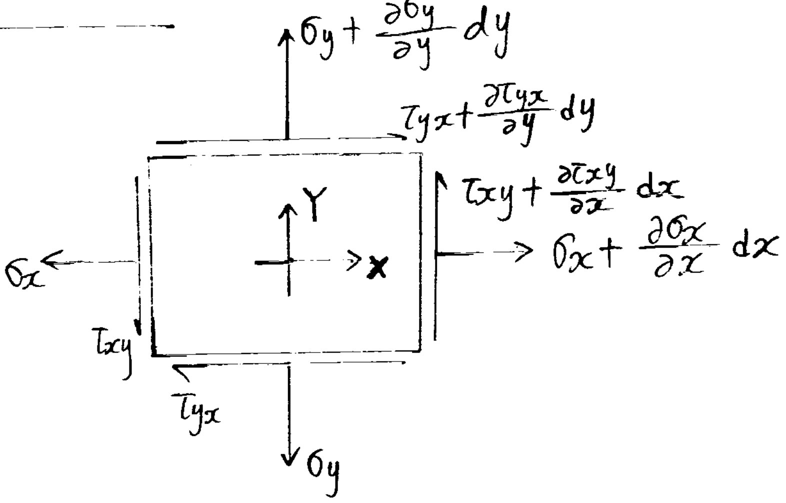
1.



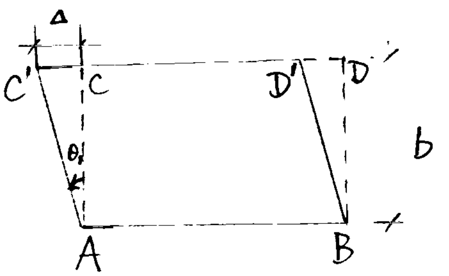
Consider the equilibrium in x-direction: $\Sigma F_x = 0$.

$$\left(\sigma_x + \frac{\partial \sigma_x}{\partial x} dx\right) dy - \sigma_x dy + \left(\tau_{yx} + \frac{\partial \tau_{yx}}{\partial y} dy\right) dx - \tau_{yx} dx + X dx dy = 0$$

$$\Rightarrow \frac{\partial \sigma_x}{\partial x} dx dy + \frac{\partial \tau_{yx}}{\partial y} dx dy + X dx dy = 0$$

$$\Rightarrow \underline{\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{yx}}{\partial y} + X = 0}$$

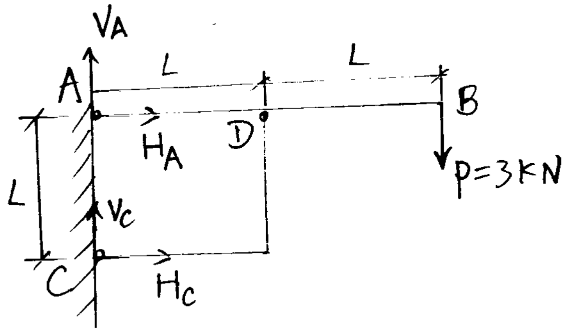
2.



Shear strain at A:

$\underline{\gamma = -\frac{\Delta}{b}}$ (negative because of θ_1 direction, equal to θ_1 in magnitude)

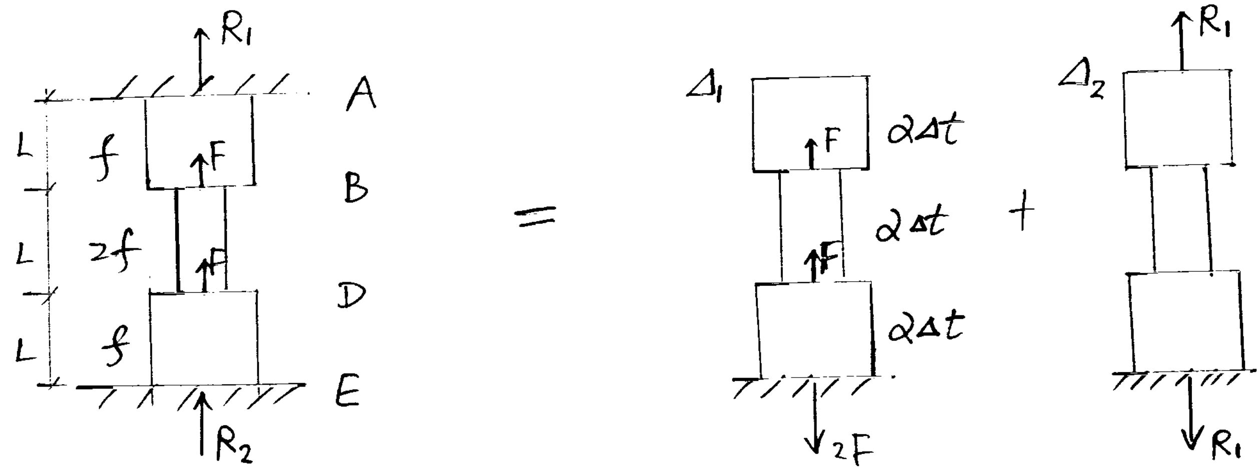
3.



Assume support reactions
at A: H_A & V_A
at C: H_C & V_C

$$\left.\begin{array}{l} \Sigma F_x = 0 \Rightarrow H_A + H_C = 0 \\ \Sigma F_y = 0 \Rightarrow V_A + V_C = P = 3 \\ \Sigma M_A = 0 \Rightarrow P \cdot 2L = H_C \cdot L \\ \Sigma M_D = 0 \Rightarrow V_C \cdot L = H_C \cdot L \end{array}\right\} \Rightarrow \left\{\begin{array}{l} \underline{H_A = -6\,KN} \\ \underline{V_A = -3\,KN} \\ \underline{H_C = 6\,KN} \\ \underline{V_C = 6\,KN} \end{array}\right.$$

4.



use method of superposition. $\Delta_1 + \Delta_2 = 0$

$$\Delta_1 = 2Ff + F\cdot 2f + \alpha \Delta t \cdot 3L = 4Ff + \alpha\Delta t \cdot 3L$$

$$\Delta_2 = R_1 f + R_1 \cdot 2f + R_1 f = 4R_1 f$$

$$\Delta_1 + \Delta_2 = 0 \Rightarrow \underline{R_1 = \frac{4Ff + 3\alpha\Delta t L}{4f}}$$

By statics $\Sigma F_y = 0 \Rightarrow R_1 + R_2 + F + F = 0 \Rightarrow \underline{R_2 = \frac{4Ff - 3\alpha\Delta t L}{4f}}$

5. $\tau_{max} = \frac{Tc}{I_p}$. $\Delta\phi = \frac{TL}{G I_p}$

(1) For solid cylinder, $(\tau_{max})_s = \frac{T_0 \cdot R}{\frac{\pi (2R)^4}{32}} = \underline{\frac{2T_0}{\pi R^3}}$

For hollow cylinder, $(\tau_{max})_h = \frac{T_0 R}{\frac{\pi[(2R)^4 - R^4]}{32}} = \underline{\frac{32 T_0}{15 \pi R^3}}$

$$\frac{(\tau_{max})_s}{(\tau_{max})_h} = \frac{15}{16}$$

(2) For solid cylinder, $(\Delta\phi)_s = \frac{T_0 L}{G \cdot \frac{\pi (2R)^4}{32}} = \underline{\frac{2T_0 L}{\pi G R^4}}$

For hollow cylinder, $(\Delta\phi)_h = \frac{T_0 L}{G \frac{\pi[(2R)^4 - R^4]}{32}} = \underline{\frac{32 T_0 L}{15 G \pi R^4}}$

$$\frac{(\Delta\phi)_s}{(\Delta\phi)_h} = \frac{15}{16}$$