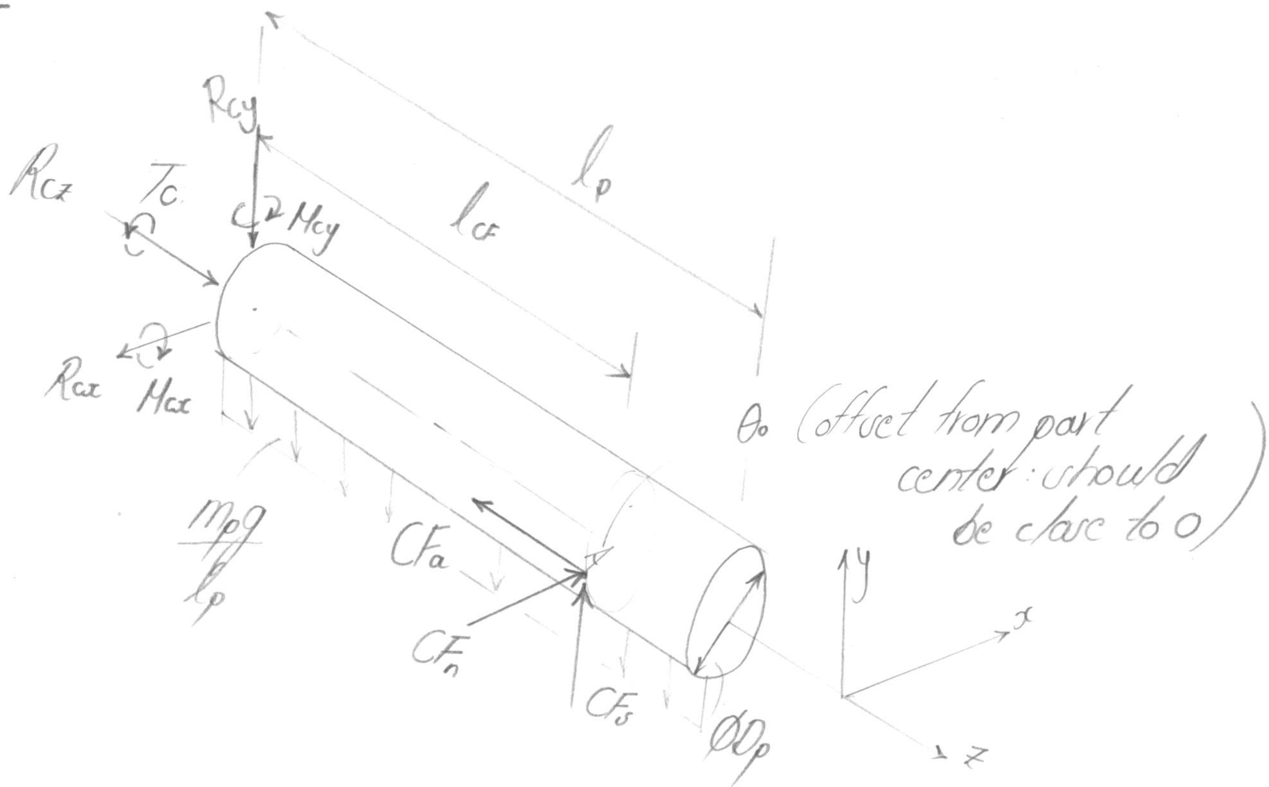
FREE BODY DIAGRAMS

A. PART



$\rightarrow R_{cx} = CF_n$

$\rightarrow R_{cy} = CF_s - m_p g$

$\rightarrow R_{cz} = CF_a$

$\rightarrow T_c = CF_s \times \frac{D_p}{2} \cos\theta_o - CF_n \times \frac{D_p}{2} \sin\theta_o$

$\rightarrow M_{cy} = CF_n \, l_{CF} - CF_a \times \frac{D_p}{2} \cos\theta_o$

$\rightarrow M_{cx} = CF_s \, l_{CF} - CF_a \times \frac{D_p}{2} \sin\theta_o - \frac{m_p g \, l_p}{2}$

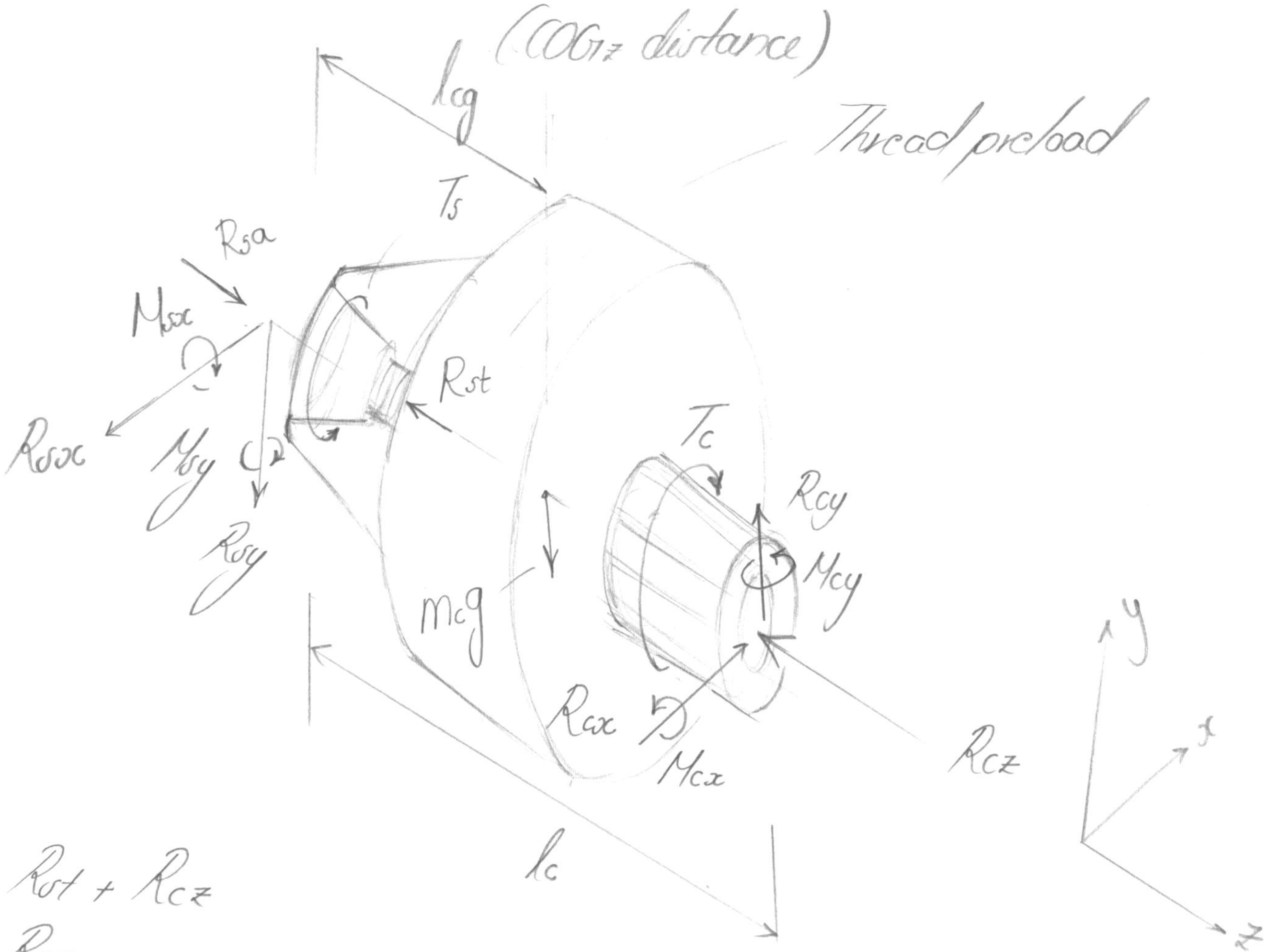
<u>assuming</u>:

a. uniform cross-section

b. mass is evenly distributed across part

c. part is treated as cantilevered from chuck.

B. CHUCK



→ $R_{sa} = R_{st} + R_{cz}$

→ $R_{sx} = R_{cx}$

→ $R_{sy} = R_{cy} - m_c g$

→ $T_s = T_c$

→ $M_{sx} = M_{cx} + R_{cy} l_c - m_c g\, l_{cg}$

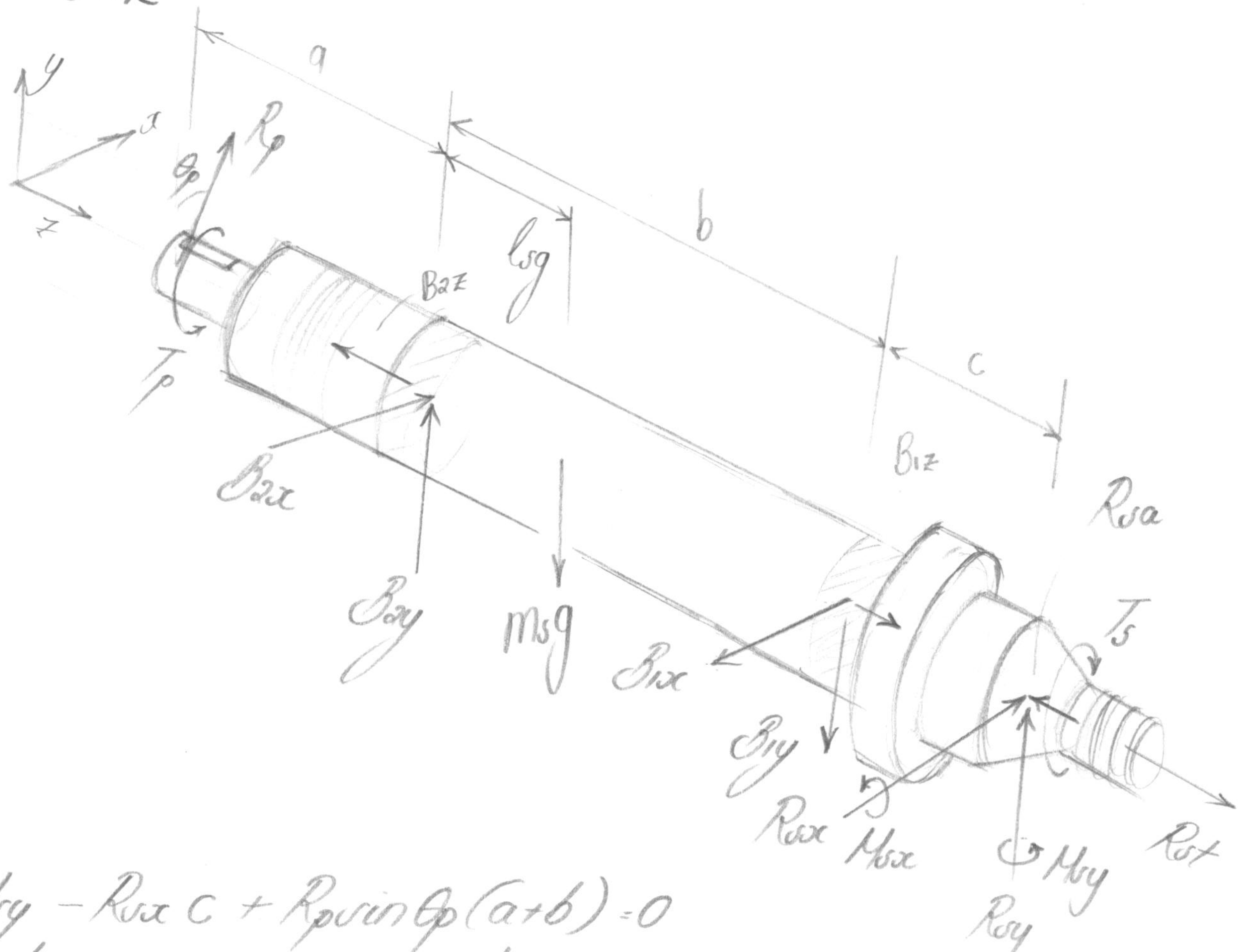
→ $M_{sy} = M_{cy} + R_{cx} l_c$

<u>assuming:</u>

a. All loads acting at the chuck approximated as acting through the center.

b. All reaction loads acting on tapered surface NOT thread. Thread only providing preload for mating surfaces.

C. SPINDLE



$$B_{2x}\, b - M_{sy} - R_{sx}\, c + R_p \sin\theta_p (a+b) = 0$$

$$B_{2x} = \frac{1}{b} M_{sy} + \frac{c}{b} R_{sx} - \frac{a+b}{b} \sin\theta_p R_p$$

→ $B_{1x} = B_{2x} + R_p \sin\theta_p + R_{sx}$

→ $B_{2y} = \frac{1}{b} M_{sx} + \frac{c}{b} R_{sy} - \frac{a+b}{b} \cos\theta_p R_p + \frac{b - l_{sg}}{b} M_s g$

→ $B_{1y} = B_{2y} + R_p \cos\theta_p + R_{sy} - M_s g$

→ $T_p = T_s$

→ If $R_{st} > R_{sa}$: $B_{2z} = B_p + R_{st} - R_{sa}$

$R_{st} < R_{sa}$: $B_{1z} = B_p + R_{sa} - R_{st}$ } B_p: bearing pre-load

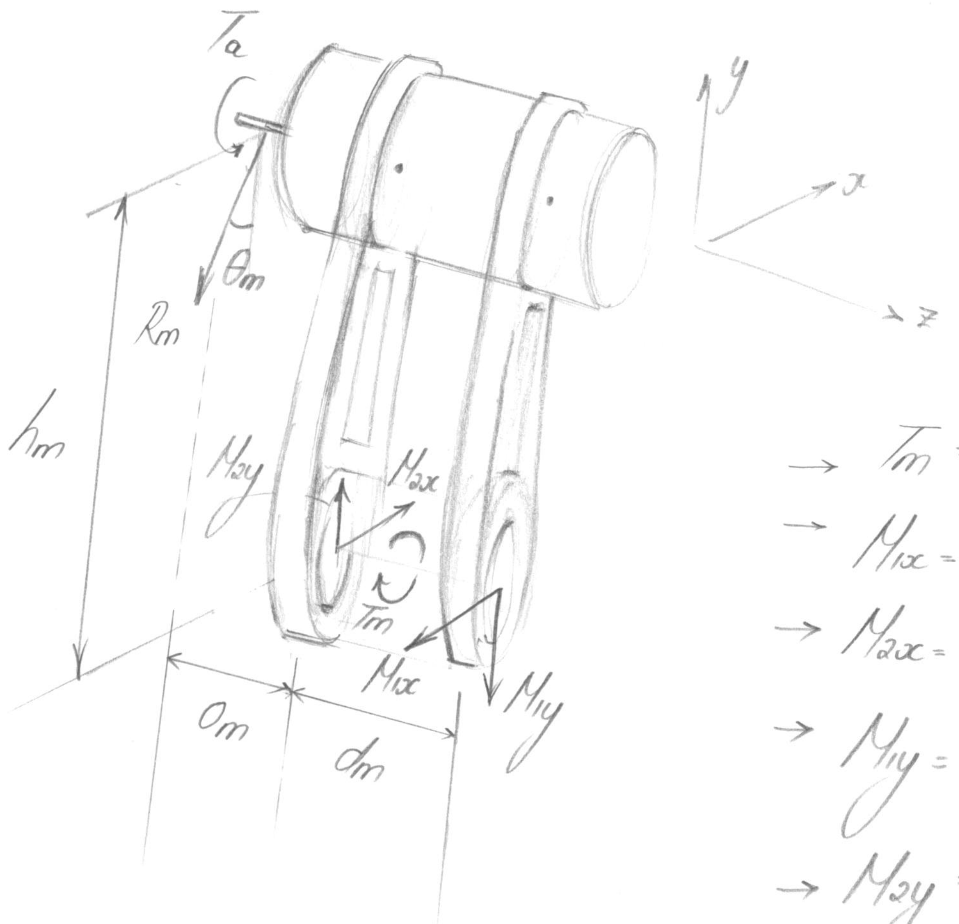
assuming:

a. Angular contact roller bearings

b. Bearing frictional torques have not been considered.

c. Moments due to cutting expected to have a stronger effect than mass of spindle.

D. MOTOR + MOUNT



$\rightarrow \quad T_m = T_a$

$\rightarrow \quad M_{1x} = \frac{O_m}{d_m} R_m \sin\theta_m$

$\rightarrow \quad M_{2x} = M_{1x} + R_m \sin\theta_m$

$\rightarrow \quad M_{1y} = \frac{O_m}{d_m} R_m \cos\theta_m$

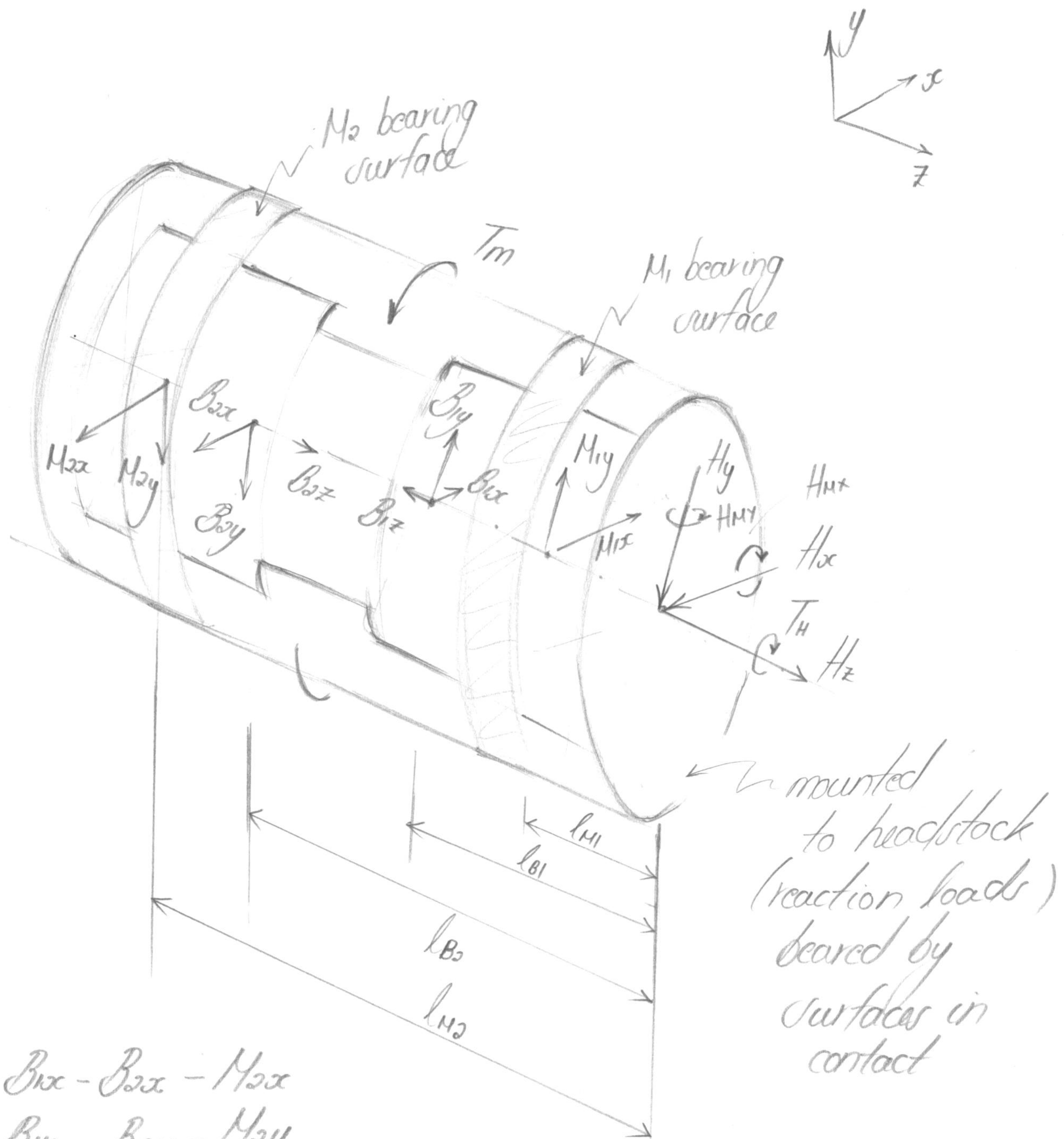
$\rightarrow \quad M_{2y} = M_{1y} + R_m \cos\theta_m$

<u>assuming</u>

a. Pre-load mechanism is implemented into this assembly, else there will be an additional pre-load force F_{pl}

b. Belt aligned such that force component in z-direction is negligible. Check!

E. Bearing Housing



$$H_x = M_{1x} + B_{1x} - B_{2x} - M_{2x}$$

$$H_y = M_{1y} + B_{1y} - B_{2y} - M_{2y}$$

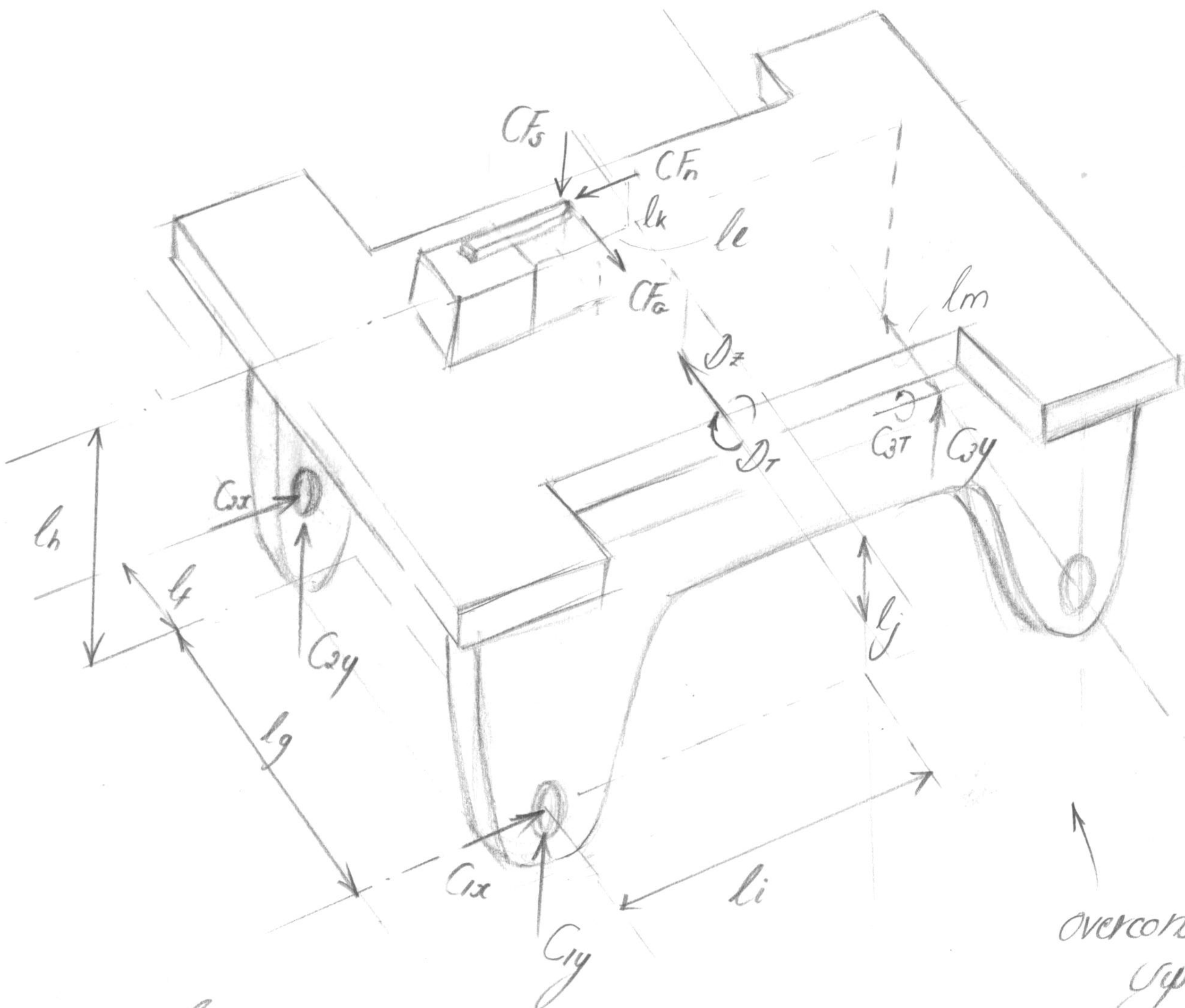
$$H_z = B_{1z} - B_{2z}$$

$$H_{Mx} = -B_{1y} l_{B1} - M_{1y} l_{M1} + B_{2y} l_{B2} + M_{2y} l_{B2}$$

$$H_{My} = -B_{1x} l_{B1} - M_{1x} l_{M1} + B_{2x} l_{B2} + M_{2x} l_{M2}$$

$$\vec{T}_H = T_M$$

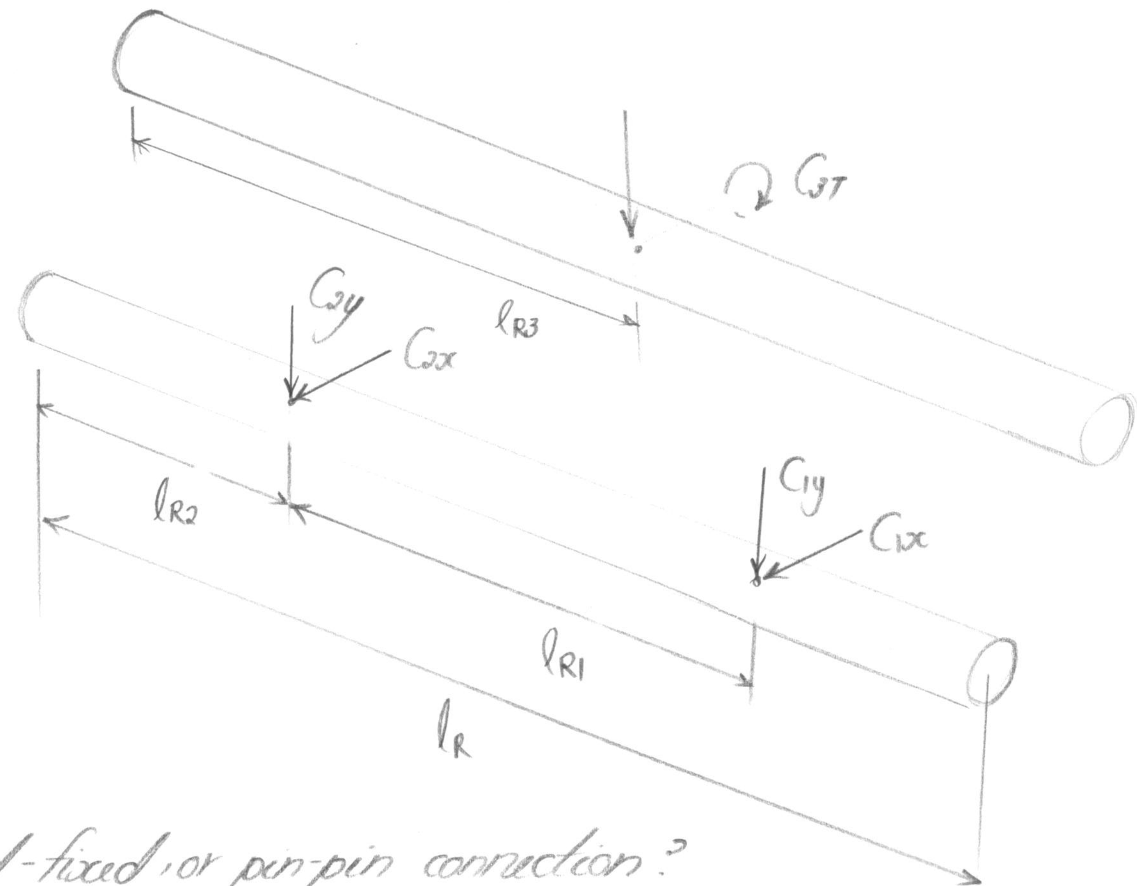
F. TOOL TO CARRIAGE



overconstrained system. Will need to use stiffnesses to determine loads.

- $C_{1x} = \frac{l_f}{l_f + l_g} CF_n - \frac{l_i}{l_f + l_g} D_z + \frac{l_i - l_e}{l_f + l_g} CF_a$
- $C_{2x} = \frac{l_g}{l_f + l_g} CF_n + \frac{l_i}{l_f + l_g} D_z - \frac{l_i - l_e}{l_f + l_g} CF_a$
- $D_z = CF_a$
- $C_{2y}(l_f + l_m) - C_{1y}(l_g - l_m) - C_{3T} = D_z(l_h - l_j) - CF_a(l_k + l_h) + CF_s l_m$
- $C_{2y} + C_{1y} + C_{3y} = CF_s$
- $(C_{1y} + C_{2y} - C_{3y}) l_i + D_T = CF_n(l_h + l_k) + CF_s(l_e)$

G. RAILS



Fixed-fixed, or pin-pin connection?