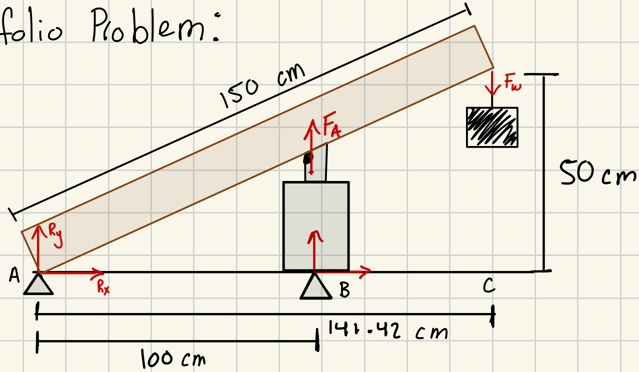
Portfolio Problem:



Rigid:

Constraints:
- $L \leq 150$
- $H \leq 50$
- 2 supports on ground (A & B)
- Max Force = 58 kN

Objective:
- Maximize Weight ($m = 4180.69$)
- Maximize displacement
- Maintain equilibrium

Degrees of Freedom:

1) Bar is a single rigid link
   - ↳ 2 supports on ground
   - ↳ Actuator point
   - ↳ Load applied at end

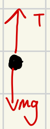
2) Bar has 3 pins:
   - ↳ Pin A (ground)
   - ↳ Pin B (ground)
   - ↳ Pin C (on bar)

Solve for m:

Static Analysis

$$50^2 + b^2 = 150$$
$$d = 141.42\,cm$$

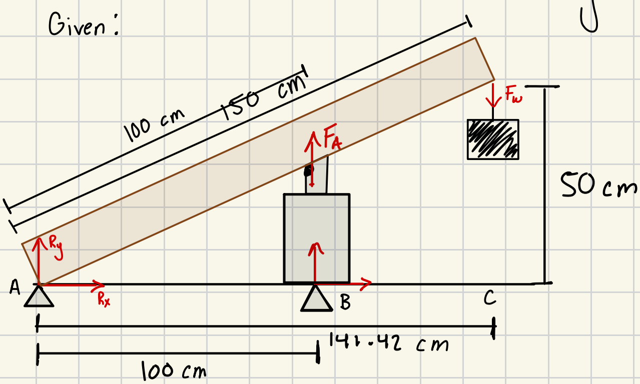
$$\Sigma M_A = 0$$
$$141.42\,(T) - 100\,(58) = 0$$
$$T = 41.01\ kN$$



$$T = mg$$
$$m = \frac{T}{g}$$
$$m = \frac{41010\,0}{9.81}$$
$$m = 4180.69\ kg$$

Not Rigid

Given:



Find:

a) max deflection

b) beam cross section so $\delta < 3\,cm$

Plan:
- Find R_y & R_x
- δ_{max}
- Assume $E = 200\,GPa$

  $I = \frac{1}{12} b h^3$

  ↳ $b = 1\ cm$, $h = 1\ cm$

Solve:

$$\Sigma F_y = 0$$
$$R_y + F_A - T = 0$$
$$R_y = T - F_A$$
$$R_y = 41.01 - 58 \rightarrow R_y = 16.99\ kN$$

$$\delta_{max} = \frac{F_w L^3}{3EI} + \frac{F_A (a^2)(3L - a)}{6EI}$$

$$\delta_{max} = \frac{41.01(1.5)^3}{3(200\times10^9)(\frac{1}{12}(0.01)^4)} + \frac{58(1^2)(3(1.5)-1)}{6(200\times10^9)(\frac{1}{12}(0.01)^4)}$$

$$\delta_{max} = 0.311\ m$$

Deflection less than 3cm:

$$0.03 = \frac{F_w L^3}{3EI} + \frac{F_A (a^2)(3L-a)}{6EI}$$

$$0.03 = \frac{41.01(1.5)^3}{3x} + \frac{58(1^2)(3(1.5)-1)}{6x}$$

$x = 2665.65$

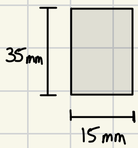
$x = EI$

$EI \geq 2665.65 \ N \cdot m^2$

Example: Aluminum $\rightarrow$ $E = 69 \text{ GPa}$

$I_{req} = 3.86 \times 10^4 \ mm^4$

Cross-section:



$\rightarrow$ Rectangle: $I = \frac{1}{12} b h^3$

$I = \frac{1}{12}(15)(35)^3$

$I = 53600 \ mm^4$