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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: Mode 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)

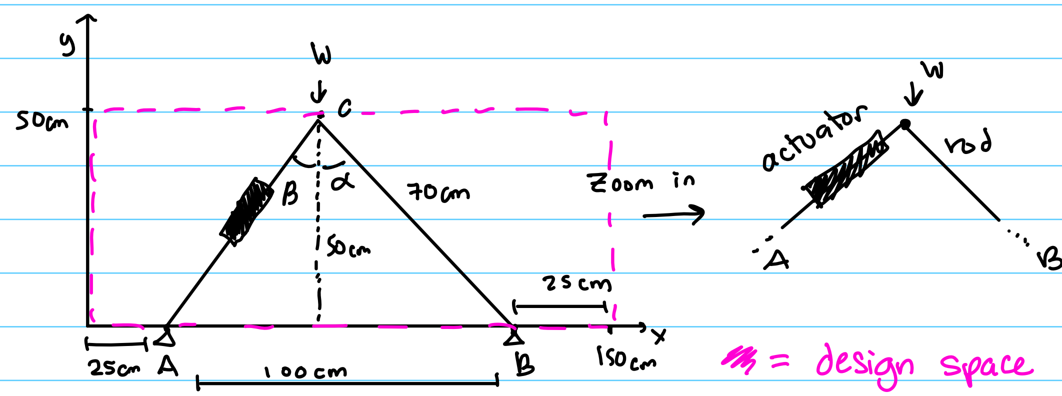
Choose points for pins to be connected to ground

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

ii) select a 70 cm rod

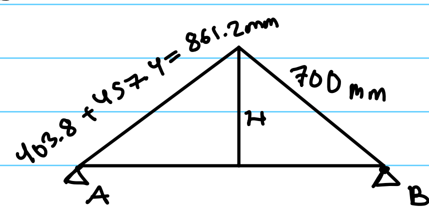
iii) design a toggle type mechanism

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

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

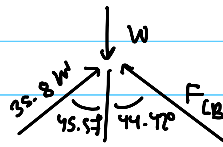
$AD = \underbrace{(1250-250)}_{AB} - 489.9 = 510.1\ mm$

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

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

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

Calculating W (pick up load):



$\Sigma F_x = 0$

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

$F_{CB} = 36.53 kN$

$\Sigma F_y = 0$

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

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

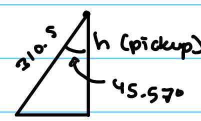
Find max pick-up height:

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) = $\boxed{217.4\ mm}$

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

Follow the following two steps, and questions to update your portfolio page:

Step 1: Consider the bar in your design to be rigid. Follow these steps to update your portfolio page from HW5:

a) Create sections to define the problem, your constraints/objectives, and your design degrees of freedom.
b) Treating the bar as rigid, revisit your submission for HW5 by describing the static analysis you conducted to determine your final design.
c) Present your final mechanism design in an image or drawing.

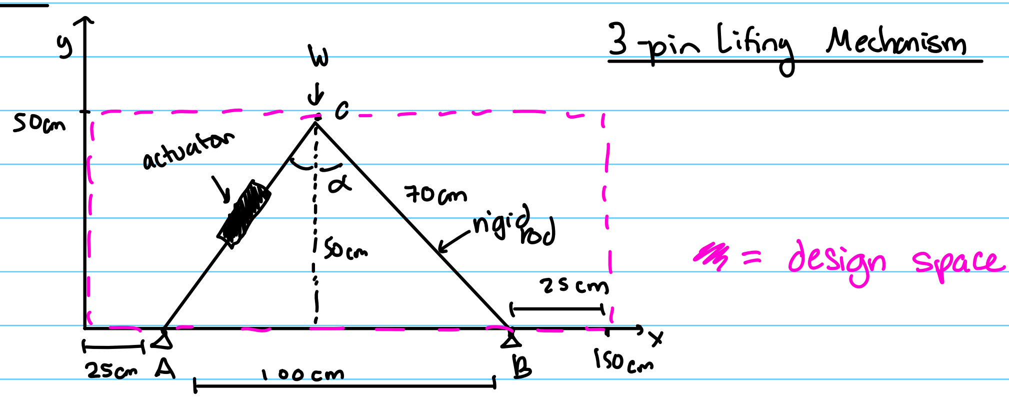
Step 2: The bar in your mechanism is no longer rigid. In fact, it is now best described as a beam which bends due to the combined action of the weight and the actuator force. Consider only the components of these forces transverse to your beam:

a) Find the maximum deflection in your beam. State your assumptions clearly and describe your analysis.
b) Choose a beam design (cross-section, material) such that its vertical deflection is below 2% of its length and is the most mass-efficient possible.
c) Present your final beam design in an image or drawing.

any changes not reflected in this pdf are on the github

Step 1

c) 3-pin Lifing Mechanism



Part 2

a) Even though the rod is acting like a beam, since we have a 3-pin system, moment and shear will NOT develop in the rod. The rod goes under axial load only. Therefore, the results obtained in the last assignment are still valid.

Rod (CB) axial force = 36.53kN

$D_a = FL/AE$

A = area (mm^2) → assume a circular rod with radious of R

$E = 200{,}000\ N/mm^2 = 200\ kN/mm^2$ (modulos of elasticity of steel)

F = axial force (kN)

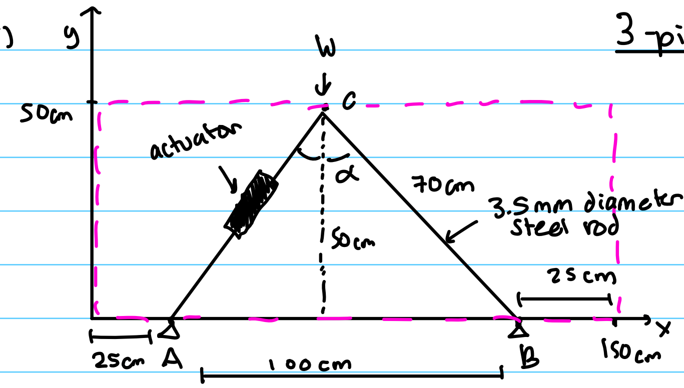
$D_a = \frac{FL}{AE} = \frac{36.53L}{(\pi R^2)(200)}$

b) $D_a \leq 0.02L$

$(D_a)_{max} = 0.02L = \frac{36.53L}{(\pi R^2)(200)}$ → $R_{min} = 1.705$ mm

↳ we can make a rod with a 1.75mm radous

(c)



3-pin Lifting Mechanism

= design space