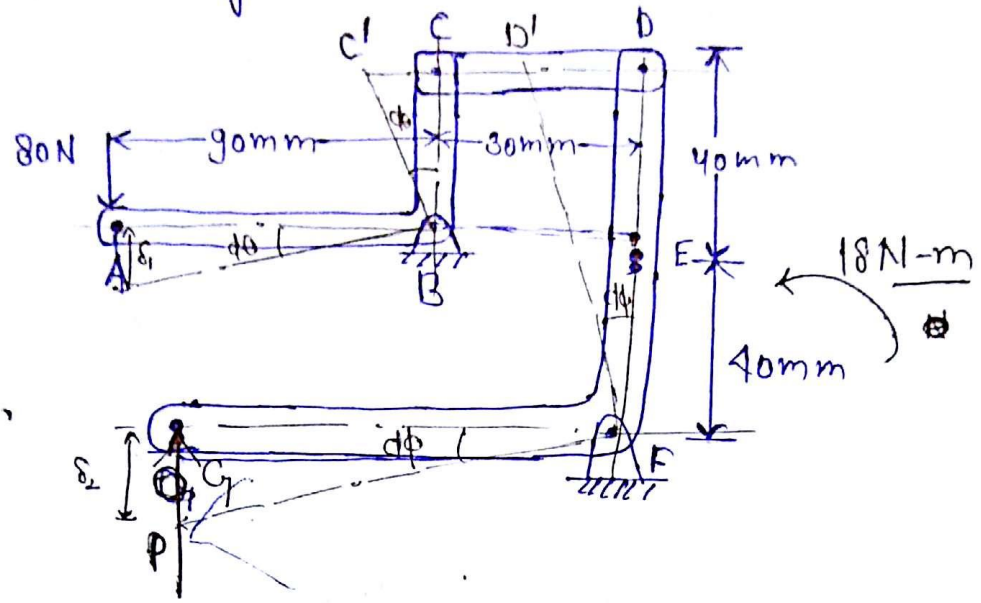


Point P will move 4x if pully move x

$P \times 4x - (1000 \times 10 \times x) = 0$

$P = \frac{1000}{4} = 250\ N$

Q Determine vertical force P that must be applied at C_1 to maintain the equm of the linkage.



$$CC' = DD'$$

$$40\,d\theta = 80\,d\phi$$

$$\Rightarrow d\phi = \frac{d\theta}{2}$$

$$80 \times 90\,d\theta + (-P \times 120\,d\phi)$$

$$80 \times 90\,d\theta = P \times 120 \frac{d\theta}{2}$$

$$\boxed{P = 120\ N}$$

if a moment of 18 N-m is acting in anticlock wise dirn one the link DFC of previous question the what should be the value of P applied at C.

work done by moment torque $= T d\theta$

$$= \int_{\theta_1}^{\theta_2} T d\theta$$

after applied 18 N-m on link DFC,

$$80 \times 0.090\, d\theta + 18 \times d\phi - P \times 0.120\, d\phi = 0$$

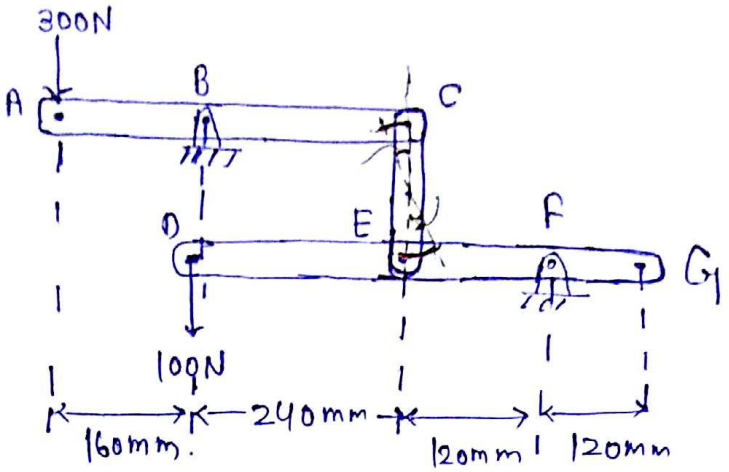
$$80 \times 0.09 \times d\theta + 18 \frac{d\theta}{2} - P \times 0.12 \frac{d\theta}{2} = 0$$

$$\boxed{P = 270 \text{ N}}$$

Prob. (H.W) Determine the couple M that must be applied to member DEFC, to maintain the equm of linkage of the previous question where load of 80 N at A and moment of 18 N-m of member DEFC,.

32.4

Ques. Determine the vertical force P that must be applied at G_1 to maintain the equm of linkage shown below.



Ans 60N ↓

Ques Determine the couple M that must be applied member DEFG to maintain the equm of the linkage of previous question (Ans 12 N-m CW)