Reaction Wheel Inverted Pendulum

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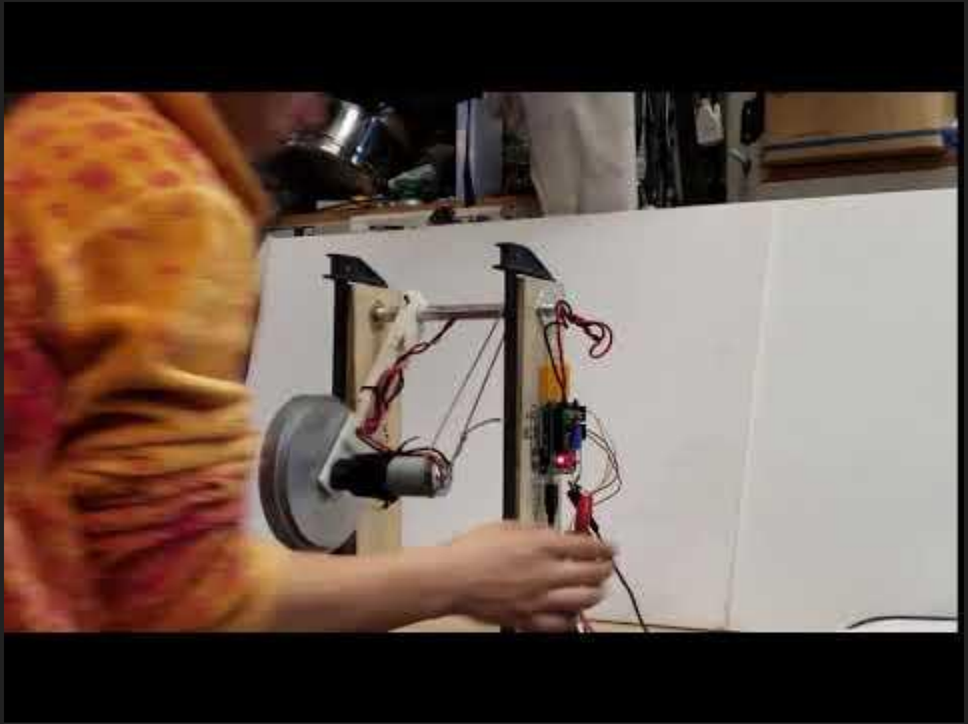
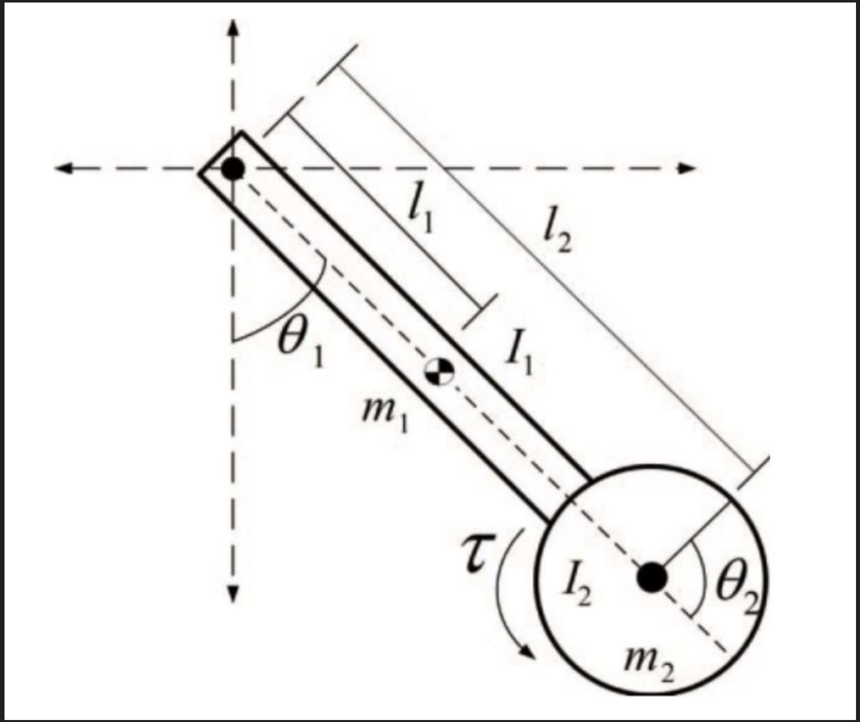


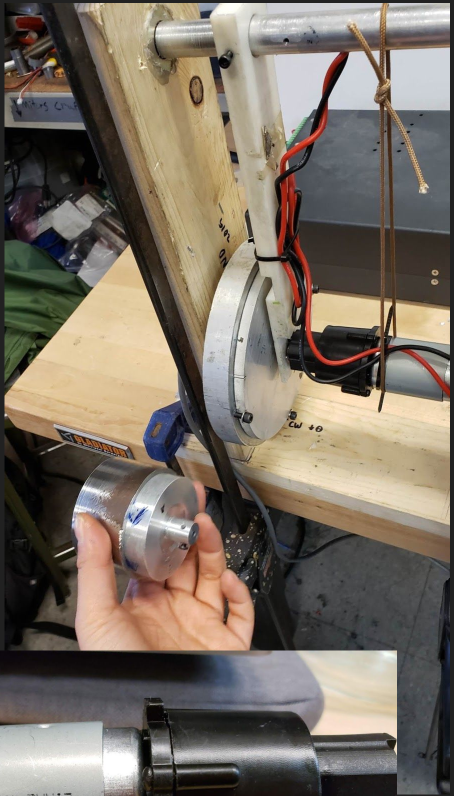
Concept / Goals



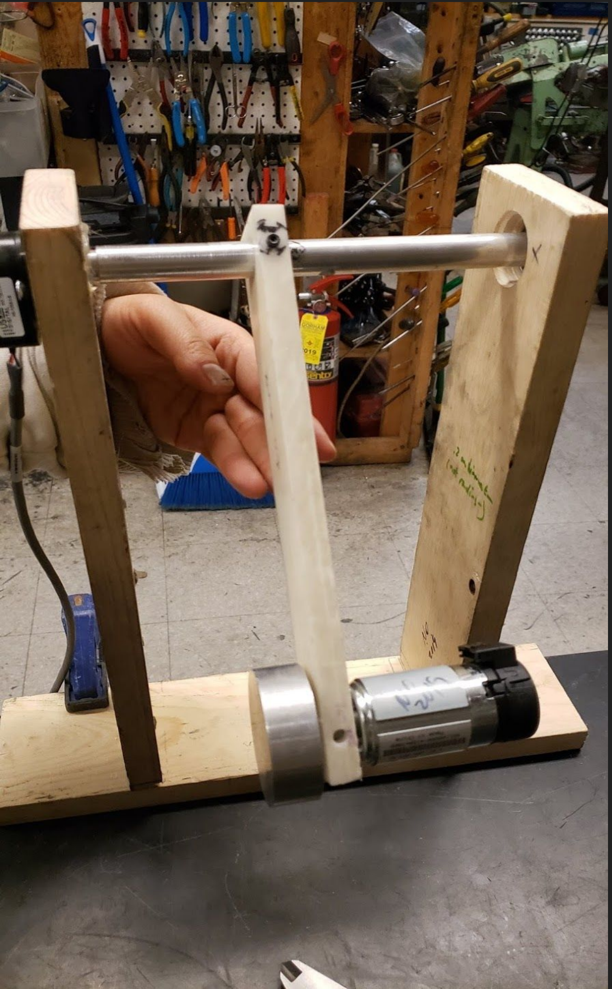
- Single-link pendulum with a torque-controlled reaction wheel
- Build from scratch
- Use PID / LQR to:
  - Achieve stability at Θ_1 = 0 quickly
  - Achieve stability at Θ_1 = 180 quickly
  - Achieve swingup quickly

Design iteration

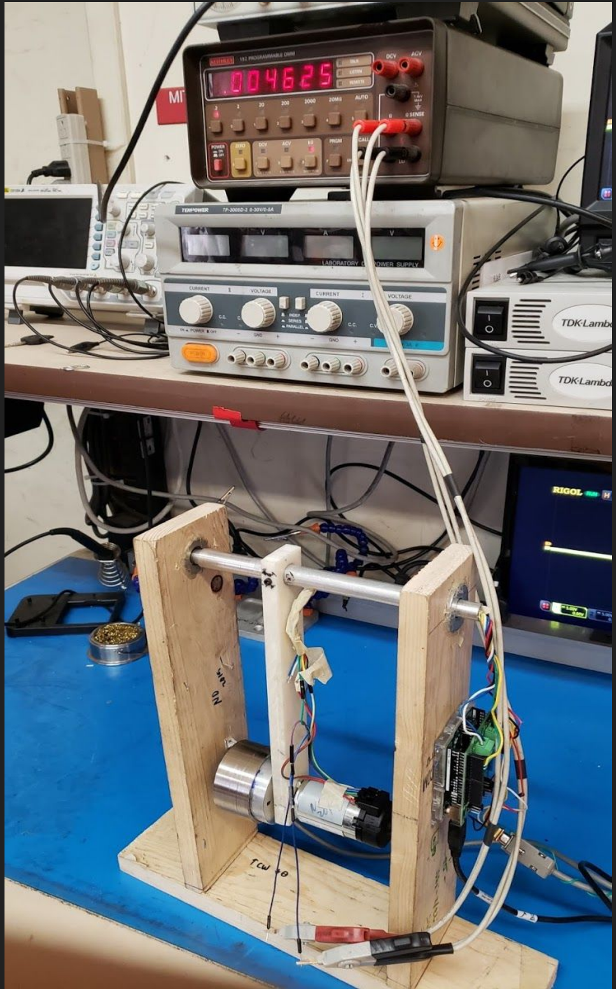
- Better hardware (better motor, better flywheel) -- torque over speed
- Motor velocity important (new motor without encoder, could not stabilize upright) -- address by estimating motor speed with PWM (brushed = high motor resistance)
- Flywheel shape (more radius, same mass)
- Fatter wires -- less smoke



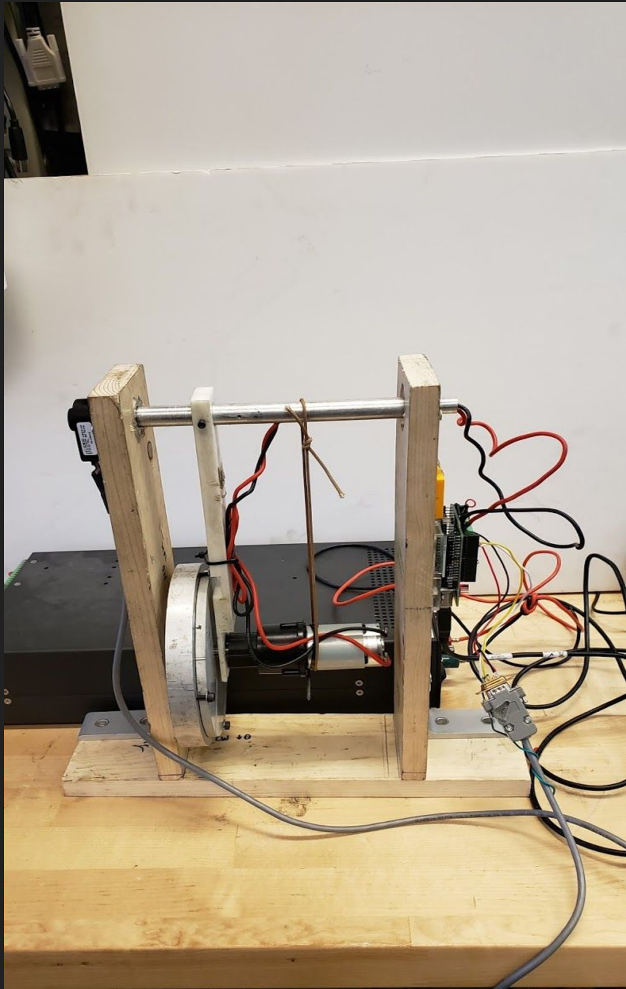
Iteration 1



Iteration 2

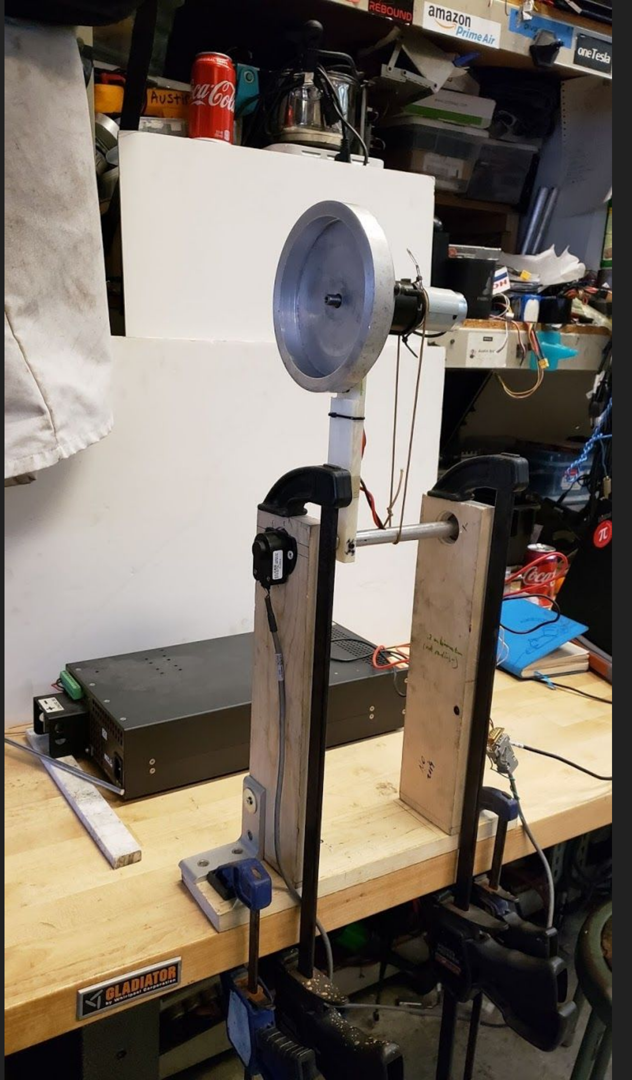


Iteration 3



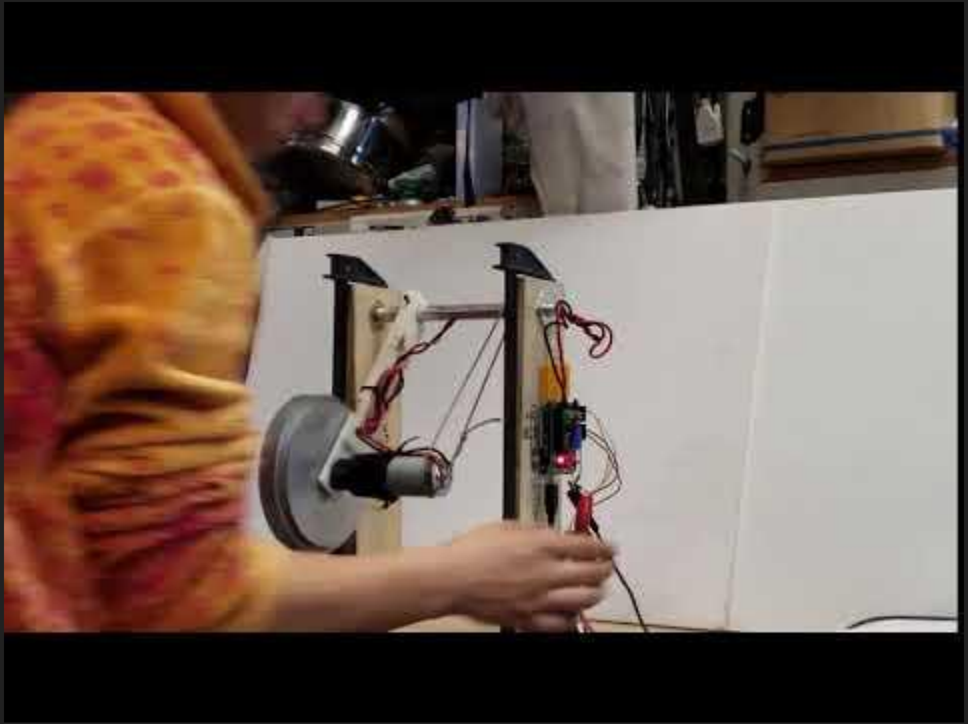
Final Design -- WIP

- Single shaft encoder (press-fit into shaft adapter) (1250 ticks/per)
- Stick pinned to shaft
- Final motor -- torque, but no encoder
- Run at 14V (on power supply), ~3 A max
- Commercial motor controller + Arduino
- Yes there are bearings
- Wood for easy prototyping adjustments
    - Avoided overconstraining

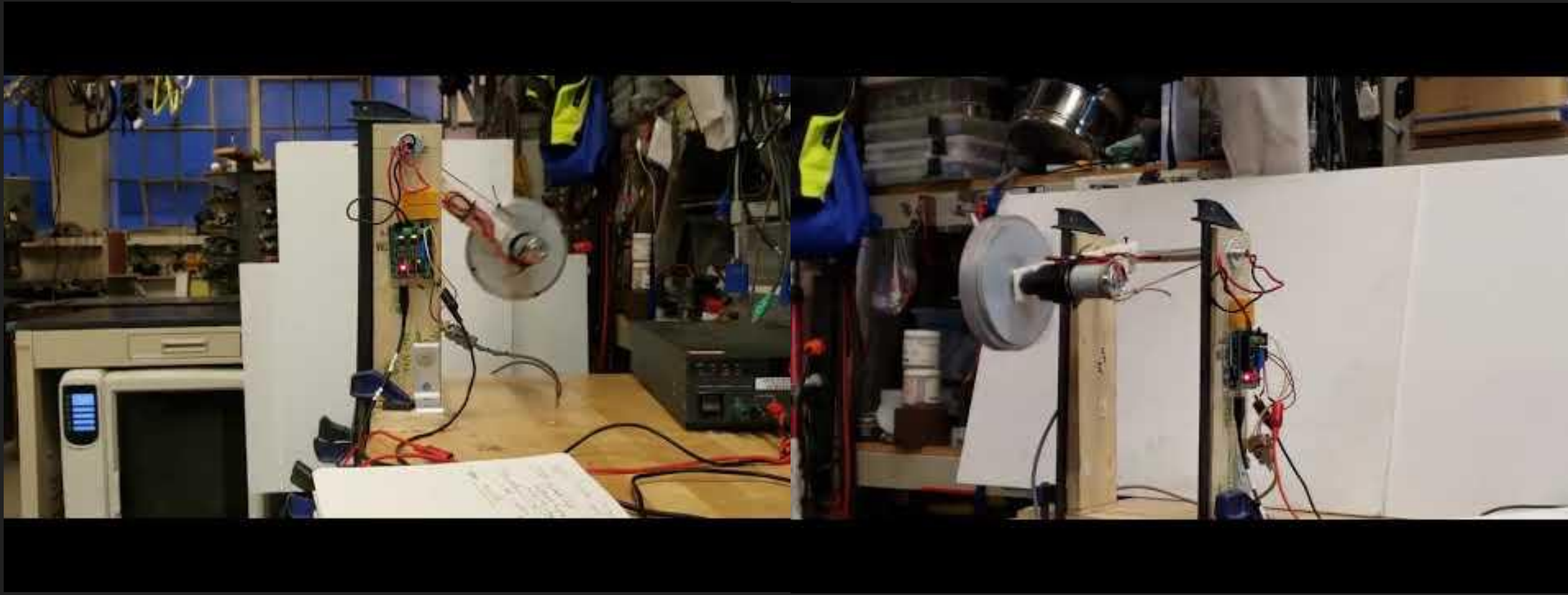


Demo 1: Three Iterations of Swingup

Final Swingup



Demo 2: Stabilize around downward fixed point



Results

(using PD control)

	Natural Downward Convergence (starting at 90 deg)	Controlled Downward Stability (starting at 90 deg)	Controlled Swingup (starting at 0 deg)
Small Flywheel	45 secs	11 secs	23 secs
Larger Flywheel	46 secs	3 secs	**3 secs**

Work in Progress

- Upright stabilization with LQR stabilization (is it torque-y enough?)
- Est. theta2
- Faster… everything
- Modeling -- same thing on wheels?
    - Learned to do lagrangian and linearize with sympy
    - Or apply… policy gradients!

Conclusions

Successes:

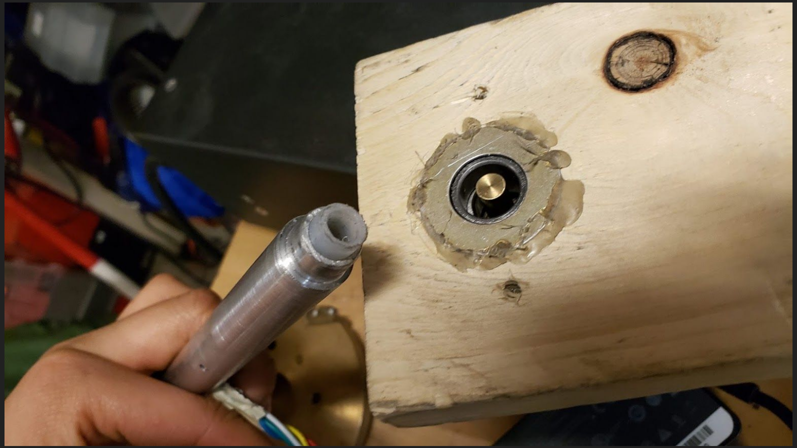
Swingup control

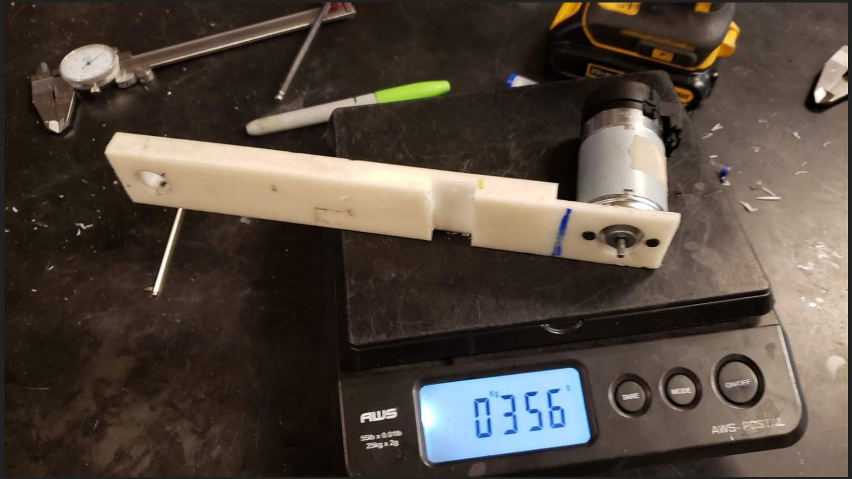
Downward stabilization

Thanks:

- Dane Kouttron - flywheel #2
- Mason Massie - new motor
- MITERS

Design tidbits





Flywheel in slow mo https://photos.app.goo.gl/faavWzmBYzNp4w5p6

Old motor: https://photos.app.goo.gl/4