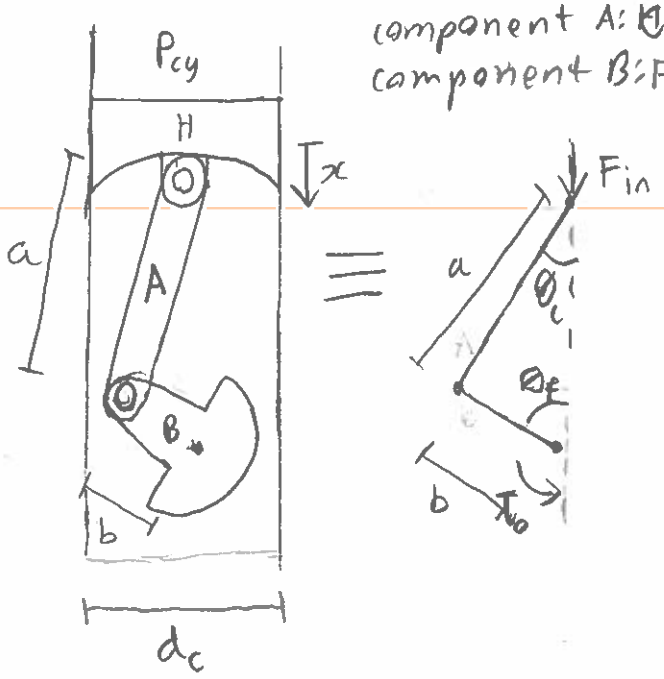
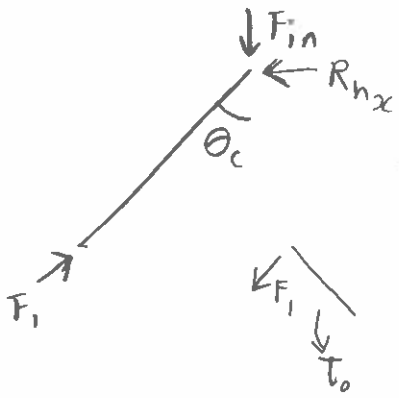
Force analysis: V-block piston configuration:

-single cylinder:




$$F_{in} = P A_p = P_{cy}\left(\frac{\pi d_c^2}{4}\right)$$




BC: ATDC

$\theta_c = 0 \quad \theta_f = 0$

At BDC

$\theta_c = 0 \quad \theta_f = 180$

at $x = b$

$\theta_c = \sin^{-1}\left(\frac{b}{a}\right)$

$\theta_f = 90°$

$$\lambda = \frac{b}{a}$$

$$T_o = F_1 b \qquad F_1 \sin(\theta_c) = F_{in}$$

$$F_1 = \frac{F_{in}}{\sin(\theta_c)}$$

$$F_1 = \frac{F_{in}}{\frac{b}{a}\sin\left(\cos^{-1}\left(\frac{x}{b}\right)\right)}$$

$$x(\theta_f) = b(1-\cos(\theta_f)) + a\left(1-\sqrt{1-\lambda^2\sin^2\theta_c}\right)$$

$$\frac{\sin(\theta_f)}{a} = \frac{\sin(\theta_c)}{b}$$

$$x(BDC) - x(TDC) = 2b$$

$$\theta_f(x) = \cos^{-1}\left(\frac{x}{b}\right)$$

$$\theta_c(x) = \sin^{-1}\left(\frac{b}{a}\sin\left(\cos^{-1}\left(\frac{x}{b}\right)\right)\right)$$

$$T_o\left(\overbrace{P_{cy}}^{+d}, x, a, b\right) = \frac{b\,a\,P_{cy}\,\pi d_c^{\overbrace{2}^{n+d}}}{4b\sin\left(\cos^{-1}\left(\frac{x}{b}\right)\right)}$$

n = number of cylinders

$d_c$ = cylinder diameter.