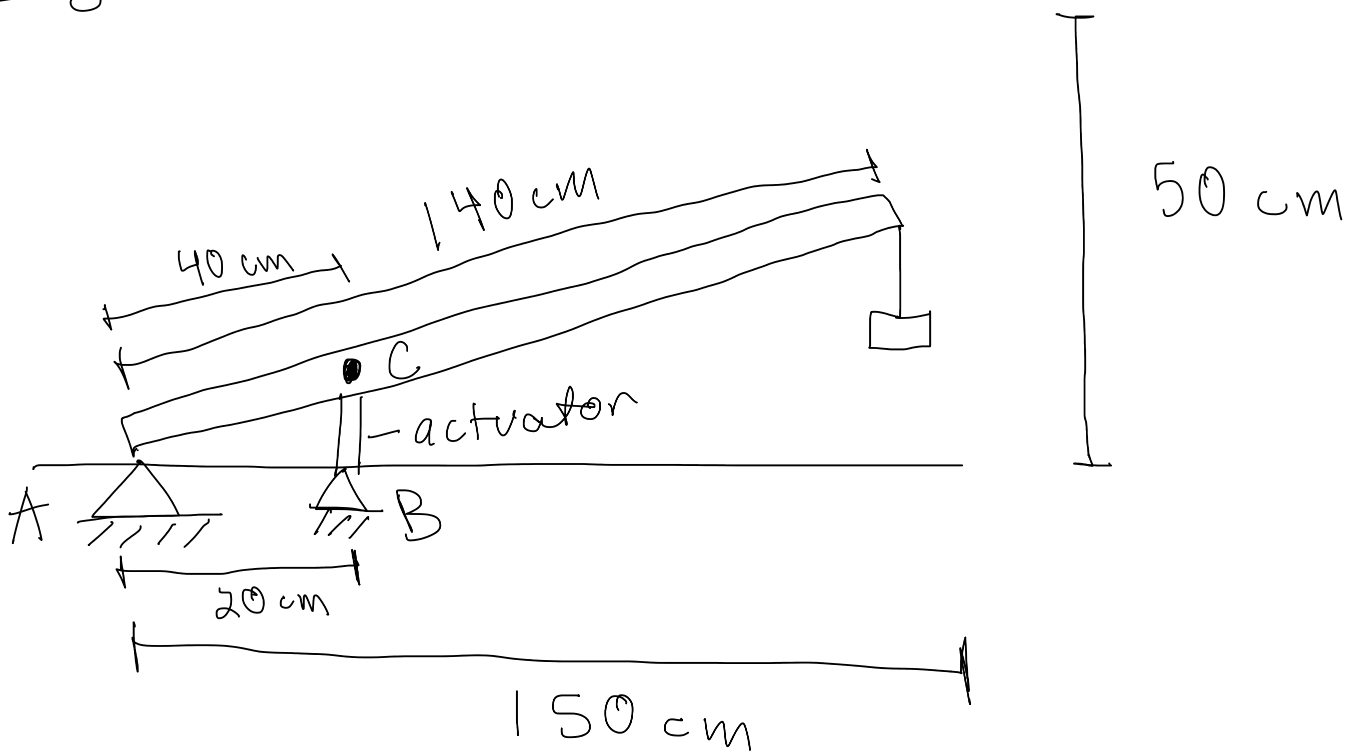
Homework 5

Friday, October 3, 2025 3:33 PM

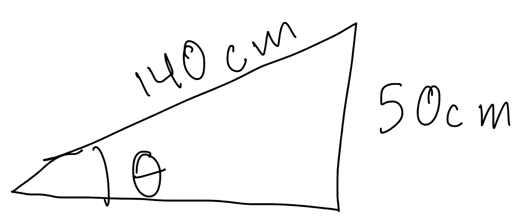
Portfolio

Design

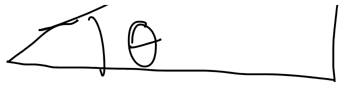


max thrust = 294 kN

max weight = 50 cm



$$\sin\theta = \frac{50}{140}$$

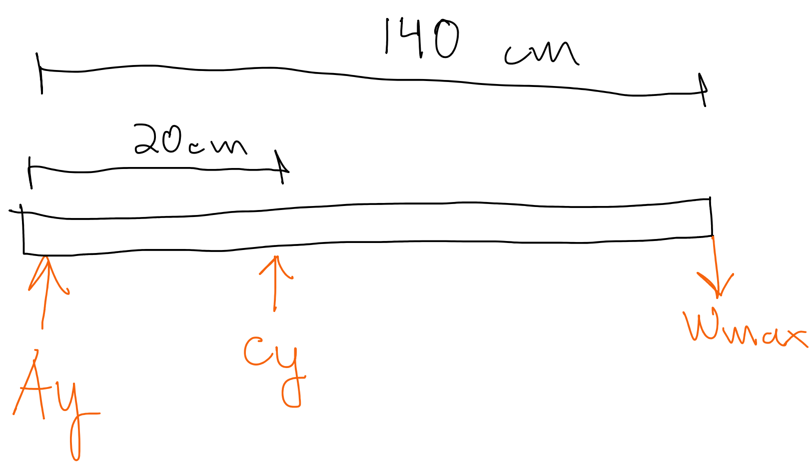


$$\theta = \sin^{-1}(50/140)$$

max angle b/t ground & rigid bar → $\boxed{\theta = 20.92^\circ}$

This angle is reasonable for an actuator and bar of this length.

FBD of rod



*assume that actuator has barely lifted rod off the ground *

$C_y = 294 \text{ kN}$

$$\sum F_y = A_y + C_y - w_{max} = 0$$

$$A_y + C_y = w_{max}$$

$$A_y + 294\,kN = w_{max}$$

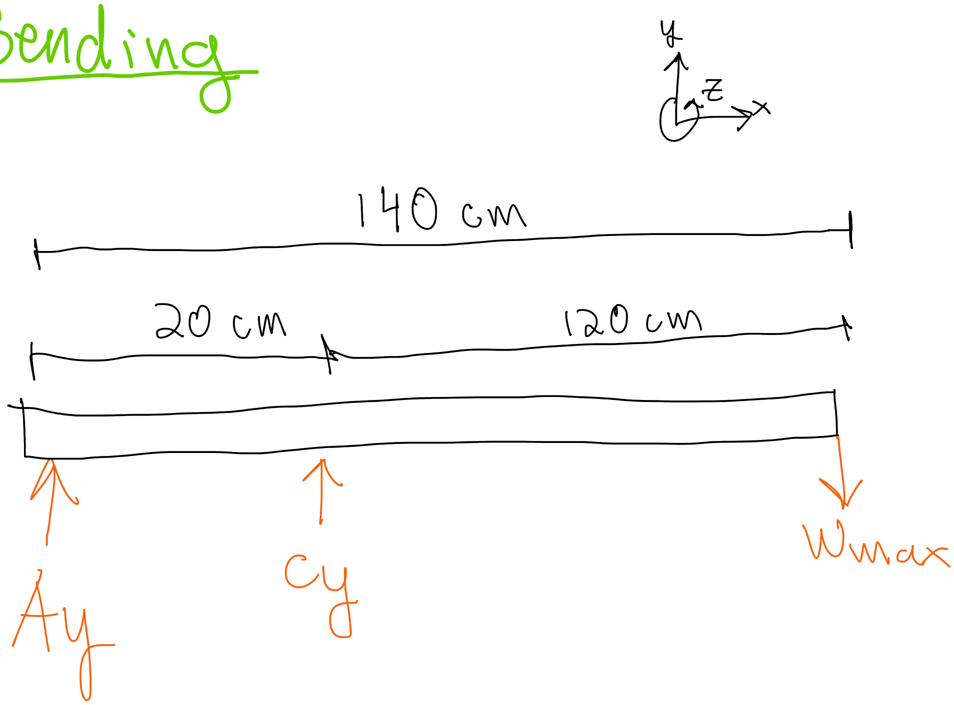
$$\sum M_A = -(0.2\,m)(294\,kN) + (1.4\,m)\,w_{max} = 0$$

$$58.8\,kNm = 1.4\,w_{max}$$

$$\boxed{42\,kN = w_{max}}$$

It makes sense that the max weight is less than the max force. This is due to equilibrium and the location of the actuator.

Bending



We can treat this as a pin-roller system w/ an applied force at $x = 20\,cm$. A is a pin, and since the weight is only in the y-direction, it can act as a roller at that point.

ⓐ $\underline{0 \le x \le 0.2\,m}$

$$M = C_y x = 294x$$

$$EI y'' = 294x$$

$$EI y' = 147x^2 + C_1$$

$$EI y = 49x^3 + C_1 x + C_2$$

$\underline{0.2\,m \le x \le 1.4\,m}$

$$M = C_y (0.2\,m) - w_{max} x$$

$$M = 58.88 - 42x$$

$$EI y'' = 58.88 - 42x$$

$$EI y' = 58.88x - 21x^2 + C_3$$

$$EI y = 29.44x^2 - 7x^3 + C_3 x + C_4$$

<u>BCs:</u>

$[x=0, y=0] \rightarrow C_2 = 0$

$[x=0, \frac{dy}{dx} = 0] \rightarrow C_1 = 0$

$[x = 0.2\,m, \frac{dy}{dx} = \frac{dy}{dx}]$

$\left[x = 0.2\,m, \ \frac{dy}{dx} = \frac{dy}{dx}\right]$

from both sides

$$58.88x - 21x^2 + C_3 = 147x^2$$

$$58.88(0.2\,m) - 21(0.2\,m)^2 + C_3 = 147(0.2\,m)^2$$

$$11.776 - 0.84 + C_3 = 5.88$$

$$\underline{C_3 = -5.056}$$

$[x = 0.2, y = y]$

$$\cancel{29.44x^2 - 7x^3} - 5.056x + C_4 = \cancel{29.44x^2 - 7x^3}$$

$$-5.056(0.2) + C_4 = 0$$

$$\underline{C_4 = 1.0112}$$

max deflection $\rightarrow$ $x = 0.2\,m$

$$y(0.2) = \frac{1}{EI}(49x^3)$$

$$y(0.2) = \frac{1}{EI}(49(0.2\,m)^3)$$

$$\boxed{y(0.2) = \frac{1}{EI}(0.392)\,m^3}$$

(b)

$$L = 140\,cm = 1.4\,m$$

$$2\% \text{ of } L = 2.8\,cm = 0.028\,m$$

$$y = 0.028\,m = \frac{0.392}{EI}$$

$$0.071 = \frac{1}{EI}$$

$$EI = 14$$

$$I = \frac{bh^3}{12} = \frac{(0.05\,m)(0.0252\,m)^3}{12} =$$

$EI = 14$

$$I = \frac{bh^3}{12} = \frac{(0.05m)(0.0252\,m)^3}{12} =$$

$E = \text{steel} = 210 \times 10^6\ Pa$

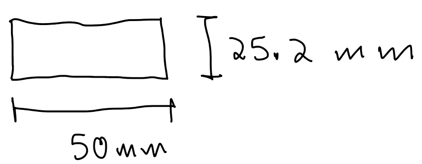
$$\frac{14}{210 \times 10^6\ Pa} = I = 6.67 \times 10^{-8}$$

$$\frac{bh^3}{12} = 6.67 \times 10^{-8}$$

$$bh^3 = 8 \times 10^{-7}$$

$\downarrow$ try $b = 50\,mm = 0.05\,m$

$b = 0.05\ m \quad h = 0.0252\,m$ ✓



Steel beam, rectangular cross-section