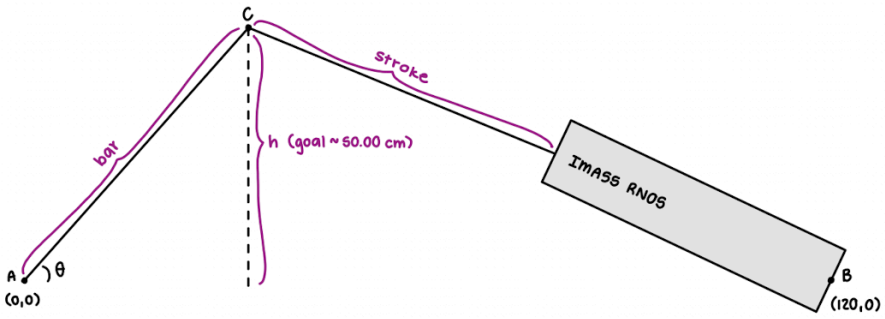
ENGRD 2020 Updated Portfolio: Mechanism Including an Actuator

The goal of this mechanism is to maximize the height that our machine/system can lift a weight using a linear actuator, within a fixed space of 150 cm by 50 cm. The system is made up of two ground-mounted pinned supports at points A and B, a rigid lifting bar, and a single rod-type actuator. Everything is assumed to be rigid.



Design Objectives:

- Maximize vertical lift height (h)
- Maximize the allowable lifting weight (not my main goal)

Constraints:

- 150 cm x 50 cm space
- Peak actuator thrust: 35.81 kN
- Pin A Coordinates: (0,0)
- Pin B Coordinates: (120.00 cm,0)
- Bar Length: 50 cm

Analysis:
We will treat the bar as a rigid body and the actuator will produce a vertical lifting reaction.

$$W_{max} = F_{actuator}\sin(\Theta) =$$

$F_{actuator}$ = 35.81 kN

$\Theta = \tan^{-1}$(bar/distance between pins) = $\tan^{-1}(0.5m/1.2m) = 22.62^{o}$

$$W_{max} = (35.81\ kN)*\sin(22.62) = 13.77\ kN$$

Therefore, the upper bound load of the rigid-body is approximately 13.77 kN.

Step 2:
Now we are going to treat the bar as a beam instead of a perfectly rigid bar. It will deflect due to the payload weight and the actuator induced transverse load.

Assumptions:

- Small deflections
- Transverse loading only
- Simply supported between A-B
- Point load at distance 4.35 cm (or at the tip of the 50 cm bar)
- Material & Properties: Steel → E = 200 GPA

Analysis:
Find the max deflection based on the above information:

$$\delta_{max} = Wb^3/48EI$$

W = 13.77 kN and the rectangular cross section has a width of 20 mm and a height of 40 mm.

$I = bh^3/12 = (0.020\ m)(0.040\ M)^3/12 = 1.07x10^{-7}\ m^4$

$$\delta_{max} = (13.77\ kN)(0.020\ m)^3/48(200x10^9\ Pa)(1.07x10^{-7}\ m^4) = 0.000107\ mm$$

This works with the restrictions (I think, I'm tired 🙂)