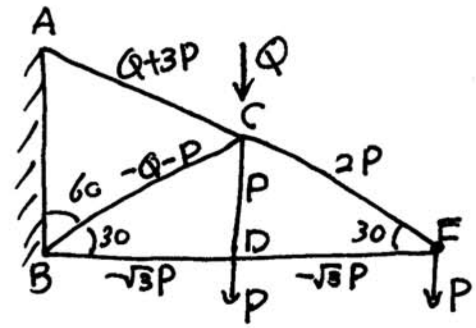
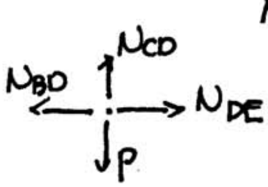
5.25



at E 

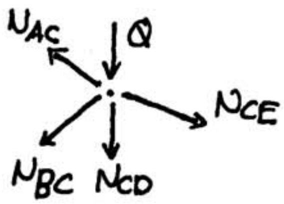
: $N_{CE}\sin 30 = P$ $\quad \underline{N_{CE} = 2P}$

$N_{DE} + N_{CE}\cos 30 = 0 \quad \underline{N_{DE} = -\sqrt{3}P}$

at D 

: $\underline{N_{CD} = P}$

$\underline{N_{BD} = N_{DE} = -\sqrt{3}P}$

at C 

$N_{CE}\cos 30 - N_{AC}\cos 30 - N_{BC}\cos 30 = 0$

$N_{AC} + N_{BC} = N_{CE} = 2P$

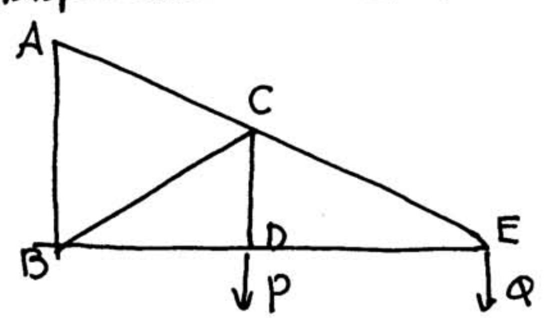
$N_{AC}\sin 30 - N_{BC}\sin 30 - Q - N_{CD} - N_{CE}\sin 30 = 0.$

$$\left.\begin{aligned} N_{AC} - N_{BC} &= 2Q + 2P + 2P \\ N_{AC} + N_{BC} &= 2P \end{aligned}\right) \quad \underline{N_{AC} = Q + 3P} \quad \underline{N_{BC} = -Q - P.}$$

$$\frac{\partial N_{AC}}{\partial Q} = 1 \qquad \frac{\partial N_{BC}}{\partial Q} = -1$$

$$\delta_Q = \frac{N_{AC}L_{AC}}{EA_{AC}} \cdot \left.\frac{\partial N_{AC}}{\partial Q}\right|_{Q=0} + \frac{N_{BC}L_{BC}}{EA} \left.\frac{\partial N_{BC}}{\partial Q}\right|_{Q=0} = \frac{3PL}{EA} \cdot 1 + \frac{PL}{EA} \cdot 1 = \frac{4PL}{EA}$$

※ Displacement at E ?

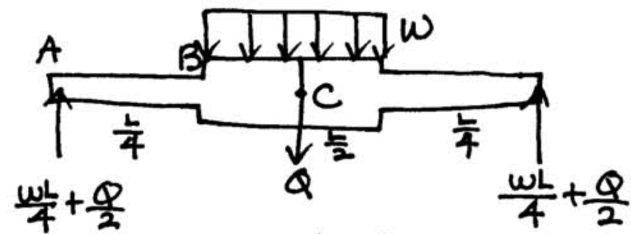


derive strain energy U

differentiate $\frac{\partial U}{\partial Q}$, then $Q = P$.

($\delta_E = 15.2\frac{PL}{EA}$)

5.26.



consider half of the beam

AB: $M_{AB} = \left(\frac{wL}{4} + \frac{Q}{2}\right)x \quad ; \frac{\partial M_{AB}}{\partial Q} = \frac{x}{2}$

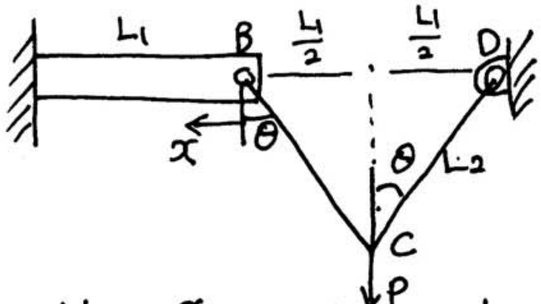
BC: $M_{BC} = \left(\frac{wL}{4} + \frac{Q}{2}\right)x - \frac{w}{2}\left(x - \frac{L}{4}\right)^2 \quad ; \frac{\partial M_{BC}}{\partial Q} = \frac{x}{2}$

$$\delta_C = 2\int_0^{L/4} \frac{M_{AB}}{EI_{AB}} \frac{\partial M_{AB}}{\partial Q}\Big|_{Q=0} dx + 2\int_{L/4}^{L/2} \frac{M_{BC}}{EI_{BC}} \frac{\partial M_{BC}}{\partial Q} dx.$$

$$= 2\int_0^{L/4} \frac{wL}{4EI_{AB}} x \cdot \frac{x}{2}\, dx + 2\int_{L/4}^{L/2} \frac{1}{EI_{BC}}\left(\frac{wL}{4}x - \frac{w}{2}\left(x - \frac{L}{4}\right)^2\right) \cdot \frac{x}{2}\, dx$$

$$= \frac{65}{6144} \frac{wL^4}{EI}.$$

5.33.



$2N\cos\theta = P \qquad N = \frac{P}{2\cos\theta}$

Beam tip force $V = N\cos\theta = \frac{P}{2}$

Bending moment $M = \frac{P}{2} \cdot x$

$\frac{\partial M}{\partial P} = \frac{x}{2}, \quad \frac{\partial N}{\partial P} = \frac{1}{2\cos\theta}$

(a) $\delta_c = \int_0^{L_1} \frac{M}{EI_1}\frac{\partial M}{\partial P} dx + 2 \cdot \frac{N \cdot L_2}{E_2 A_2} \cdot \frac{\partial N}{\partial P}$

$= \int_0^{L_1} \frac{P}{4E_1I_1} x^2 dx + \frac{P L_2}{2\cos^2\theta\, E_2 A_2} \qquad \cos\theta = \frac{\sqrt{L_2^2 - \frac{L_1^2}{4}}}{L_2}$

$= \frac{PL_1^3}{12E_1I_1} + \frac{PL_2}{2E_2A_2} \cdot \frac{L_2^2}{L_2^2 - L_1^2/4}$

(b) $\frac{PL_1^3}{12EI_1} = \frac{2PL_1}{3EA_2}, \quad \frac{r_1}{r_2} = \frac{2.5}{\sqrt{2}}$

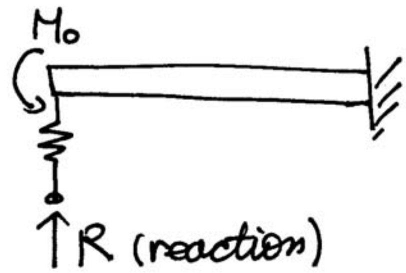
5.51 Shaft $T = T_0, \quad \frac{\partial T}{\partial T_0} = 1$

Beam $M = T_0, \quad \frac{\partial M}{\partial T_0} = 1.$

$$\theta_c = \int_0^{L_1} \frac{M}{EI}\frac{\partial M}{\partial T_0}\,dx + \int_0^{L_2} \frac{T}{GJ}\frac{\partial T}{\partial T_0}\,dx$$

$$= \int_0^{1.5} \frac{T_0}{EI}\,dx + \int_0^{1.2} \frac{T_0}{GJ}\,dx = 0.02187 + 0.03043 = 0.0523 \text{ rad}.$$

5.66.



$R = Ke$

$U_{sp} = \frac{1}{2}\cdot R\cdot e = \frac{R^2}{2K}$

$M = Rz - M_0 \qquad \frac{\partial M}{\partial R} = z$

$$\delta_R = \frac{\partial U_{sp}}{\partial R} + \frac{\partial U_{bending}}{\partial R} = 0.$$

$$= \frac{R}{K} + \int_0^L \frac{M}{EI}\cdot\frac{\partial M}{\partial R}\,dx$$

$$= \frac{R}{K} + \frac{RL^3}{3EI} - \frac{M_0L^2}{2EI} = 0 \qquad \therefore R = \frac{3M_0KL^2}{6EI + 2KL^3}$$