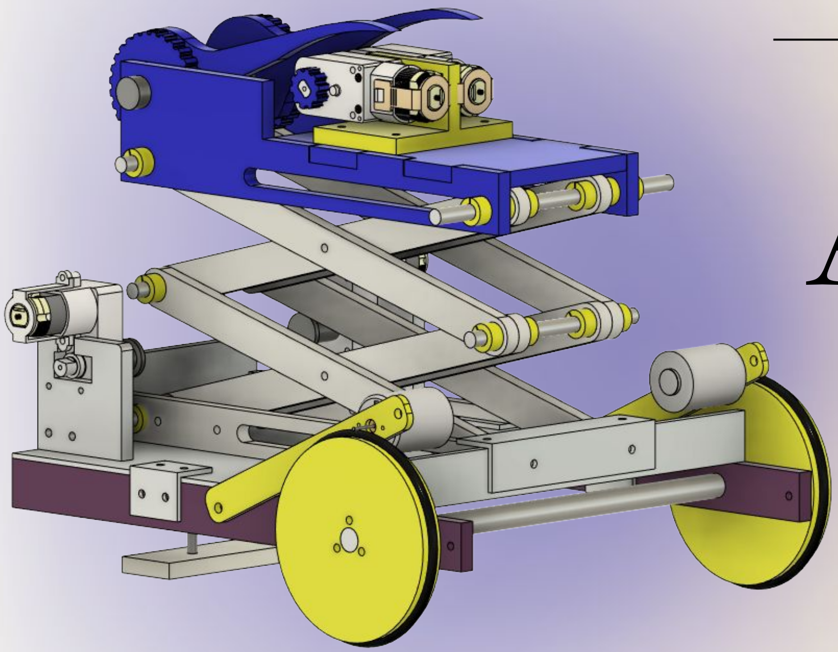


Forklift Certified

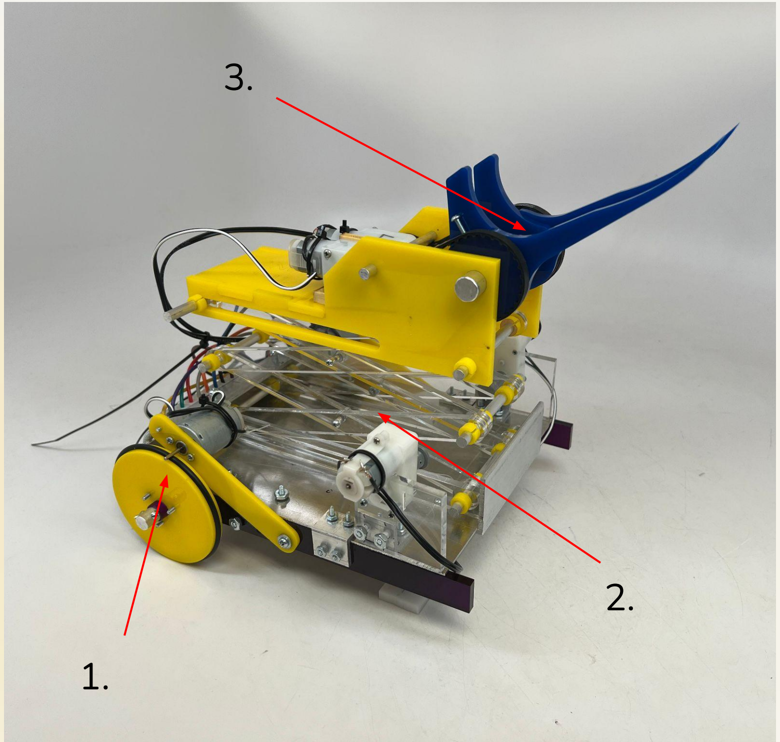
A.N.T. | Team 07
MAE 3

Angie T.M. | Nicholas Franzwa | Troy Schalge

Determining Our Goals

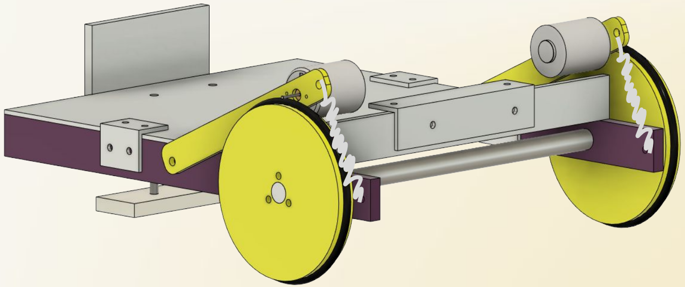
Goals
- Be able to pick up both cue ball and camera
- Move around the arena
- Fit within the 10x10x10 limit starting off and reach the highest object

Key Components
1. Independently Controlled Friction Drivetrain
2. Scissor lift powered by 2 geared motors
3. Dual gear motor arm

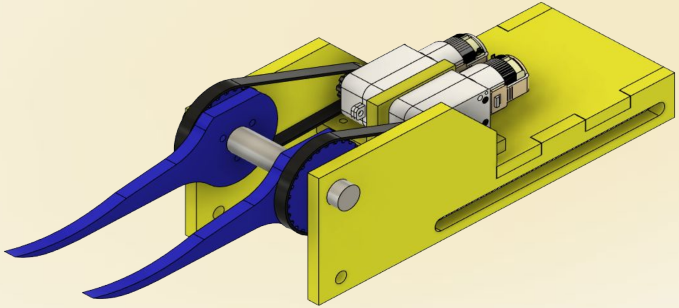


Moving with Precision

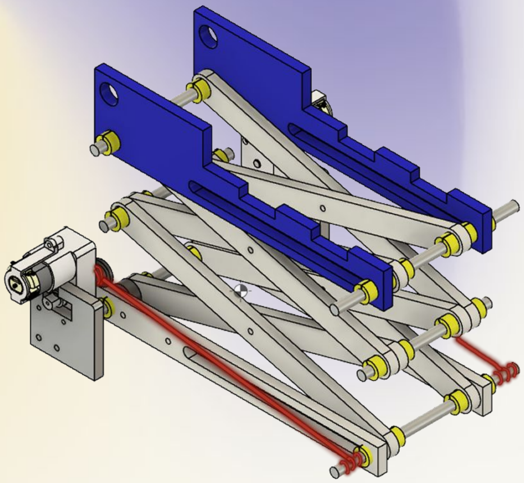
Drivetrain



Arm/Scooper



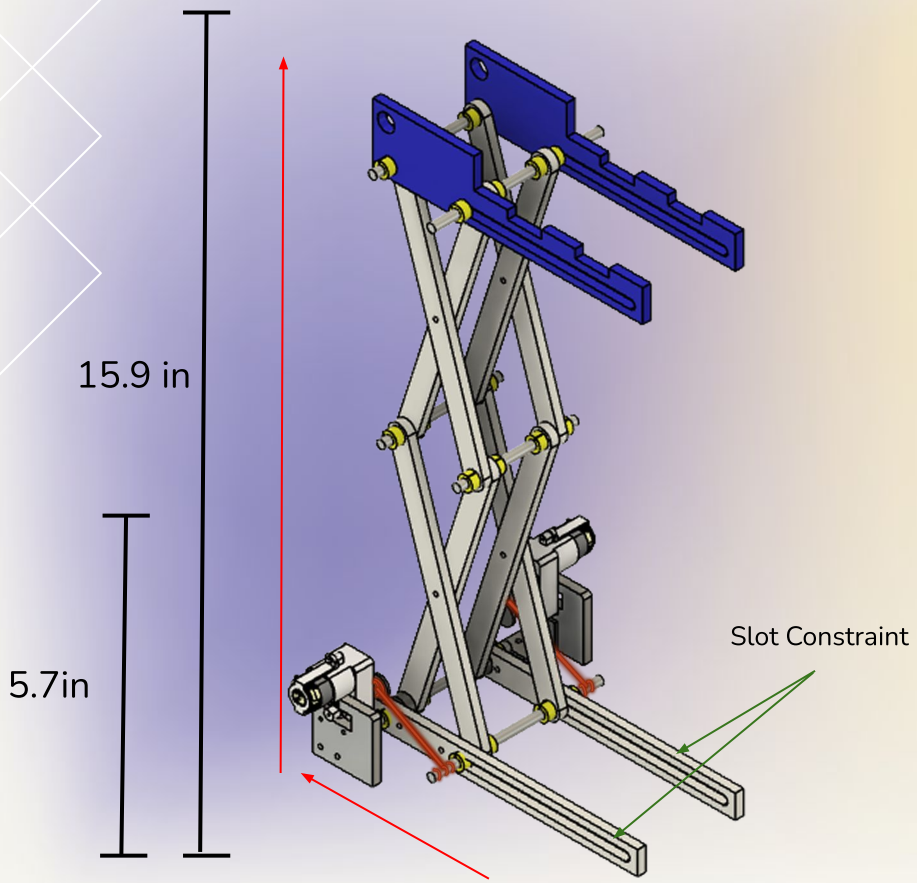
Scissor Lift



Reaching the Object

Scissor Lift Mechanism

Troy

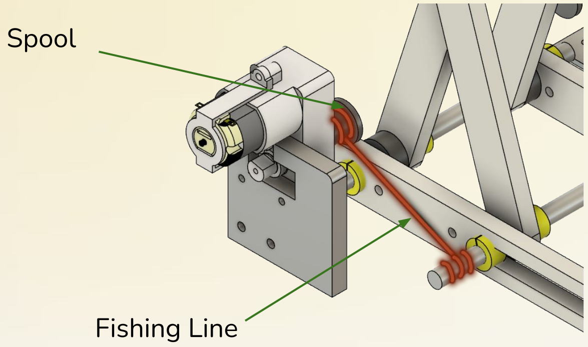


Mechanism

- Converts torque to horizontal force through spool, fishing line and slot constraint

Specifications

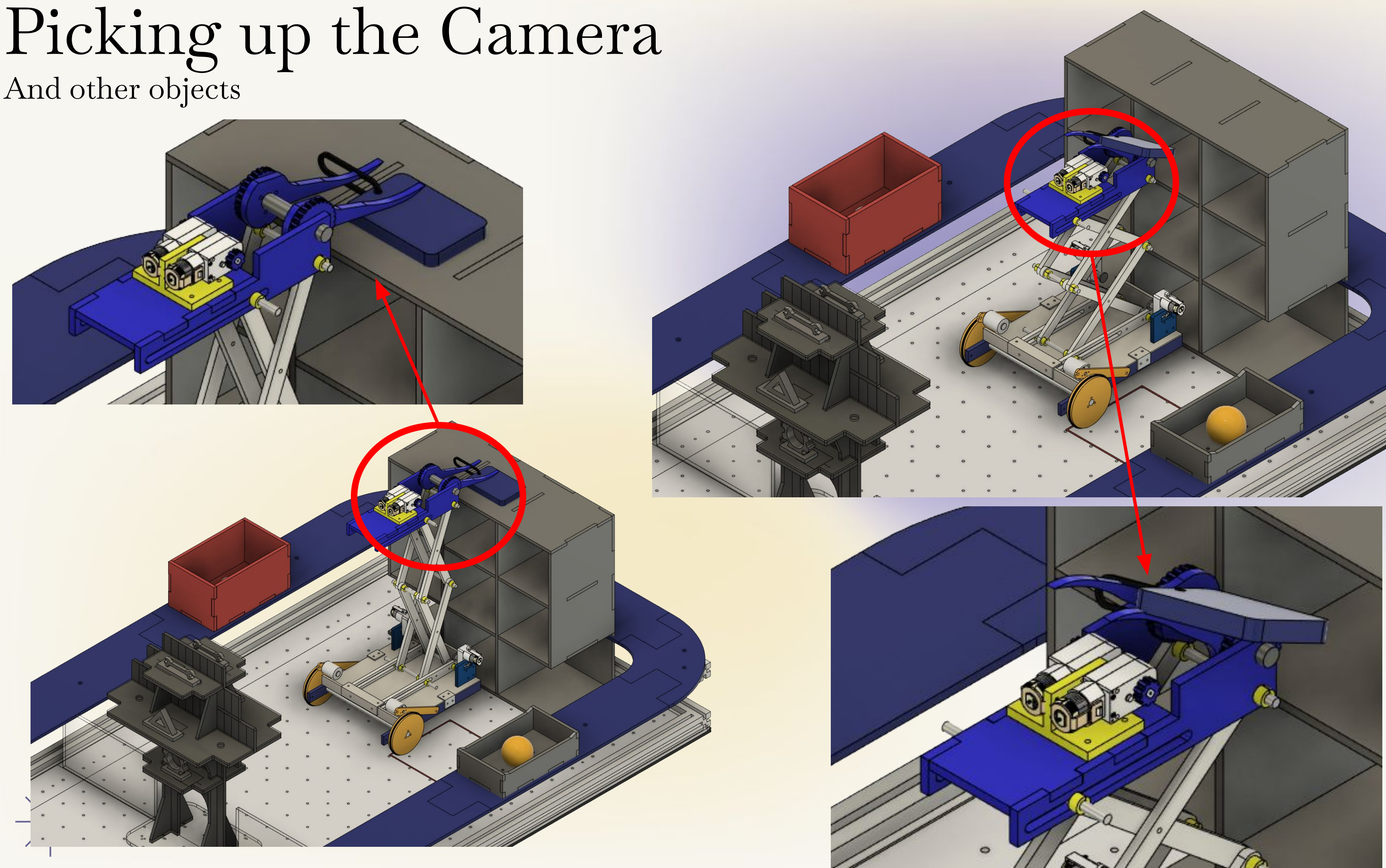
- 1 Degree of Freedom
- Initial height of 5.7in
- Max height of 15.9in

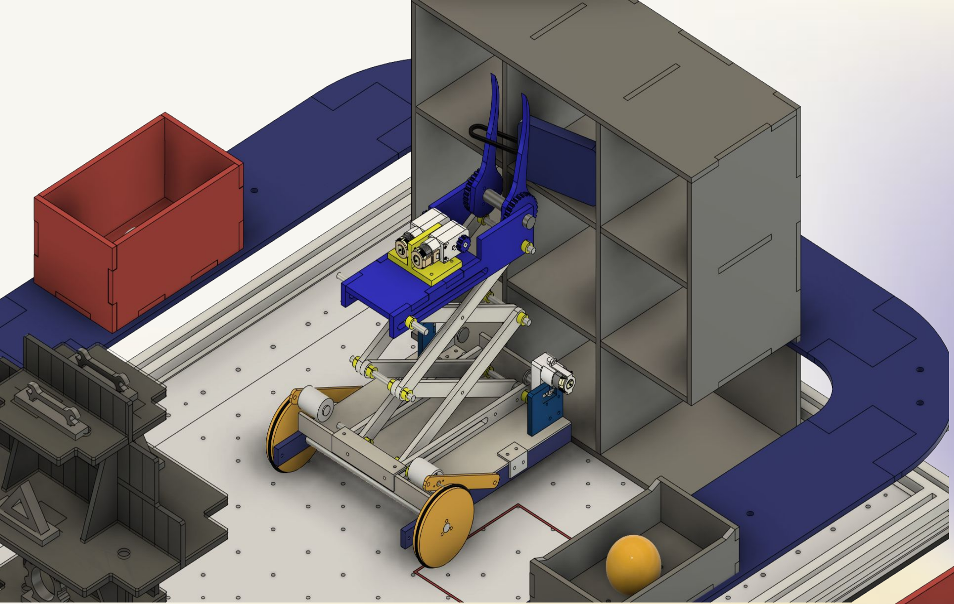


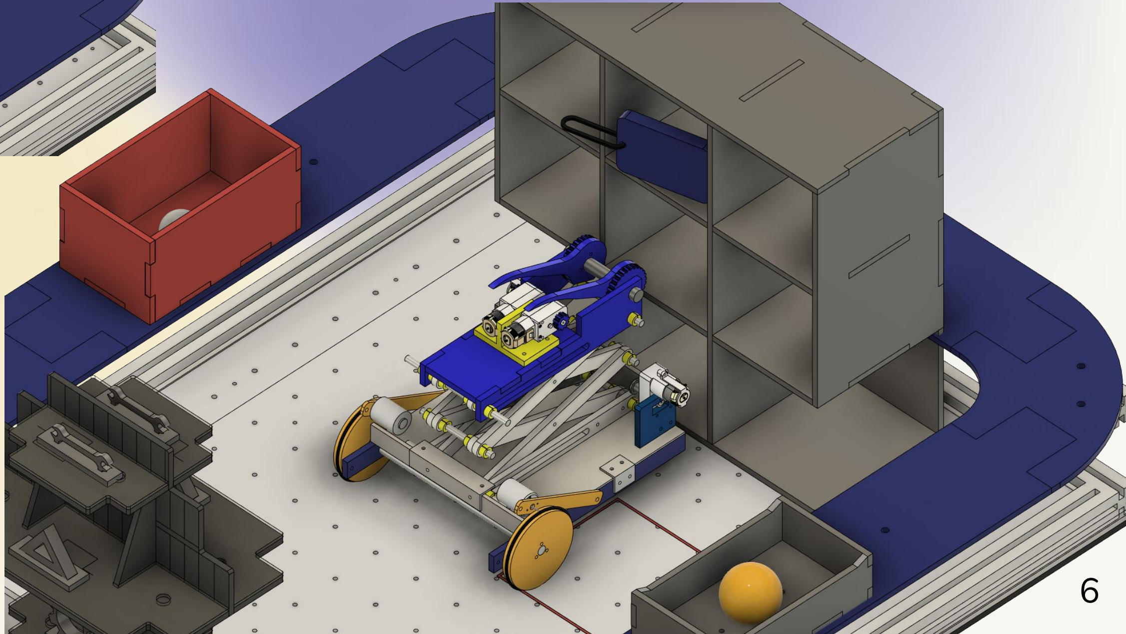
Picking up the Camera

And other objects

Troy







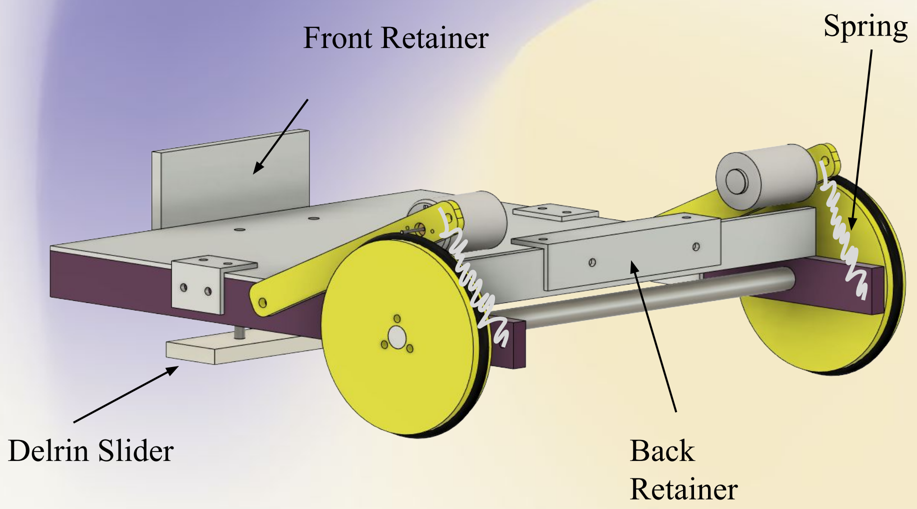
Nick

Friction is Friend

Friction Drive Drivetrain

Only left with non-geared high speed motors

Solution - Friction Drive!



Objective/Goal:

- Rotate 360° ~7s
- Move from Geisel to lockers ~3s
- Bear load of robot while retaining rigidity

Design:

- Individually controlled friction drive
- Springs to increase normal force between shaft and o-ring
- Metal base to lower center of gravity
- Delrin Slider

Integration:

- Scissor lift constrained by retainers

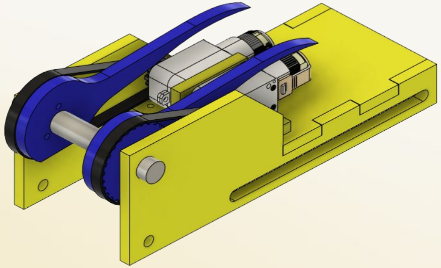
Scooping up the competition

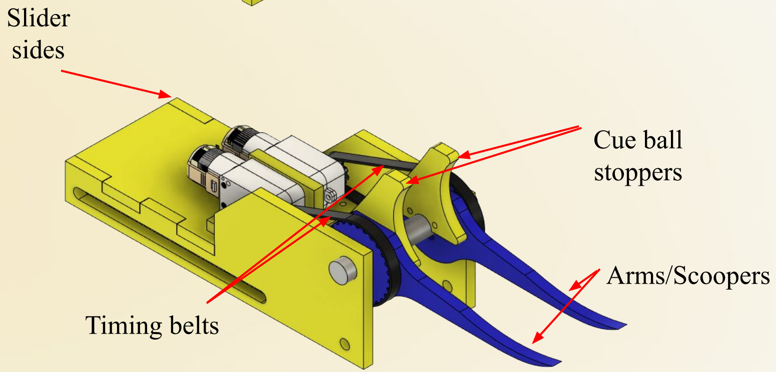
Timing Belt Arm/Scooper

Objective/Goal:
- Ability to grab most items
- Quick, Reliable and Accurate
- Compact

Design:
- Dual motor
- Gear reduction with timing belt - 28:10
- 2 arms
- Able to extend ~5”

Robot Integration:
- Directly apart of the scissor lift





Scissor Lift Rises

Objective/Goal:

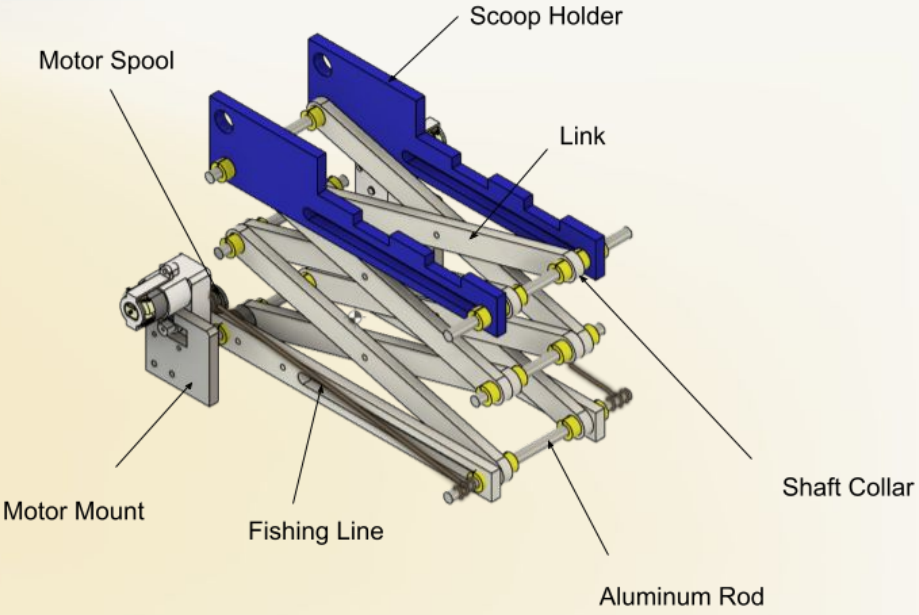
- Reach highest object (~15”)
- Stable vertical movement
- Compact
- Lift desired weight of about 600 grams (.6 kg)

Initial Design:

- Pair of 3 linkages on each side, 12 links in total
- Little constraint
- Spools were shorter

Final Design:

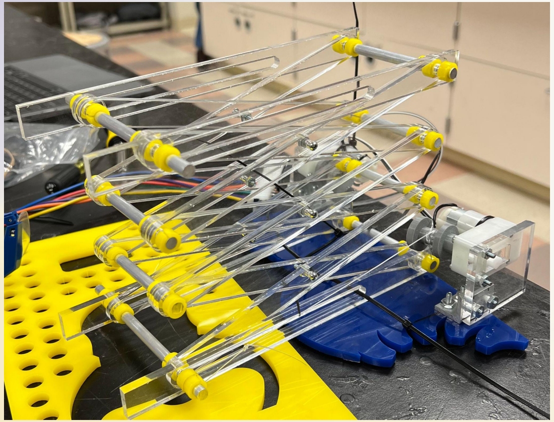
- Remove 2 pairs of linkages
- Longer spools
- Used L brackets and bolts to constrain
- Shaft collar, nuts + bolts to hold linkages in place



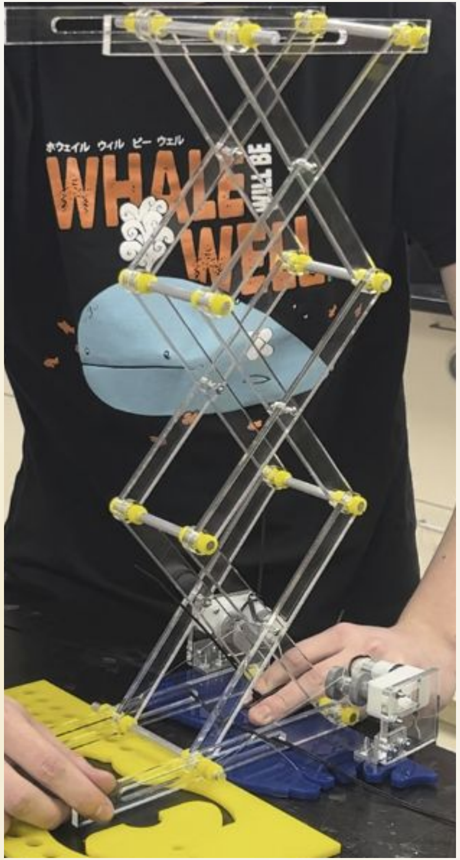
Angie

Risk Reduction -

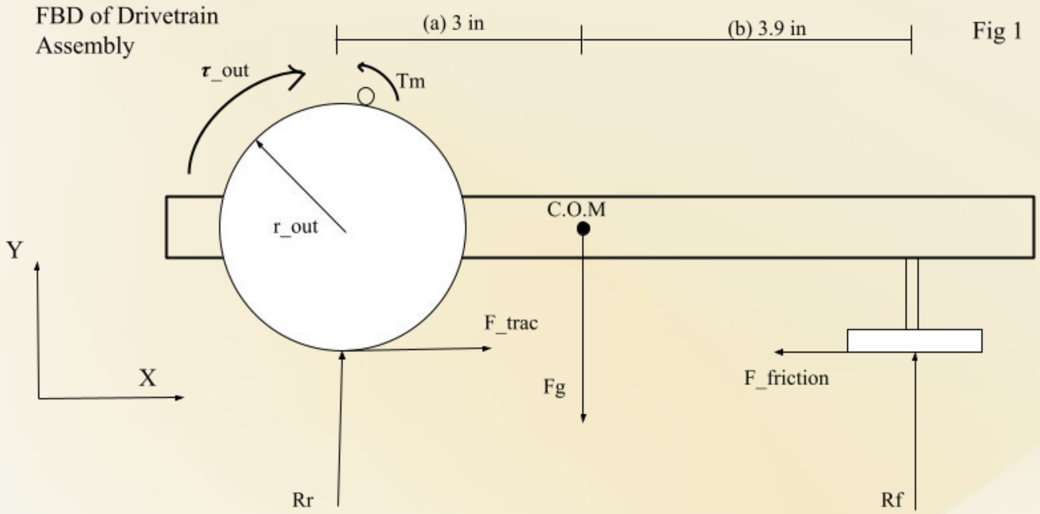
Will the Scissor Lift Work?

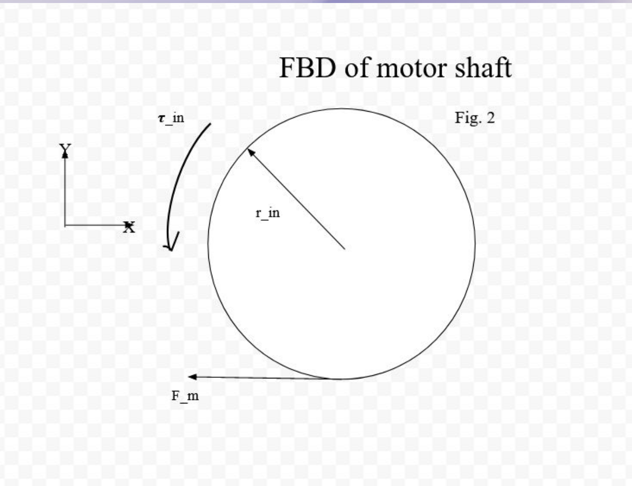


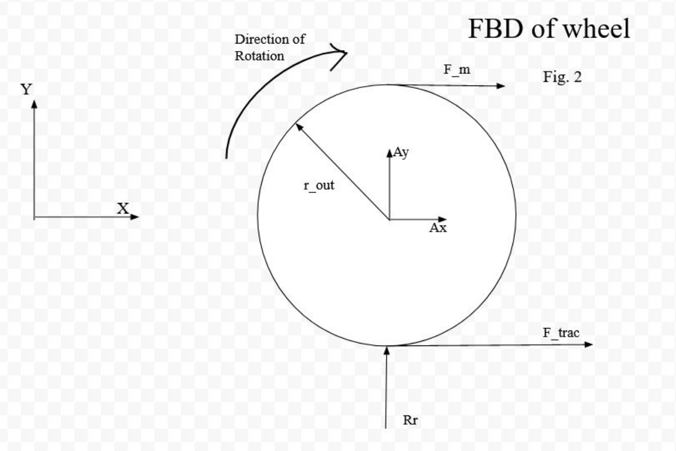
- Created a 1:1 model of scissor lift design
- Had the lift be on a temporary base and attached the motors + motor mount
- Scissor lift was able to go up and return to initial position when string was slack
- Kept alignment throughout testing
- Motor could easily support weight of scissor jack



FREE BODY DIAGRAMS







Drivetrain Analysis (Theoretical)

Nick

$$(1)\ \Sigma F_x = F_{trac} - F_{friction}$$

$$(2)\ \Sigma F_y = R_f + R_r - mg = 0$$

$$(3)\ \Sigma M_a = R_f(a + b) - mg(a)$$

$$F_{trac} = \mu_{ra}\left(mg - \frac{mg(a)}{a+b}\right) - \mu_{delrin}(mg)$$

$$F_{trac} = 2.73N$$

$$\Sigma F_x = A_x + F_{trac} = 0$$

$$\Sigma F_y = A_y + R_r = 0$$

$$\Sigma M_a = F_{trac}(r_{out}) - \tau_{out} = 0$$

$$F_{trac}(r_{out}) = \tau_{out}$$

Necessary torque output for movement

$$\tau_{out} = 0.11Nm$$

Assumptions:

- Disregard internal friction and any friction that isn't caused by delrin slider/wheels
- No slippage between metal shaft and rubber o-ring or o-ring and contest table
- Max power output from non-geared motor
- All components of drivetrain operate as a rigid body
- Point mass approximates center of mass

$$\frac{\tau_{out}}{\tau_{in}} = \frac{r_{out}}{r_{in}}$$

$$\tau_{out} = 3.3Nm$$

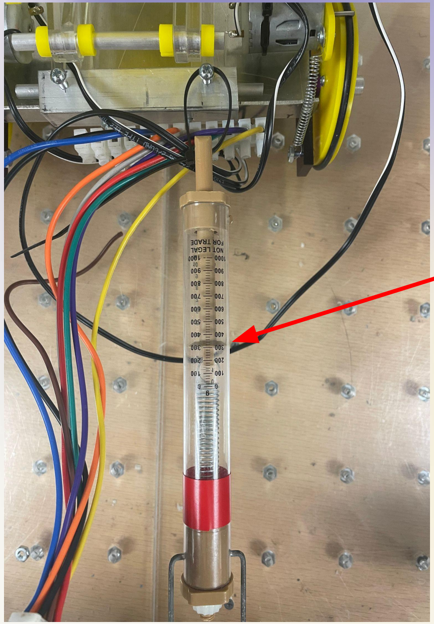
Theoretic max torque output given stall torque of DC motor

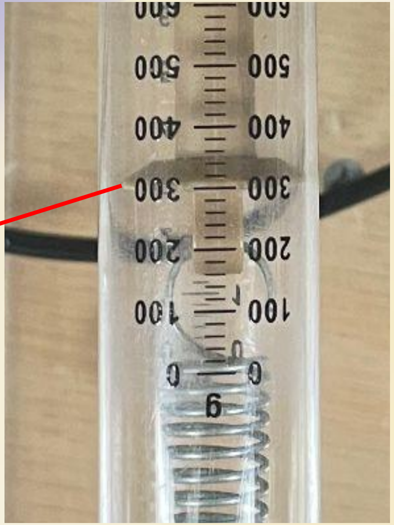
$$FOS = \frac{\tau_{avail}}{\tau_{need}} = \frac{3.3Nm}{0.11Nm} = 30$$

Troy

Theory vs Reality

How did we experiment? What were the results?





- Net force found using spring scale

$$\Sigma F_x = F_{traction} - F_{friction} - F_{spring} = 0$$

$$Here\ F_{spring} = 3.0N,\ F_{friction} = 4.56N$$

$$Thus\ F_{traction} = 7.56N > 3.53N\ necessary\ to\ initiate\ movement$$

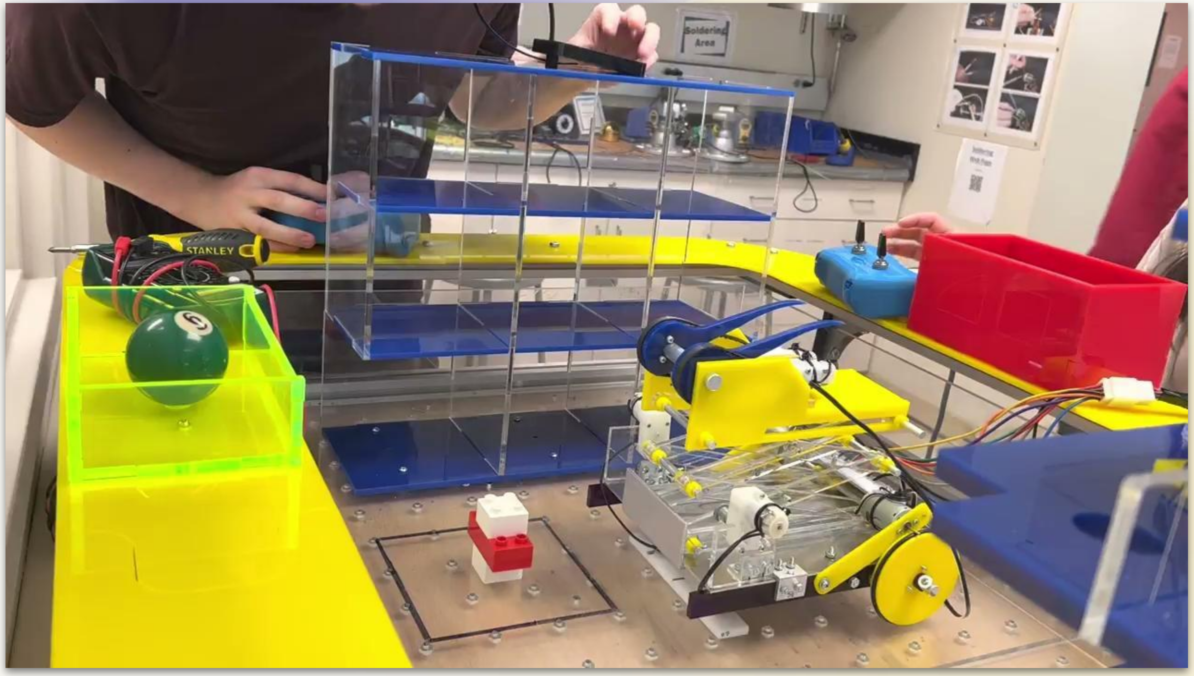
Measured Torque Output

$$\tau_{out} = F_{traction}(r_{out}) = 7.56N(0.04191m) = 0.317Nm$$

$$0.317Nm > 0.148Nm$$

Forklift Certified in Action

Angie



Theoretical Max - 411 Points

60s run - 301 Points