NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
CLEVELAND STATE UNIVERSITY
BOGDAN KOZUL
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Meet the Team!

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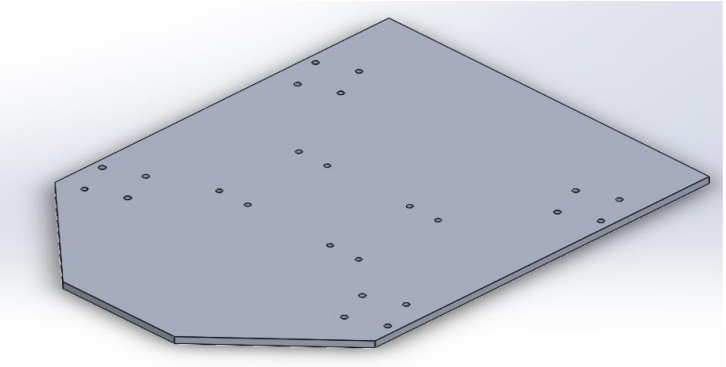
Design Objectives

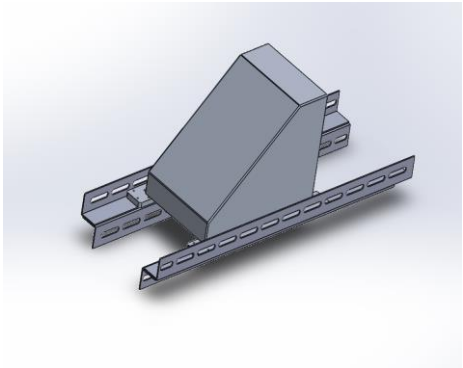
1. Simplify and Optimize hydraulic system
2. Create pneumatic controls
3. Optimize gearing ratios
4. Keep curb weight below 210 pounds

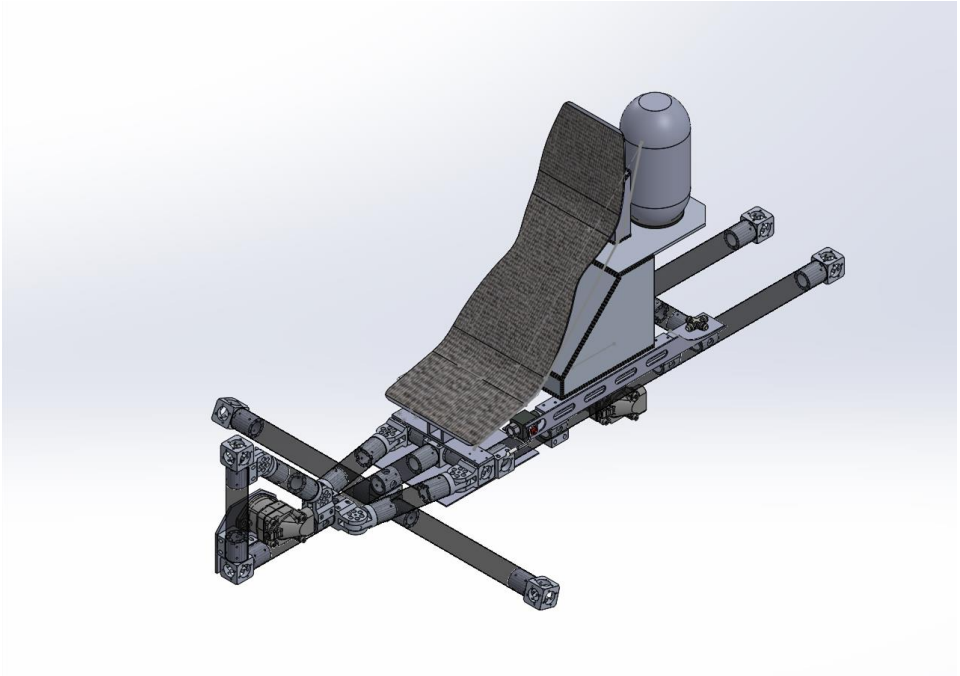
Summary of Midway Review

- Improving upon and redesigning last year's bike
- Simplify the hydraulic system
- Created and prototyped pneumatic controls
- Investigating gearing options

Vehicle Design



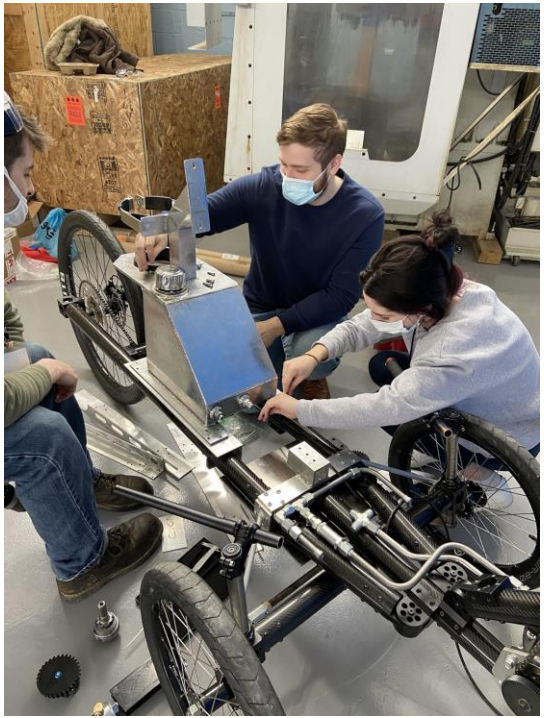




Selection of Hardware

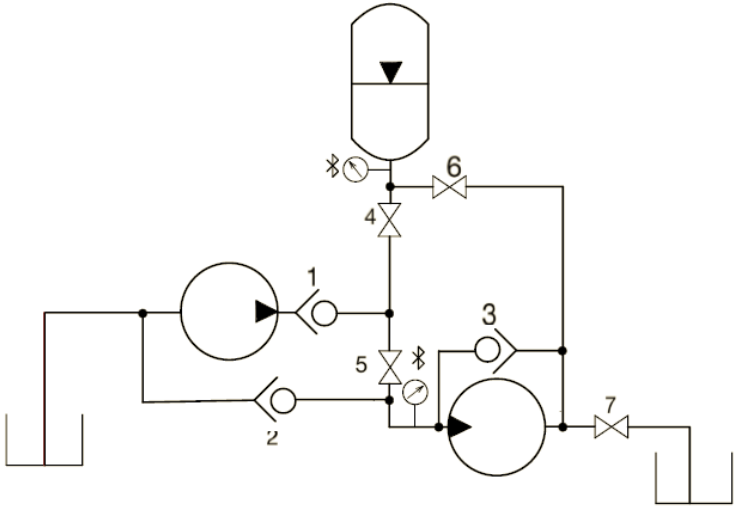
- Bluetooth pressure sensor
- 50T elliptical gear
- Bent axis reciprocating piston pump/motor (F11-005)
- 3D printed pneumatic gearing
- Aluminum mounting hardware
- ½” mild steel tubing

Progress Since Midway

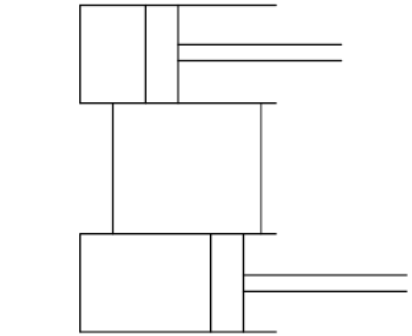


- Hydraulic system circuit completed and functional
- Pneumatic circuit completely remodeled and working
- Vehicle testing complete
- Better mounting angles manufactured

Circuits from Midway



Hydraulic Circuit



Pneumatic Circuit

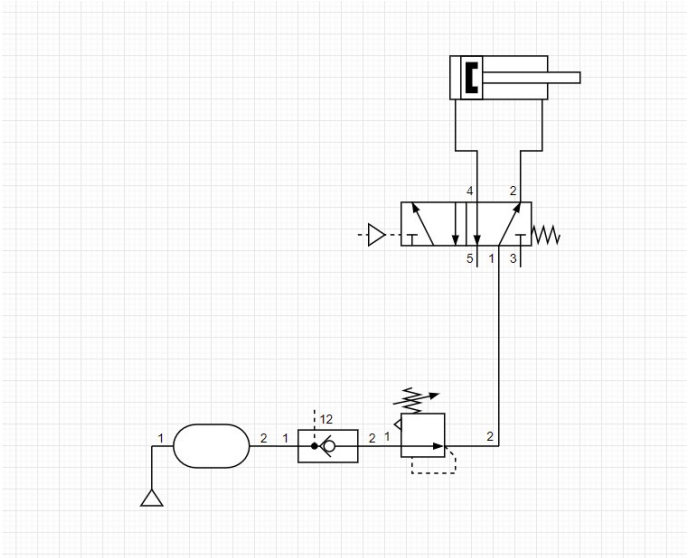
Pneumatic Revamp

Problems with old design:

- Actuator hard to place/mount in convenient area for rider
- Unreasonably hard to push during riding
- Changing the volumes did not create any appreciable force difference for our needs
- Speed of actuation was directly proportional to how fast and hard the rider pushes, about 2-5 second actuation

New Design:

- Greater force transmission due to pressurized reservoir
- Easy 5/2 toggle valve makes switching between regen and pedal effortless
- Quicker actuation and less effort needed during riding. About 1 second actuation.

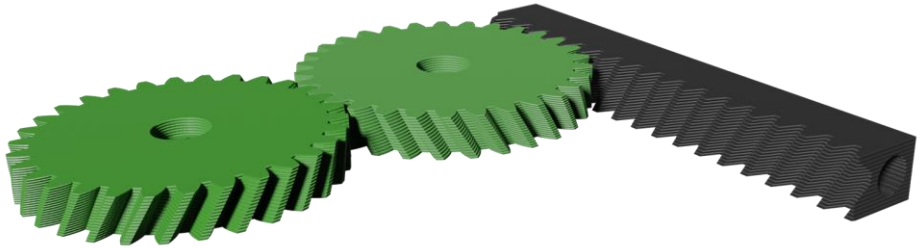


Pneumatic Circuit

Pneumatic Testing

Several teeth sizes were tested:

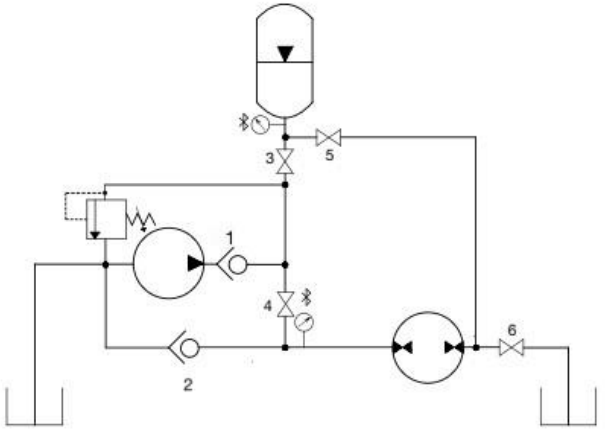
Tooth #	Transmitted Force
30T:	30 in*lbs
35T:	35 in*lbs
40T:	40 in*lbs



Improvements on the Hydraulic Circuit

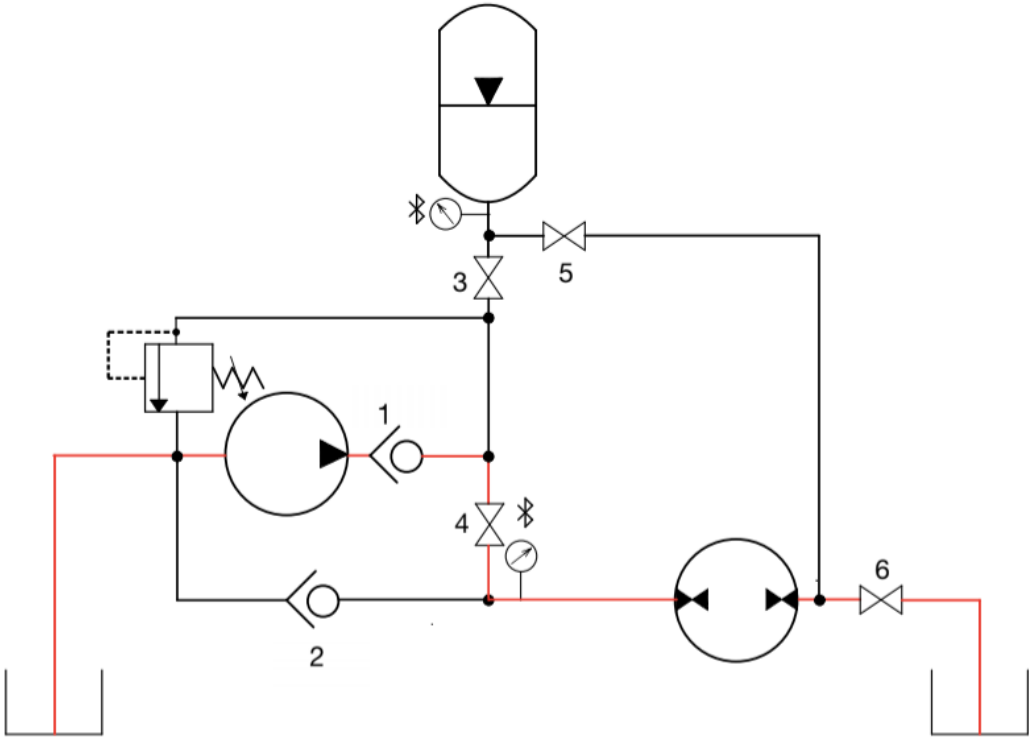
Added in a pressure relief valve.

- Positioning
- Function
- Increased line sizing to ½” throughout the whole design instead of just half of the circuit



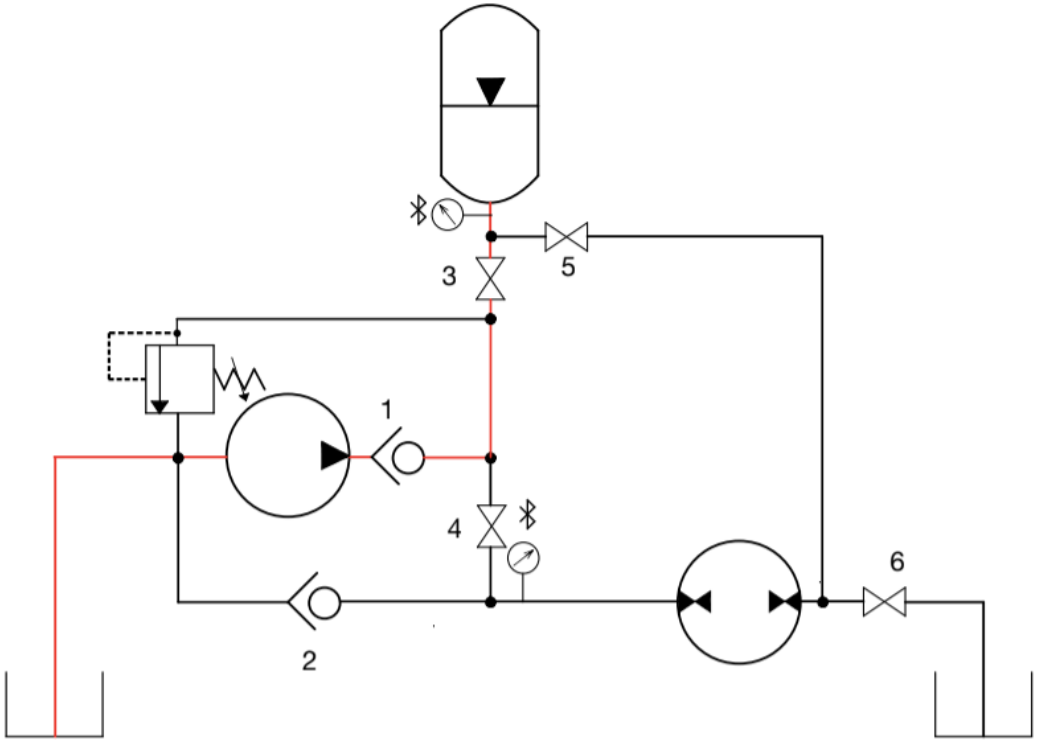
Hydraulic Circuit

Pedaling



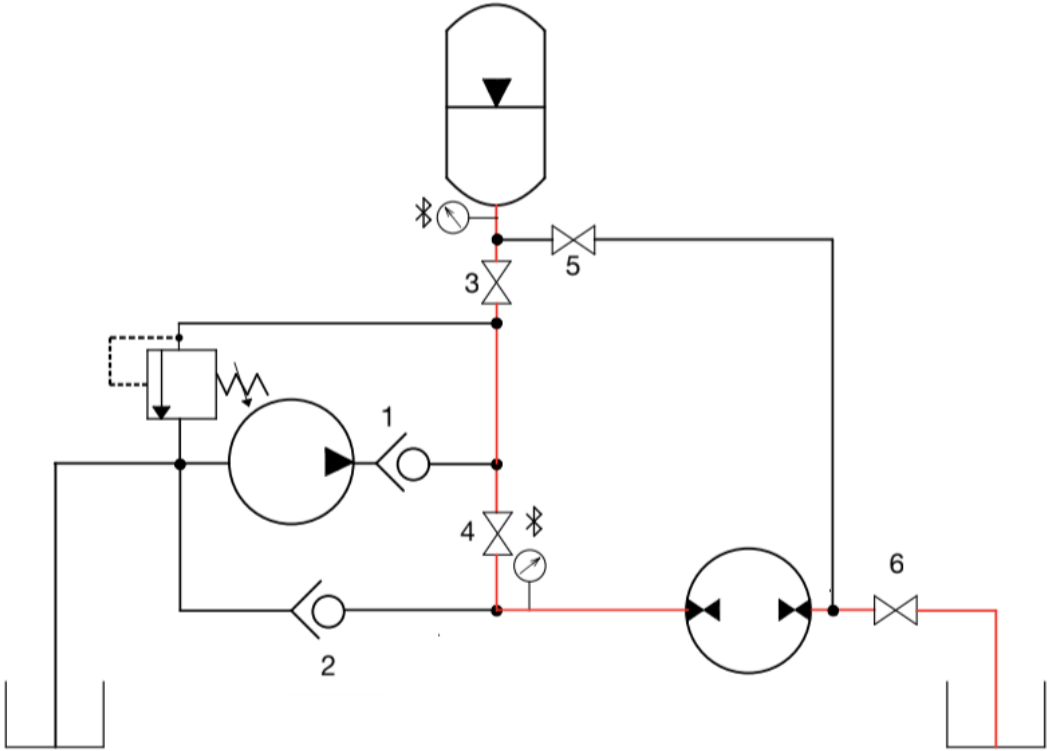
Ball valve #3	Close
Ball valve #4	Open
Ball valve #5	Close
Ball valve #6	Open

Charging Accumulator



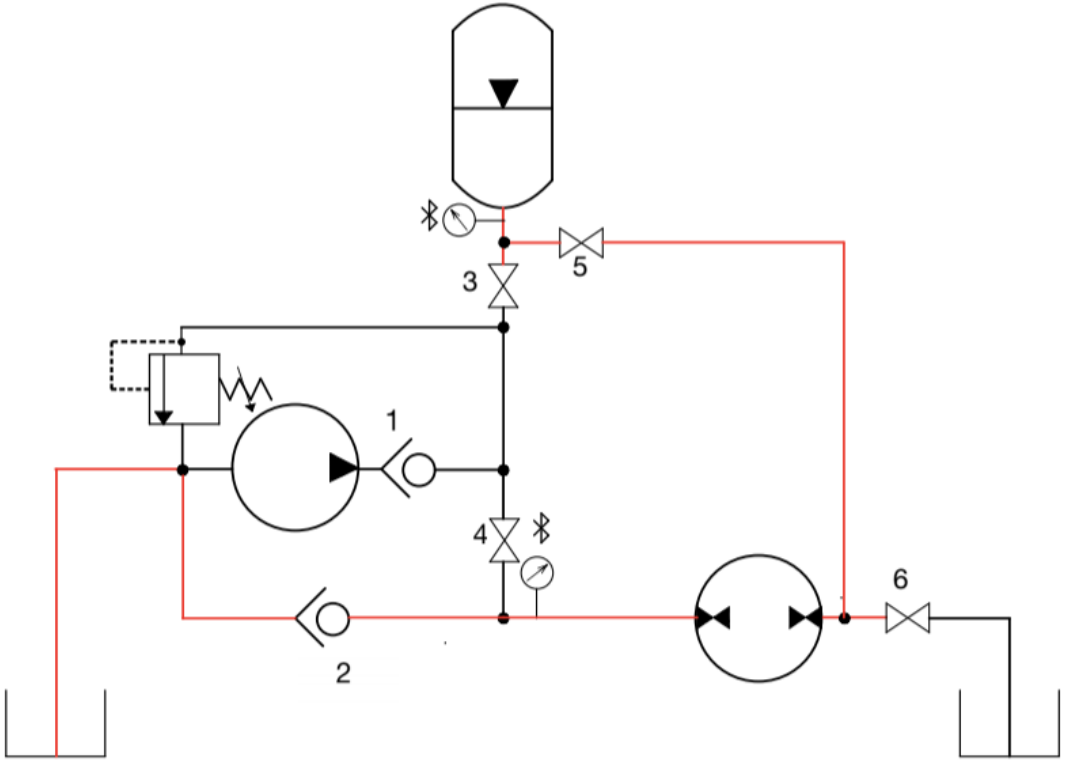
Ball valve #3	Open
Ball valve #4	Close
Ball valve #5	Close
Ball valve #6	Open

Discharge



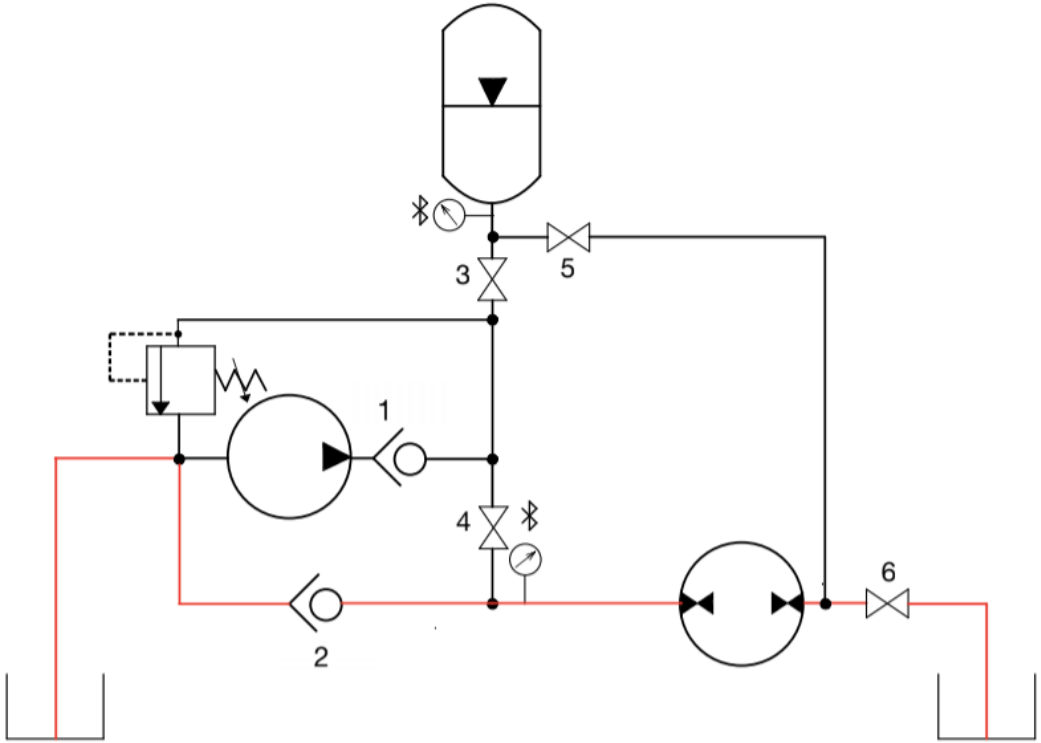
Ball valve #3	Open
Ball valve #4	Open
Ball valve #5	Close
Ball valve #6	Open

Regenerative Braking



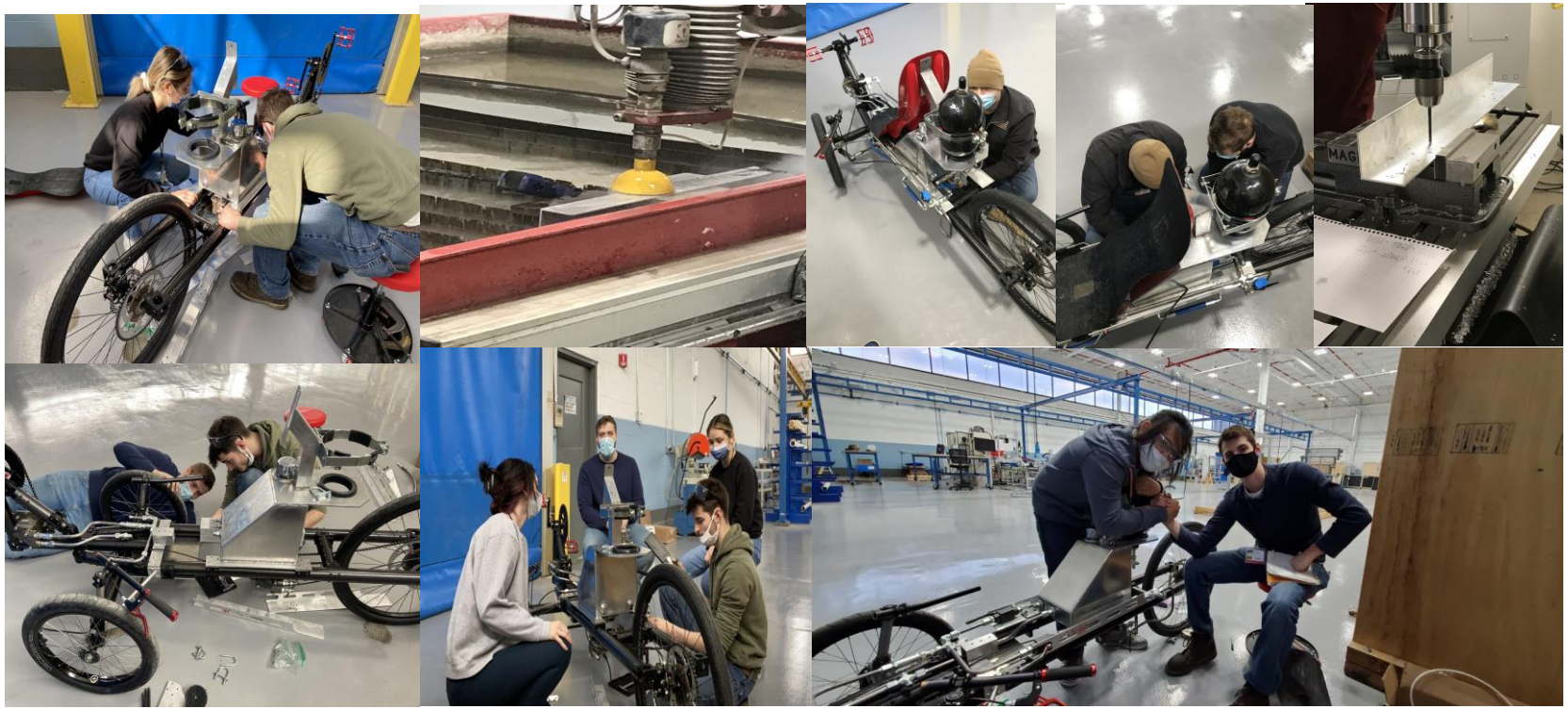
Ball valve #3	Close
Ball valve #4	Close
Ball valve #5	Open
Ball valve #6	Close

Downhill Riding

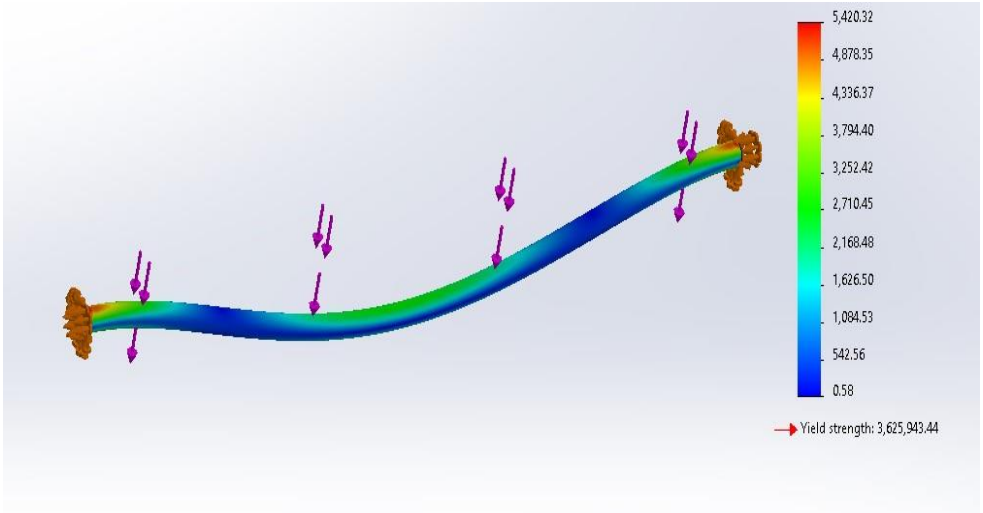


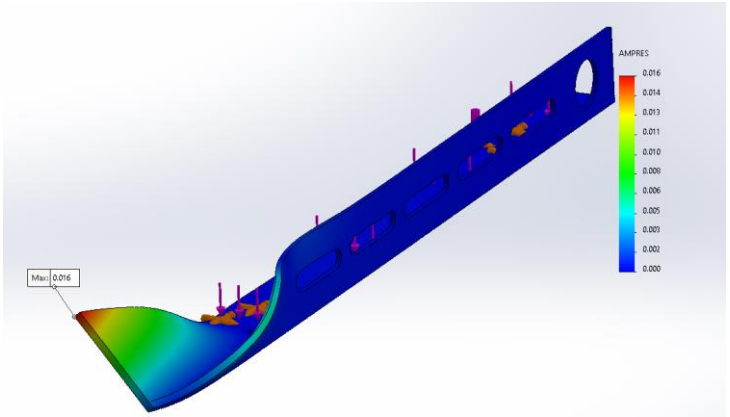
Ball valve #3	Close
Ball valve #4	Close
Ball valve #5	Close
Ball valve #6	Open

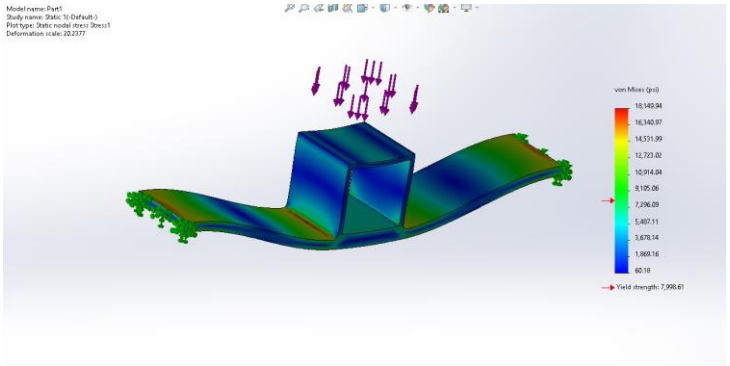
Vehicle Construction



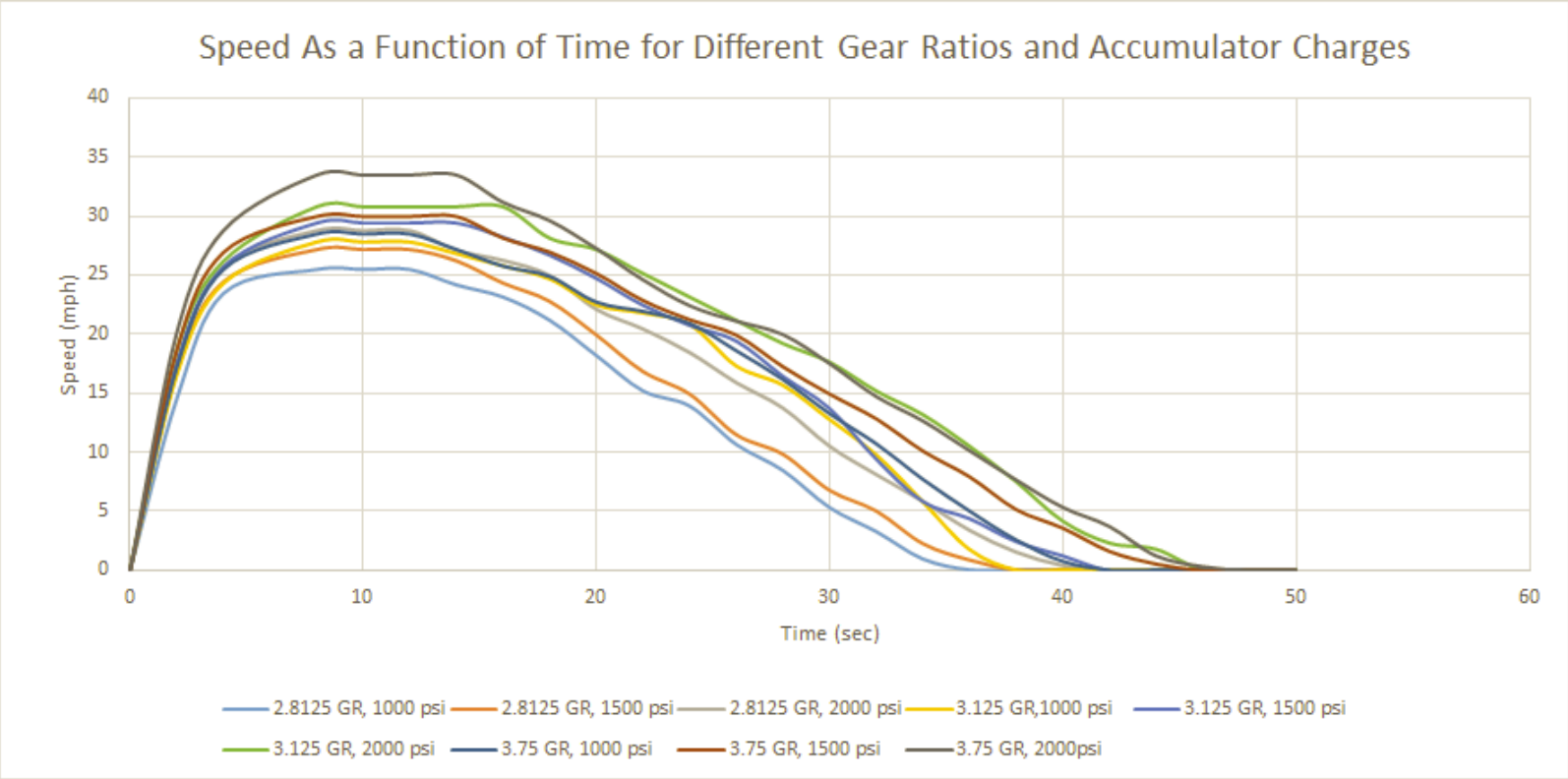
FEA Analysis





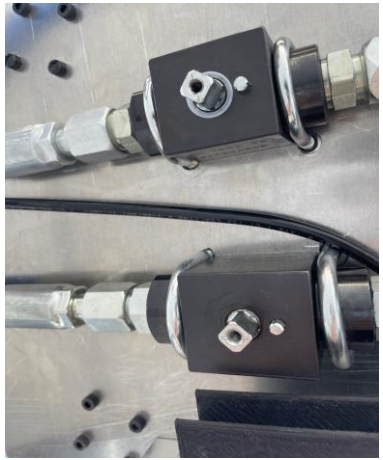


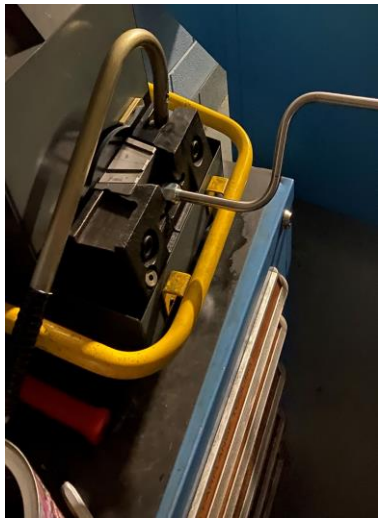
Speed


Speed As a Function of Time for Different Gear Ratios and Accumulator Charges
Speed (mph)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
Time (sec)
2.8125 GR, 1000 psi
2.8125 GR, 1500 psi
2.8125 GR, 2000 psi
3.125 GR,1000 psi
3.125 GR, 1500 psi
3.125 GR, 2000 psi
3.75 GR, 1000 psi
3.75 GR, 1500 psi
3.75 GR, 2000psi

Lessons Learned

- Coordination of schedules is critical
- Test tool Capabilities before ordering material
- Material Selection
- Spare parts should be kept on hand





Future Improvements

- Tighter turning radius
- Stability/balance improvements
- Accumulator charging method
- Pedal drive with accumulator discharge for uphill riding
- More robust pneumatic gearing
- Onboard compressor for pneumatic reservoir recharging

Final Vehicle

- Top Speed: 30.8mph
- Curb Weight: 185 lbs
- Full Throttle Efficiency: 10%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Questions?