Lifting the Forklift's Fork
Force Torque Power Energy Analysis

Introduction

Fork:

- Primary intake mechanism of robot
- Tilts up and down
- Utilizes power source(s) to lift up and down
- Desired motion: Lift 0.5 revolutions in 3 seconds

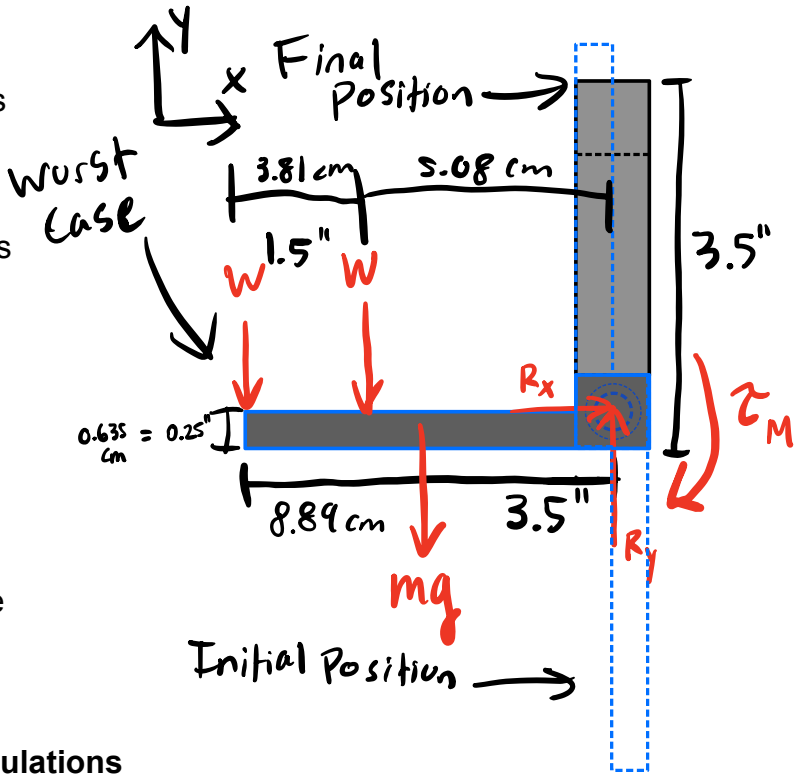
Assumptions:

- Quasi-static motion (acceleration is assumed negligible, such that

  $$\sum \tau = \sum F = 0$$

- Fork is 3D-Printed out of PLA at 100% density
  - Constant thickness of 0.25"
- Center of mass of fork is in center of fork
- Boxes do not slip and do not move in relation to the fork
- No friction/energy loss to environment

FBD(Right View):



Calculations

Masses/Weights: mass of crates $W = (0.032)(9.81) = \boxed{0.31392\ N}$

$\rho_{PLA} = 1.25\ g/cm^3$ $mg = \rho V g = (1.25\ g/cm^3)(10^{-3})(0.635 \cdot 8.89)(9.81) = \boxed{0.0692\ N}$

Energy Needed: $E_{needed} = \Delta PE = \sum mg\Delta h = W(2(0.0508)) + W(2(0.0889)) + mg(0.0889)$

$= \boxed{0.0939\ J}$

Power Needed: $P_{needed} = \frac{E_{needed}}{3sec} = \boxed{0.0313\ W}$

Torque Needed: $T_{needed} = \sum \tau = W(0.0889) + W(0.0508) + mg(\frac{1}{2}(0.0889)) = \boxed{0.0469\ Nm}$

Selected power source: Geared Motor

- Max Torque = 0.2801 Nm
    - Factor of Safety: $\frac{\tau_{avail}}{\tau_{needed}} = \frac{0.2801}{0.0469} = 5.9683$
- Max Energy = 35.89 J
    - Factor of Safety: $\frac{E_{avail}}{E_{needed}} = 382.3648$
- Max Power = 0.5982 W
    - Factor of Safety: $\frac{P_{avail}}{P_{needed}} = 19.1193$

Conclusions

From this analysis, I can conclude that the fork mechanism will have more than enough torque, energy, and power in order to function effectively, since each factor of safety is well above 5. I chose the geared motor because we need consistent, somewhat quick rotation of the fork: this required a motor. The geared motor is a better choice than the non-geared motor because it is slower than the extremely fast non-geared motor and has a greater torque. If, in the future, there is any limiting factor of this mechanism, it would be the torque, since this has the smallest factor of safety: 5.9683.