# NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

**FINAL PRESENTATION**
**Cleveland State University**
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NFPA Fluid Power Vehicle Challenge

# The 2022 Cleveland State Bike Team!


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# Final Bike Design

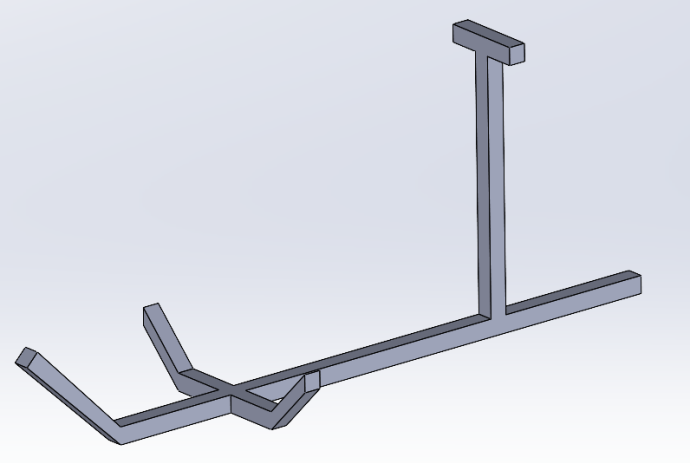
# Design Objectives

- Simplify and optimize the hydraulic circuit
- Optimize the gear ratio for maximum efficiency and sprint time
- Make pedal charging an easier and quicker operation
- Keep the bike as lightweight as possible

# Summary of the Midway Review

- Implement a new hydraulic circuit
- Redesign the frames mounting options
- Implement a pneumatic system to simplify user operation
- Planned on optimizing the gear ratio by utilizing a CVPT transmission.

# Vehicle Design

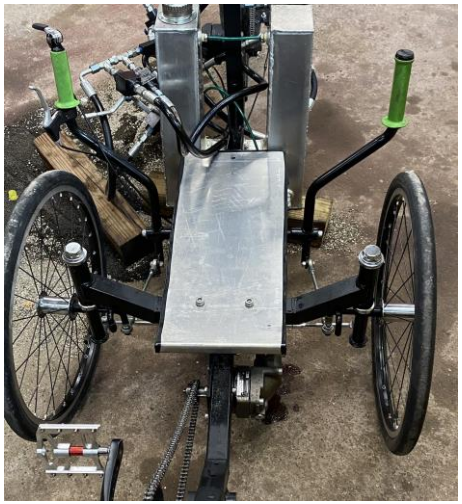


# Selection of Hardware

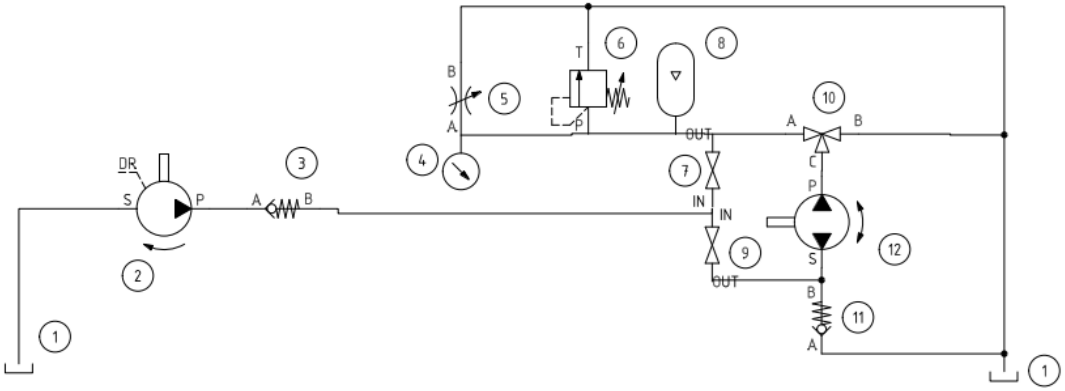
- Bluetooth Parker Senso-node pressure sensor
- 60T Front Drive Gear, 21T and 13T Driven Gears
- Bent axis reciprocating piston pump/motor (Parker F11-005)
- A True three-way ball valve
- ⅛” Aluminum mounting plate and safety guard
- 1.5” square steel tubing for frame
- SPD Clip-in Pedals

# Progress Since Midway

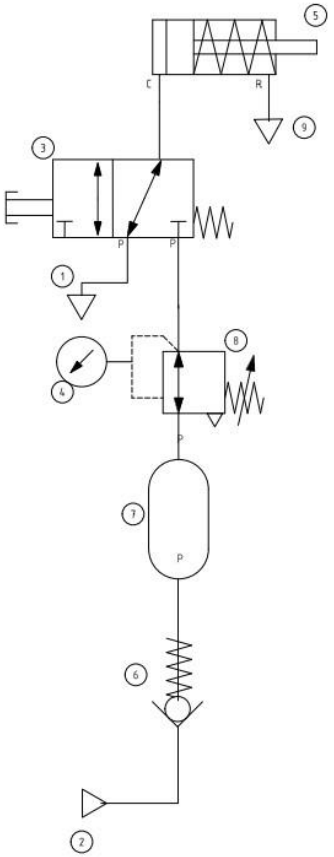
- Additional Adjustments to Hydraulic Circuit After Testing
- Added ⅛” Aluminum Mounting Plate
- Seat Height Adjustment and Additional Support
- Drained and cleaned hydraulic lines.
- Fabricated and fastened a removable safety guard to protect the rider from front pedal gearing. As well as additional safety measures.
- Tested and mounted two gears on the motor so two different gear ratios can be achieved. One High Torque-Low Speed and One Low Torque-High Speed.



# Circuits from Midway

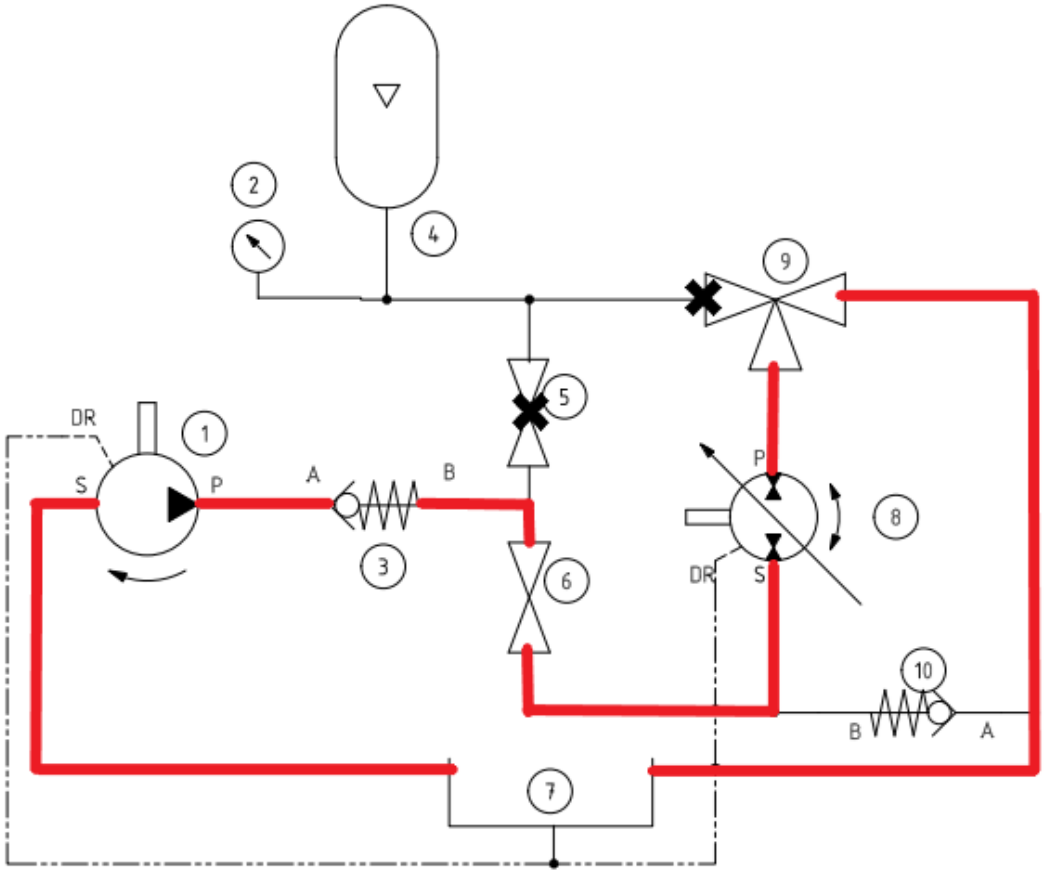



Hydraulic Circuit

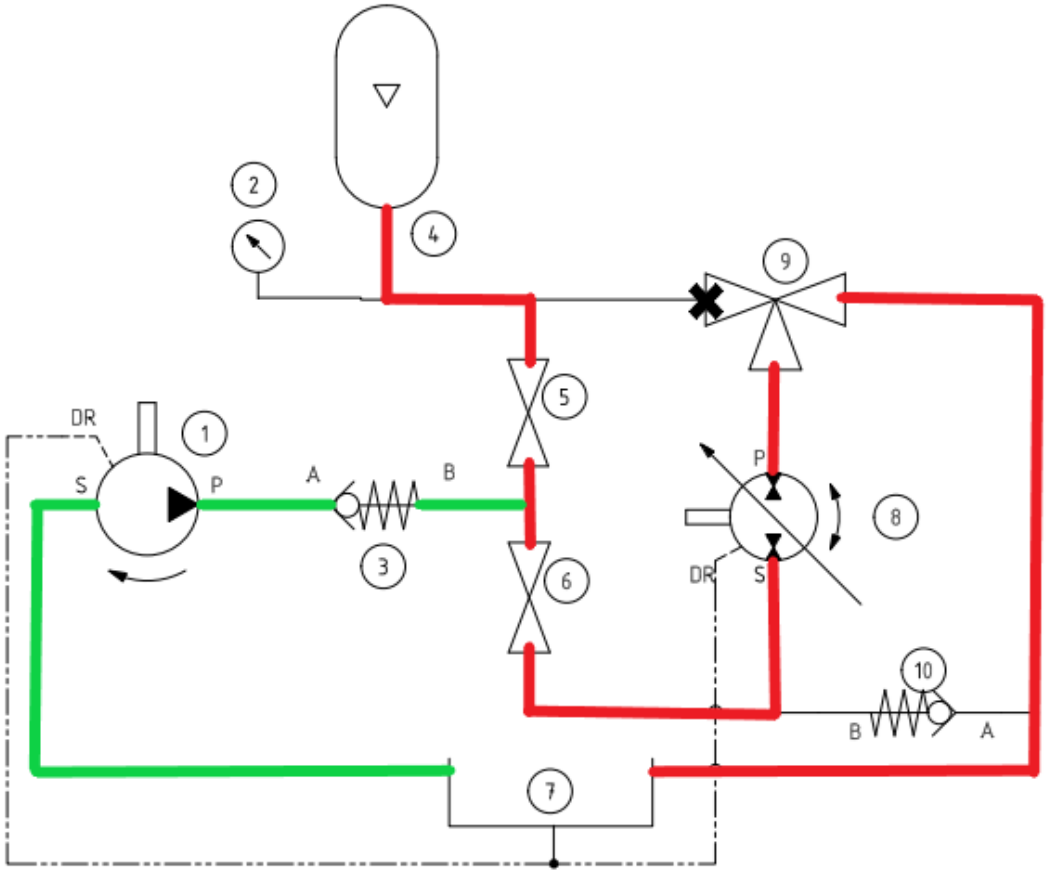


Pneumatic Circuit

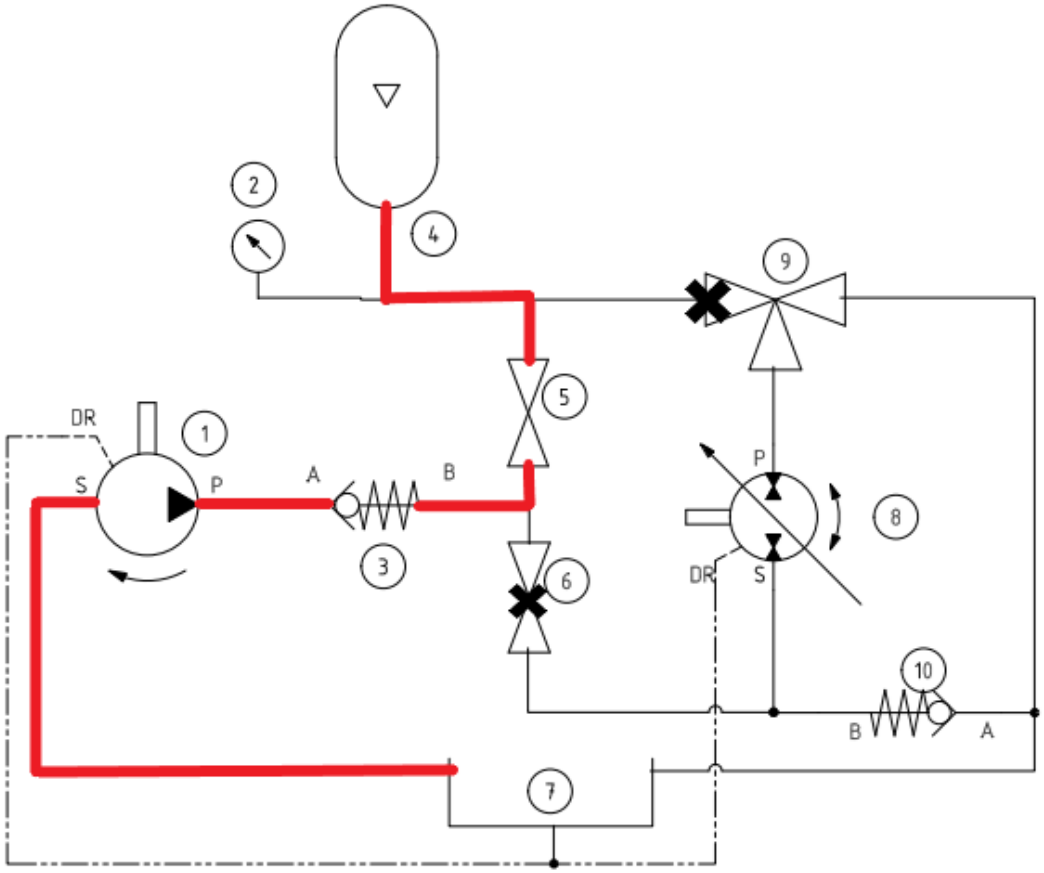
# Pedaling - Direct



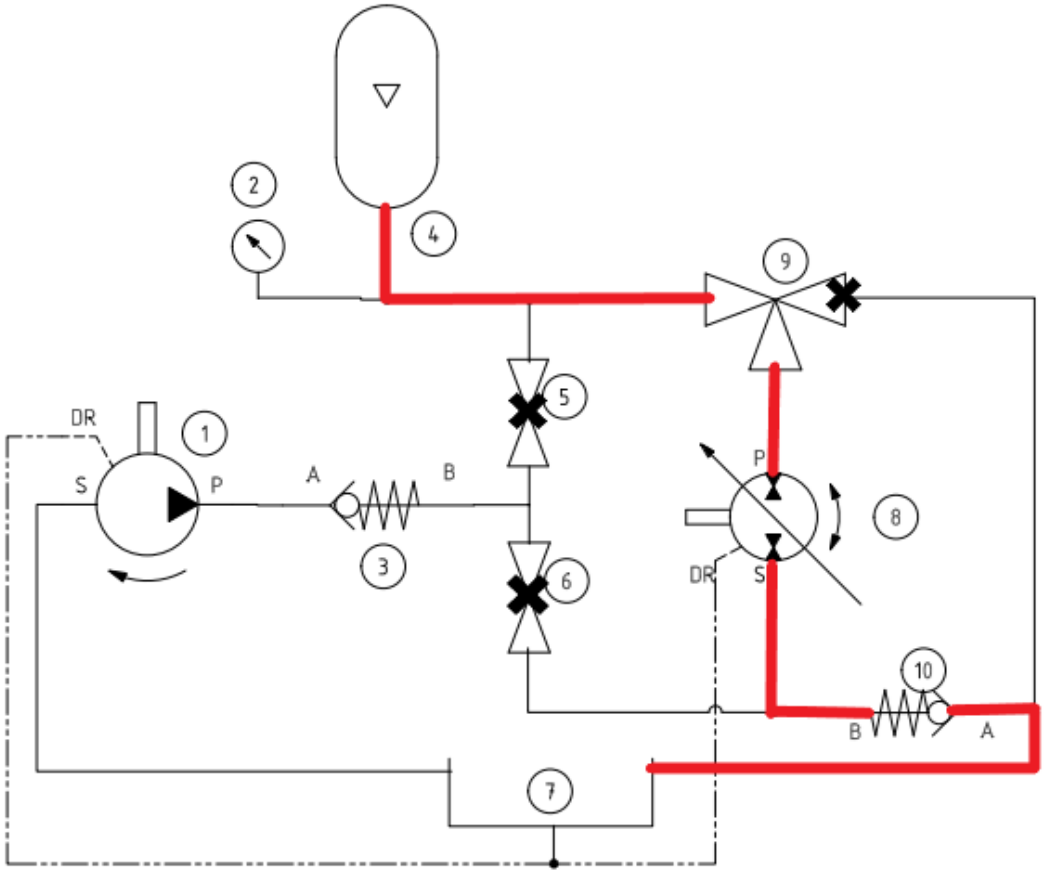
# Accumulator Drive + Pedal Drive



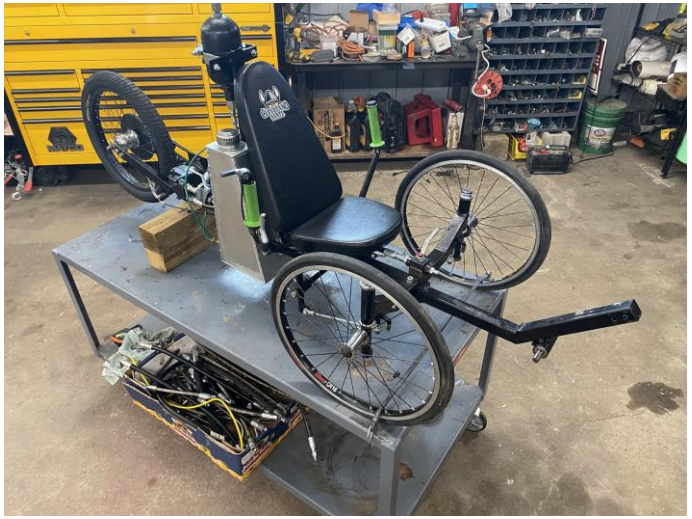
# Charging Accumulator

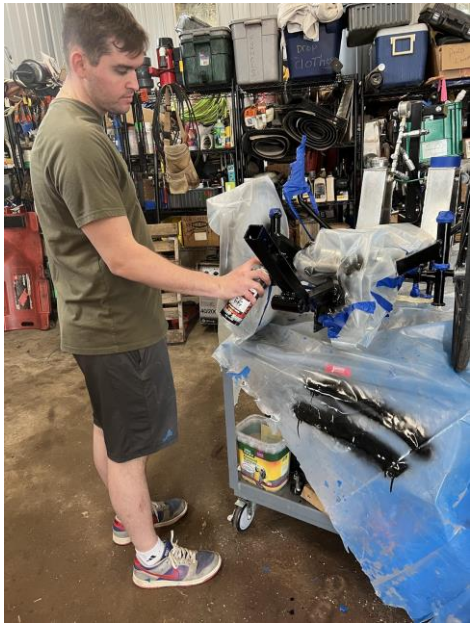


# Regenerative Braking



# Vehicle Construction

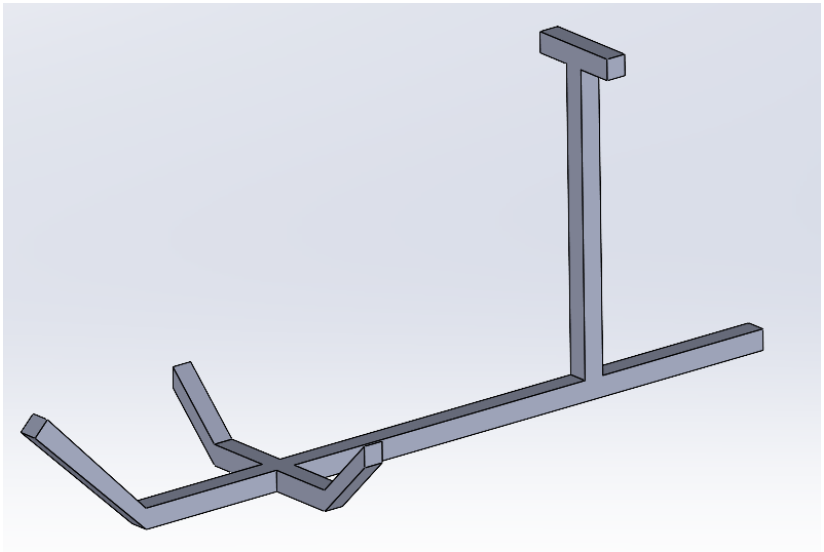


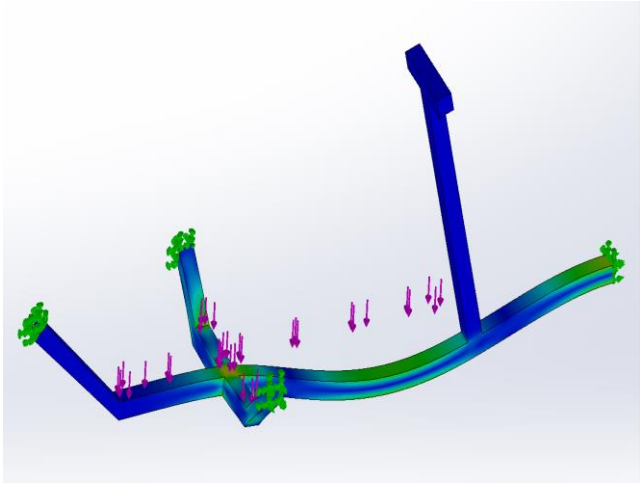


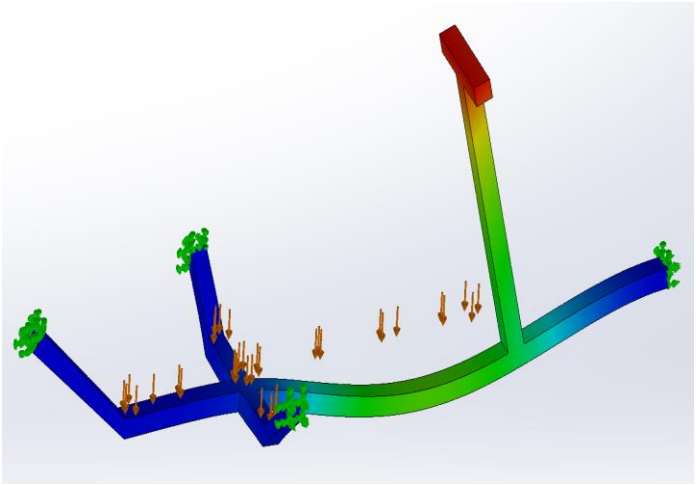
# FEA Analysis

Maximum Stress: 50 MPa

Maximum Deflection: 0.8mm







# Problems Encountered

- Time/Availability Constraints:  no pneumatics, cvpt
- Non-true 3 way valve causing pressure loss
  - pressure was applied to all 3 ports
- Difficulty charging to 3,000 psi
- Case drain leak/low psi PTFE

# Gear Ratios and Precharge

Dual Gear Ratios: 60T/13T = 4.62

60T/32T = 1.875

@700 psi precharge

| | **Charge Time (3000 psi)** | **Top Pedal Speed** |
|---|---|---|
| High Gear Ratio | Unobtainable | 14 mph |
| Low Gear Ratio | 3 minutes 46 seconds | 5 mph |

# Efficiency Testing

| Precharge (psi) | Pressure (psi) | Distance (ft.) | Efficiency |
|---|---|---|---|
| 600 | 2500 | 798 | 7% |
| 600 | 3000 | 1,211 | 10% |
| 700 | 3000 | 1,332 | 11% |
| 1000 | 3000 | 878 | 7% |

# Sprint Testing

| Precharge (psi) | Gear Ratio | Time (s) |
|---|---|---|
| 600 | 1.875 | 21.4 |
| 600 | 4.62 | 20.2 |
| 700 | 4.62 | 19.6 |
| 1000 | 4.62 | 18.7 |

# Lessons Learned

- Proper component sizing and selection is important to a well performing circuit.
- Keeping a consistent schedule is important to meeting project deadlines.
- Spare fittings and hardware are important for the continuation of project progress.

# Future Improvements

- Addition of the CVPT to optimize gear ratios
- Pneumatic components installed on bike
- Gear set for front precharge/drive
- Separate hand pump lever for manual charging


# Final Vehicle

- Top Speed:  26mph
- Curb Weight: 160lbs
- Full Throttle Efficiency: 10%

# Question?