Principle of Virtual WORK

In statics, we are usually concerned with eqb of rigid bodies.

We are using $\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M = 0$ & Lami's theorem.

to get Reaction, Tension etc.

Method of Principle virtual work is another method to find out such Reaction, Tension etc of a eqb. system of rigid bodies

Virtual WORK

$$Work = F \times s \times \cos\theta$$

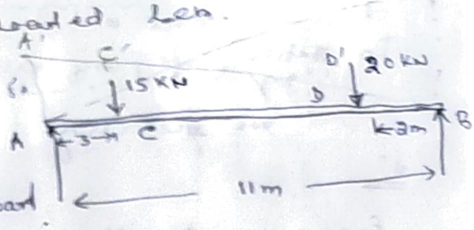
s → distance / displacement

$$\text{Virtual work} = F \times \delta s$$

δs → Virtual displacement

If, (Σ Virtual work $= 0$), then system /configuration is in eqb.

Ex-1: Using the method of virtual work, determine the reaction at support A & B of the transversely loaded beam.



Sol^n

Hold the beam at B' & Push AB at A' upward.

$\therefore \delta A$ = displacement of A = AA'

$\delta C = CC'$

$\delta D = DD'$

$\delta B = 0$.

Applying virtual work in the configuration,

$R_A(\delta A) + 15\underbrace{(-\delta C)} + 20(-\delta D) + R_B \times 0 = 0$

↳ due to displacement is opposite to Force.

From $AA'B\ \Delta$

$$\frac{\delta A}{11} = \frac{\delta D}{2} = \frac{\delta C}{8}$$

$\Rightarrow R_A \times \frac{11}{2}(\delta D) - 15\left(\frac{8}{2}\right)\delta D - 20(\delta D) = 0$

$\Rightarrow R_A = 14.55$ KN (Ans)

Simillarly to determine $R_B = ?$

~~Keeping~~ Holding 'A', Push B to B'

$\therefore$ Applying virtual work ~~diffrent~~ in the configuration,

$\therefore R_B \times (\delta B_2) + 20(\delta D_2) + 15(\delta C_2) = 0$

$$\left[\frac{\delta C_2}{3} = \frac{\delta B_2}{11} = \frac{\delta D_2}{9}\right]$$

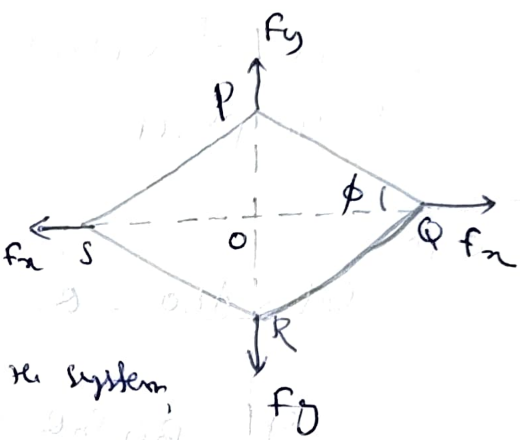
$\Rightarrow R_B \times \frac{11}{3}(\delta C_2) - 20 \times 3(\delta C_2) - 15 \times \delta C_2 = 0$

$\Rightarrow R_B = 20.45$ (Ans)

To cross-check use method of moments

Exp. 2 four weightless bars of length a are hinged together at their junctions and form the shape of rhombus, Applying virtual work, Find the relation between F_x & F_y

Sol^n



From the geometry,

$$OP = OR = a \sin\phi$$

$$OQ = OS = a \cos\phi$$

Allowing differential, virtual displacement to the system,

$$\delta(OP) = a\cos\phi \cdot \delta\phi$$

$$\delta(OQ) = -a\sin\phi \cdot \delta\phi$$

Applying Principle of virtual work to the system.

$$2F_y \times \delta(OP) + 2F_x(OQ) = 0$$

$$\Rightarrow 2F_y \times a\cos\phi \cdot (\delta\phi) + 2F_x(-a\sin\phi)\cdot\delta\phi = 0$$

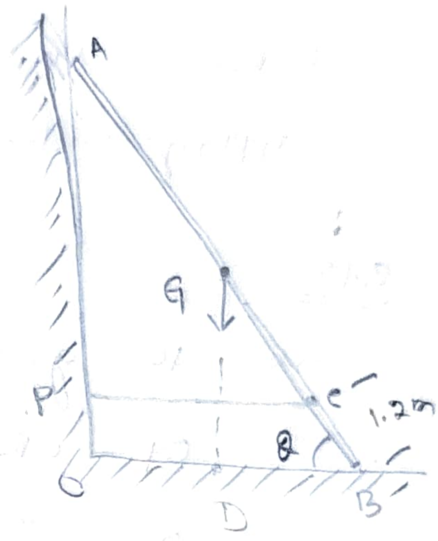
$$\Rightarrow \tan\phi = \frac{F_y}{F_x}$$

Exp-3

ladder = AB = 4.4 mt.

wt of ladder = 250 N

Rope PC is tied with the wall, Using Principle of virtual work determine the tension of string (PC)



Soln

Let $\angle ABO = \theta$.

$\therefore y_G = BG \sin\theta = \frac{4.4}{2} \sin\theta = 2.2 \sin\theta$

$PC = x_c = AC \cos\theta = 3.2 \cos\theta$

Applying differential displacement,

(Floor friction less)

$\delta y_G = 2.2 \cos\theta.(\delta\theta)$

$\delta x_c = -3.2 \sin\theta(\delta\theta)$

Now apply principle of virtual work

$250 (\delta y_G) + F_{CP} \times (\delta x_c) = 0$

$\Rightarrow 250(2.2 \cos\theta) - F_{CP} \times 3.2 \sin\theta.(\delta\theta) = 0$

$\Rightarrow F_{CP} = 171.87 \cot\theta$

when $\theta = 65$.

$F_{CP} = 80.15$ N

Ans