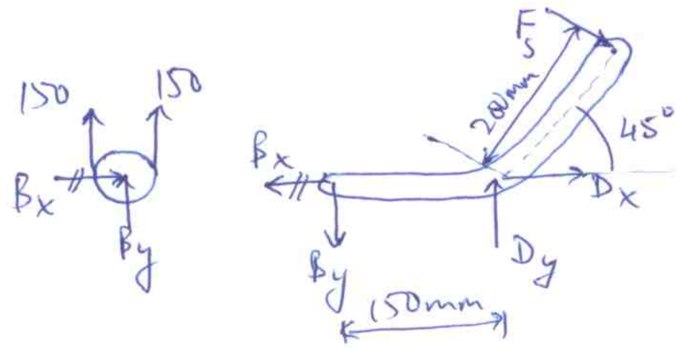
CE102 – Tutorial # 2

P1.



Disk B: $\sum F_x = 0 \Rightarrow B_x = 0$

$\sum F_y = 0 \Rightarrow B_y = -300\,N.$

Lever BDE:

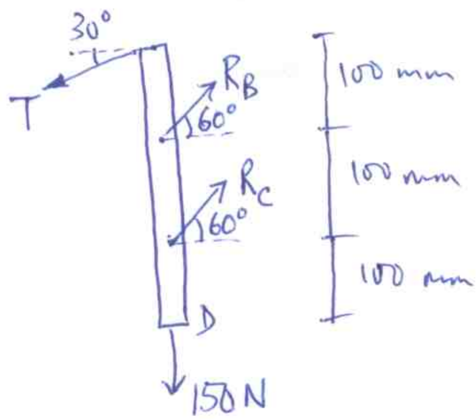
$\sum M_D = 0: \; B_y(150) - F_s(200)$

$\Rightarrow F_s = -225\,N$

$\sum F_x = 0: \; D_x + F_s \cos 45 = 0 \Rightarrow D_x = 159.1\,N.$

$\sum F_y = 0: -B_y + D_y - F_s \sin 45 = 0 \Rightarrow D_y = -459.1$

P.2.



$$\begin{cases} \sum M_B = 0: \; (T\cos 30)(100) + (R_C \cos 60)(100) = 0 \\ \sum F_x = 0: \; T\cos 30 - (R_B + R_C)\cos 60 = 0 \\ \sum F_y = 0: \; T\sin 30 + 150 - (R_B + R_C)\sin 60 = 0 \end{cases}$$

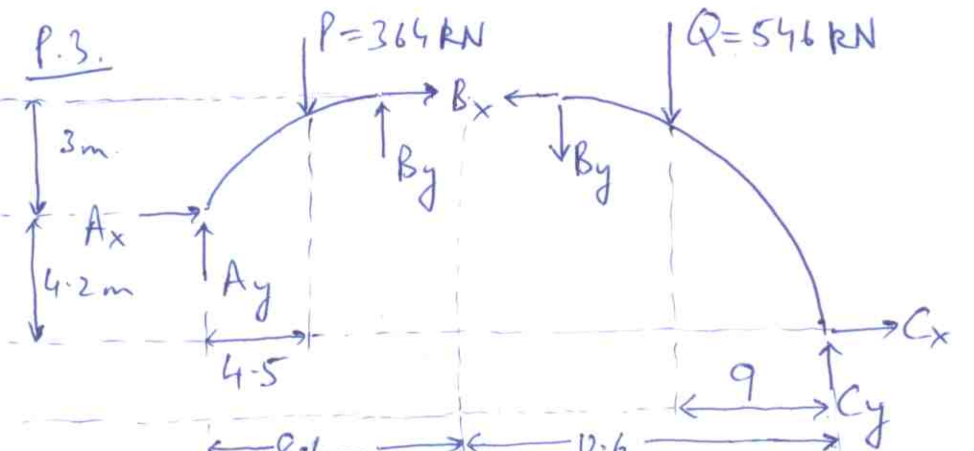
$\Rightarrow T = -R_C \dfrac{\cos 60}{\cos 30}, \quad R_B = -2R_C$

$R_C(-\cos 60 \tan 30 + \sin 60) + 150 = 0$

$R_C = -259.81\,N, \quad R_B = 519.62\,N$ ◄

$T = 150\,N.$ ◄

P.3.



Left FBD: $\sum M_A = 0 \Rightarrow (364)(4.5) + B_x(3) - B_y(8.4) = 0$

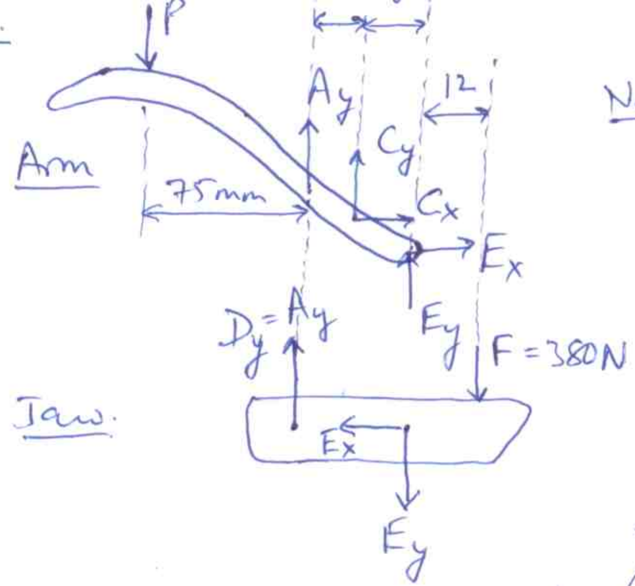
Right FBD: $\sum M_C = 0 \Rightarrow B_x(7.2) + B_y(12.6) + 546(9) = 0$

$\Rightarrow B_x = -630\,N$ ◄, $B_y = -30\,N$ ◄

$\sum F_x = 0 \Rightarrow C_x = B_x = -630\,N$ ◄

$\sum F_y = 0 \Rightarrow Q + B_y - C_y = 0 \Rightarrow C_y = 516\,N.$ ◄

P.4.



Note: Symmetry used, and direction of D_y consistent with symmetry, with $D_y = A_y$.

∵ jaws are 3-force members, D_y, F and $-E_x\mathbf{i} - E_y\mathbf{j}$ must be parallel for equil
∵ D_y & F are parallel $\Rightarrow E_x = 0$
also comes from $\Sigma F_x = 0$ for jaws.

Jaws:

$\Sigma F_x = 0 \Rightarrow E_x = 0$

$\Sigma F_y = 0 \Rightarrow A_y - E_y - 380 = 0$

$\Sigma M_E = 0 \Rightarrow A_y(40) + 380(12) = 0 \Rightarrow A_y = -114$ N

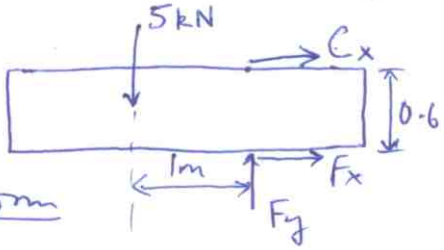
$E_y = -494$ N.

Arm: $\Sigma M_c = 0 \Rightarrow P(95) - A_y(20) + E_y(20) = 0$

$\Rightarrow P = 80$ N.

Note: A machine is a force multiplier. Here input force is P = 80 N, output force is F = 380 N.

P.5.



Platform

$\Sigma M_F = 0: \quad 5(1) - C_x(0.6) = 0$

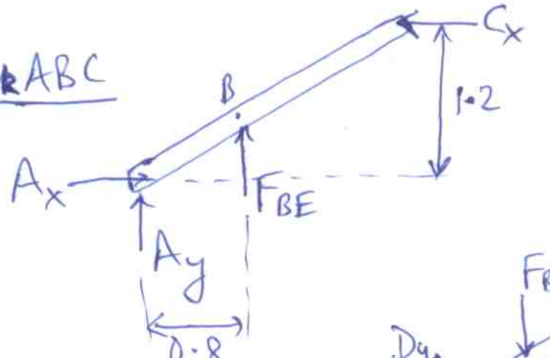
$C_x = 8.333$

$\Sigma F_x = 0: \quad C_x + F_x = 0 \Rightarrow F_x = -8.333$

$\Sigma F_y = 0: \quad -5 + F_y = 0 \Rightarrow F_y = 5$

Note that BE is a 2-force member, so F_{BE} is vertically directed.

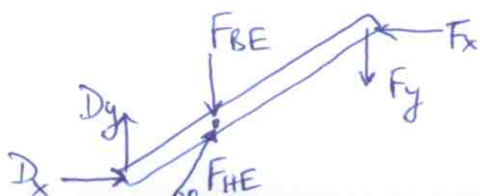
Link ABC



$\Sigma M_A = 0: \quad C_x(1.2) + F_{BE}(0.8) = 0$

$F_{BE} = -12.5$kN, ie (↓) ◄

ie BE is in tension. ◄



Link DEF

Note that HE is 2-force member

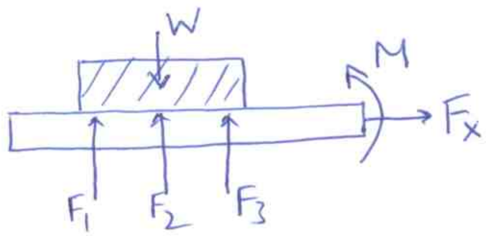
$$\theta = \tan^{-1}\left(\frac{1.6}{0.8}\right) = \tan^{-1}(2)$$

$$\sum M_D = 0: \quad F_{BE}(0.8) + F_y(2.4) - F_x(1.2) - F_{HE}(DH \sin(90-\theta)) = 0$$

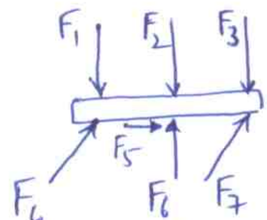
$$\Rightarrow F_{HE} = 22.36\,kN$$

P. 6:

FBD 1

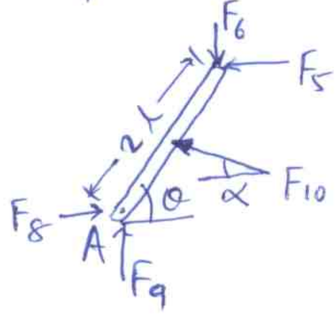


FBD 2



Horizontal link with rollers.

FBD 3



Middle Link (connected to piston)

$$\alpha = \tan^{-1}\left[\frac{(l\sin\theta - e)}{(d - l\cos\theta)}\right] = 12.6629^\circ$$

$\theta = 60^\circ$ (given)

FBD 1 : $\sum F_y = 0$: $W = F_1 + F_2 + F_3$.

FBD 2 : $\sum F_x = 0$: $(F_4 + F_7)\sin\theta + F_6 - (F_1 + F_2 + F_3) = 0$

$$\Rightarrow F_6 = W - (F_4 + F_7)\sin\theta$$

$\sum F_y = 0$: $(F_4 + F_7)\cos\theta + F_5 = 0$

$$\Rightarrow F_5 = -(F_4 + F_7)\cos\theta$$

FBD 3 : $\sum M_A = 0$: $F_6(2l\cos\theta) - F_5(2l\sin\theta)$
$- F_{10}\cos\alpha\,(l\sin\theta) - F_{10}\sin\alpha\,(l\cos\theta) = 0$

$$\Rightarrow \left[W - \cancel{(F_4+F_7)\sin\theta}\right](2l\cos\theta) + \left[\cancel{(F_4+F_7)\cos\theta}\right]\cancel{(2l\sin\theta)}$$
$$- F_{10}\,l\,(\cos\alpha\sin\theta + \sin\alpha\cos\theta) = 0$$

$$\Rightarrow F_{10} = \left[W \big/ \left\{l(\cos\alpha\sin\theta + \sin\alpha\cos\theta)\right\}\right] * 2l\cos\theta$$

$$= 5.238\,kN. \quad \Rightarrow p = \frac{F_{10}}{\pi d^2/4} = 4.1682\,N/mm^2$$

p = total pressure in both pistons.

$\Rightarrow$ pressure in each piston $= p/2 = 2.084\ N/mm^2$

NOTE: Total unknowns $= 10\ (F_1 - F_{10})$.

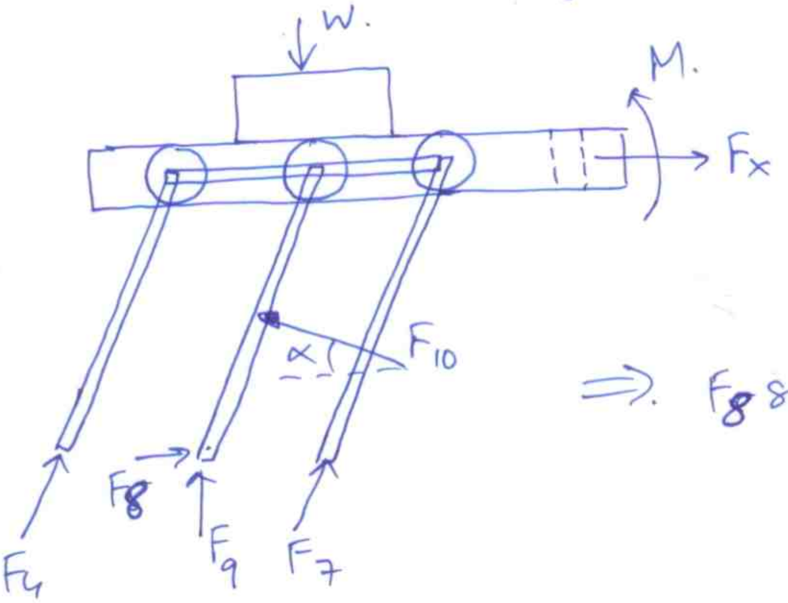
$+2\ (F_x, M)$.

$= 12$

Total eqns (provided we have dimensions on FBD1, FBD2 to find moments of applied forces) $= 3 \times 3 = 9$

$\Rightarrow$ problem is statically indeterminate. However due to cancellation indicated in the eqn on previous page, we can solve for F_{10} & hence p.

Much shorter way: ☆☆



FBD 4

Sum forces in direction $\perp^{ar}$ to inclined arms. (use $F_x = 0$ from $\Sigma F_x = 0$ in FBD 1).

$$\Rightarrow F_8 \sin\theta - F_9 \cos\theta + W\cos\theta - F_{10}\sin(\theta+\alpha) = 0 \longrightarrow (A)$$

Now $\Sigma M_B = 0$ for FBD 3: $\Rightarrow (F_8 \sin\theta - F_9\cos\theta)2l - F_{10}\sin(\theta+\alpha)\,l = 0 \longrightarrow (B)$

(A) & (B) $\Rightarrow (F_{10}\sin(\theta+\alpha) - W\cos\theta)2l - F_{10}\sin(\theta+\alpha)\,l = 0$

$$\Rightarrow F_{10} = \frac{2W\cos\theta}{\sin(\theta+\alpha)} \longrightarrow \text{same as result on previous page.}$$