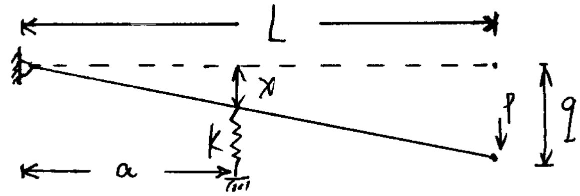
(1) Solution:

(a)

$$V = -p \cdot q$$

$$U = \frac{1}{2} k x^2$$



$$\left(\frac{x}{q} = \frac{a}{L} \Rightarrow x = \frac{qa}{L} \right)$$

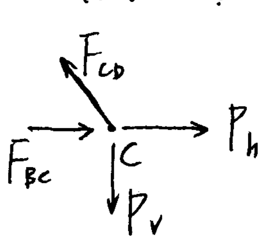
$$\Pi = U + V = \frac{1}{2} k \left(\frac{qa}{L}\right)^2 - pq$$

$$\frac{\partial \Pi}{\partial q} = 0 \Rightarrow kq\frac{a^2}{L^2} = p$$

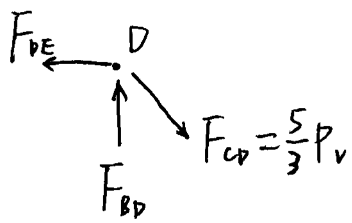
$$\Rightarrow \underline{q = \frac{P}{K} \cdot \frac{L^2}{a^2}}$$

(b) There is 1 degree-of-freedom, which is q in this case.

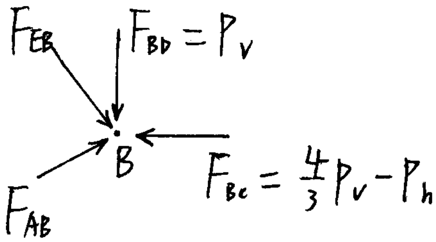
(2) Solution:



$$\begin{cases} \frac{3}{5} F_{CD} = P_v \Rightarrow F_{CD} = \frac{5}{3} P_v \\ -F_{BC} + \frac{4}{5} F_{CD} = P_h \Rightarrow F_{BC} = \frac{4}{3} P_v - P_h \end{cases}$$



$$\begin{cases} F_{DE} = \frac{4}{5} \cdot F_{CD} = \frac{4}{5} \cdot \frac{5}{3} P_v = \frac{4}{3} P_v \\ F_{BD} = \frac{3}{5} \cdot F_{CD} = \frac{3}{5} \cdot \frac{5}{3} P_v = P_v \end{cases}$$



$$\begin{cases} \frac{4}{5}F_{AB} + \frac{3}{5}F_{EB} = F_{BC} = \frac{4}{3}P_v - P_h \\ \frac{3}{5}F_{AB} - \frac{4}{5}F_{EB} = F_{BD} = P_v \end{cases}$$

$$\Rightarrow \begin{cases} F_{AB} = \frac{5}{3}P_v - \frac{4}{5}P_h \\ F_{EB} = -\frac{3}{5}P_h \end{cases}$$

Member	F_i	$\frac{\partial F_i}{\partial P_h}$	$\frac{\partial F_i}{\partial P_v}$
AB	$\frac{5}{3}P_v - \frac{4}{5}P_h$	$-\frac{4}{5}$	$\frac{5}{3}$
BC	$\frac{4}{3}P_v - P_h$	-1	$\frac{4}{3}$
CD	$\frac{5}{3}P_v$	0	$\frac{5}{3}$
BD	P_v	0	1
ED	$\frac{4}{3}P_v$	0	$\frac{4}{3}$
BE	$-\frac{3}{5}P_h$	$-\frac{3}{5}$	0

T.C.E. : $\quad C = \sum_{i=1}^{6} \int_0^{F_i} \frac{F_i L}{AE} dF_i - P_v \Delta_v - P_h \Delta_h$

Applying Principles of stationary value :

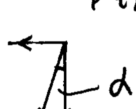
$$\frac{\partial C}{\partial P_v} = 0 \Rightarrow \frac{L}{AE} \sum_{i=1}^{6} F_i \frac{\partial F_i}{\partial P_v} = \Delta_v$$

$$\therefore \Delta_v = \frac{1}{20}\left[\frac{50}{3}\cdot\frac{5}{3} + \frac{40}{3}\cdot\frac{4}{3} + \frac{50}{3}\cdot\frac{5}{3} + 10 + \frac{40}{3}\cdot\frac{4}{3}\right] \Rightarrow \underline{\Delta_v = 5.055 \text{ mm}}$$

$$\frac{\partial C}{\partial P_h} = 0 \Rightarrow \frac{L}{AE} \sum_{i=1}^{6} F_i \frac{\partial F_i}{\partial P_h} = \Delta_h$$

$$\therefore \Delta_h = \frac{1}{20}\left[\frac{50}{3}\left(-\frac{4}{5}\right) + \frac{40}{3}(-1)\right] \Rightarrow \underline{\Delta_h = -\frac{4}{3} \text{ mm}}$$

Therefore, the magnitude of Δ will be $\Delta = \left[5.055^2 + \left(-\frac{4}{3}\right)^2\right]^{\frac{1}{2}}$ $\underline{= 5.228 \text{ mm}}$ Direction will be $\alpha = \tan^{-1}\frac{1.333}{5.055} \underline{= 14.775^\circ}$



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