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Given a 2D design space of 150cm long and 50cm tall, a rigid bar of a fixed length (your choice), 3 pin supports of which two need to be mounted on the ground and a linear actuator (pick from this online catalog, use max force values only), design a frame/mechanism to lift the maximum possible weight to the highest possible height. Assume all the supports and bar/actuator are rigid.

Using Actuator: Model IMA55-RN05

Max Load: 35.8 kN

Min stroke: 76.2 mm

max stroke: 457.4 mm

base length: 403.8 mm

Plan:

Design space 2-D → 150 cm (length) x 50 cm (height)

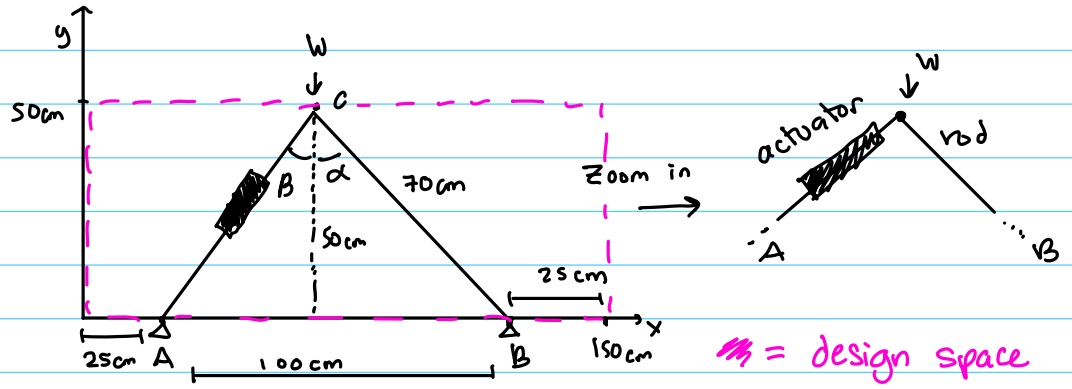
Choose points for pins to be connected to ground

i) Place A (25,0) and B (125, 0) for pins connected to ground

ii) select a 70 cm rod

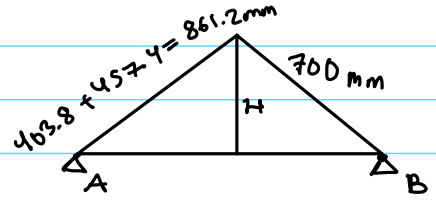
iii) design a toggle type mechanism

Sketch:



Note: since max height = 50 cm, the actuator cannot use max stroke.

Sketch if it opens to max stroke:



Here, H = 591.6 mm > 500 mm which doesn't match given boundry.

Therefore, H is limited to 50 cm

$DB = \sqrt{700^2 - 500^2} = 489.9 \text{ mm}$

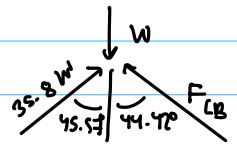
$AD = \underbrace{(1250-250)}_{AB} - 489.9 = 510.1 \text{ mm}$

Actuator Length (AC): $\sqrt{(500)^2 + (510.1)^2} = 714.3 \text{ mm}$

$\alpha = \text{Tan}^{-1}(BD/CD) = \text{Tan}^{-1}\left(\frac{489.9}{500}\right) = 44.42°$

$\beta = \text{Tan}^{-1}(AD/CD) = \text{Tan}^{-1}\left(\frac{510.1}{500}\right) = 45.57°$

Calculating W (pick up load):



$\Sigma F_x = 0$

$35.8(\sin 45.58) = F_{CB} \sin 44.42$

$F_{CB} = 36.53 \text{ kN}$

$\Sigma F_y = 0$

$W = 35.8(\cos 45.57) + 36.53(\cos 44.42)$

$W = 25.06 + 26.09 = \boxed{51.15 \text{ kN}}$

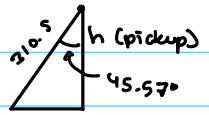
Find max pick-up height:

open actuator length (AC) = 714.3mm

base length = 403.8 mm

stroke length: 714.3 − 403.8 = 310.5 mm

h (pickup) = 310.5 at 45.57°



h (pickup) = $\boxed{217.4 \text{ mm}}$

Overall results: any other smaller stroke less than 310.5mm results in smaller pickup load and smaller pick-up height