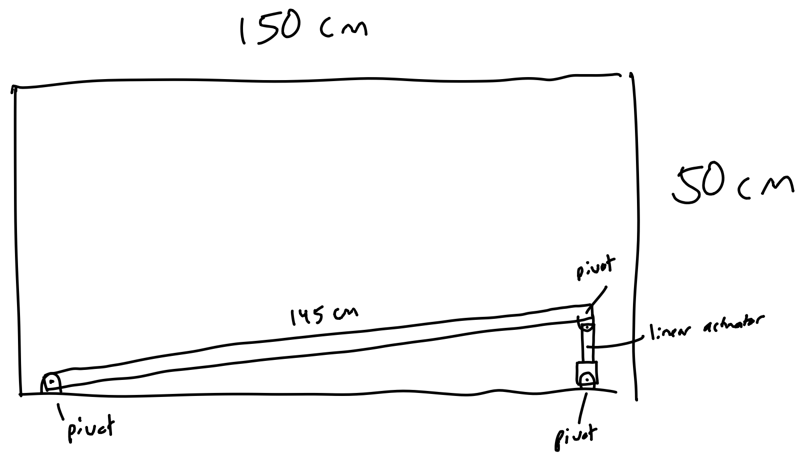
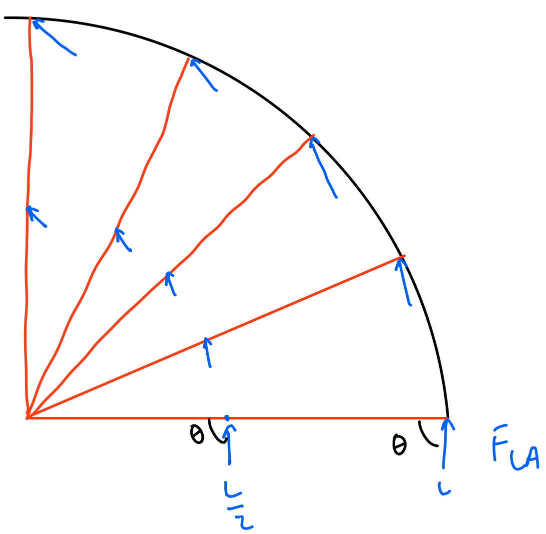
Portfolio



(Projected)
Path of pivot of bar + actuator:



$M = rF\underbrace{\sin\theta}$

$\sin\theta$ decreases proportionately as bar moves upward, independent of r

$\therefore M \propto r$ and F

$\therefore$ placing linear Actuator at L provides most torque, maximizes upwards force of L.A.

Selected: RSX because it has the greatest stroke length and force

Assumption: Speed, screw/nut type, and duration capacity are not considered b/c they are not specified in the question.

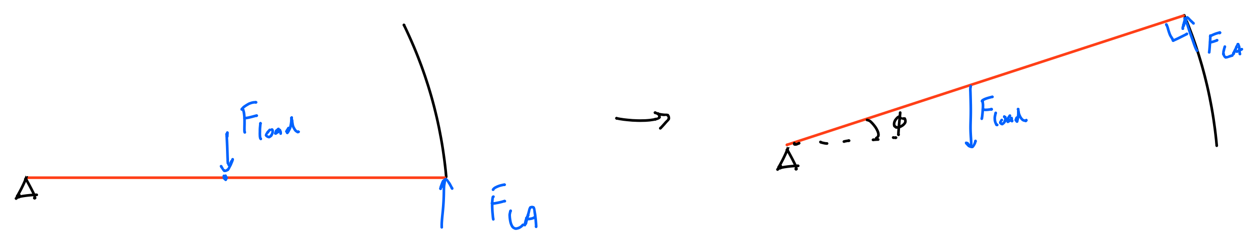
Length: 145 cm - A little leeway (as opposed to a max 150 cm length and hence max torque) to provide for size of actuator, size of pivot, size of load - essentially a little leeway.

Bending Analysis

Maximum deflection?

Due to setup with the actuator being attached to the beam by a pin, it can be concluded that the linear actuator constantly applies a force <u>perpendicular</u> to the beam as the lever's angle with the ground increases.

But, as the lever's height increases, the weight of the load is still straight down, meaning the force it applies directly to the bar is no longer decreases.



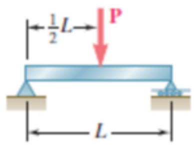
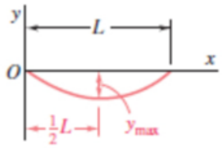
In terms of torque...

$$T_{load} = rF\cos\phi$$

when $\phi = 0$, T_{load} is at maximum

Hence, to analyze beam bending, I consider a horizontal loading scenario. When horizontal, the beam is pinned-pinned and the maximum deflection occurs at $\frac{L}{2}$.

From Beer, et al.

Beam and Loading	Elastic Curve	Maximum Deflection	Slope at End	Equation of Elastic Curve
1 		$-\frac{PL^3}{48EI}$	$\pm\frac{PL^2}{16EI}$	For $x \leq \frac{1}{2}L$: $y = \frac{P}{48EI}(4x^3 - 3L^2x)$

Maximum deflection:

$$y = -\frac{PL^3}{48EI}$$

A mass efficient design would be a wide flanged I-beam where mass is distributed to the edges of the shape, increasing the I value.

Want vertical deflection $\leq$ 2% of its length:

length = 145 cm = 1.45 m

$y = .02(1.45) = 0.029$ m

My chosen RSX linear actuator can lift a maximum load of 294 kN

$$\Sigma M_{pivot}: -W_{load}\cdot\frac{x}{2} + x(294\times10^3) = 0$$

$$W_{load\,max} = 588\times10^3 \text{ N}$$

Choose rolled steel I-beam → $E \approx 200$ GPa

$$y = \frac{PL^3}{48EI} \rightarrow I = \frac{(588\times10^3)(1.45)^3}{48(200\times10^9)(0.029)} = 6.439\times10^{-6}\ m^4 = 6.439\times10^6\ mm^4$$

Considering the x-x axis of bending for the cross-section, I think that W150×13.5 (little leeway, $I = 6.83\times10^6$ mm^4) or W130×23.8 (more leeway, $I = 8.91\times10^6$) would be efficient and stable choices.

Final Design: