Problem

Create a bar with 3 pin supports and a linear actuator that can lift the maximum possible weight to the highest possible height ($\leq 50cm$)

Design Choices

$L_{bar} = 1.20m$ Actuator: $a = 1.0m$ from the left pivot along the bar

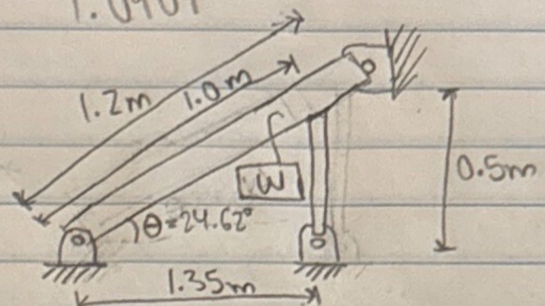
Left pivot: $x=0$ Right ground anchor for actuator at $x = 1.35m$ $h_{max} = 0.5m$

Previous Static Analysis: $\theta = \sin^{-1}\left(\frac{0.5}{1.2}\right) = 24.62°$ $x_a = a\cos\theta = 0.9091m$

Static load Used $= 9000N = F$ $y_a = a\sin\theta = 0.4167m$

$$W_{max} = \frac{Fd}{L_{bar}\cos\theta} = \frac{(9000)(0.9272)}{1.0909} = 7649.46N \approx 7.65kN$$

Final Mechanism:



Now, the bar is no longer rigid

Assume: linear Euler-Bernoulli beam theory applies, $F=9000N$, $W=7650N$, $E=200GPa$

Deflection at free tip W: $\delta_w = \frac{WL^3}{3EI}$ Deflection at free tip due to load P: $\delta_P = \frac{Pa^2(3L-a)}{6EI}$ $\delta_{tot} = \delta_w + \delta_P$

$A = 6.16in^2 = 0.003974m^2$ $t = 0.00635m$ $R_m = \frac{A}{2\pi t} = 0.0996m$ $D_o = 0.2056m$ $I = 1.973\times10^{-5}m^4$

$\delta_w = \frac{WL^3}{3EI} = 1.12mm$ $\delta_P = \frac{Pa^2(3L-a)}{6EI} = 0.92mm$ $\delta_{tot} = \delta_w + \delta_P = 2.03mm$

2% of $L = 24mm$ $\delta_{tot} = 2.03mm < 24mm$

New Mechanism: