South Dakota State University
Fluid Power Vehicle Challenge

First Year Team

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Design Changes Since Midway Review

- Hydraulics
  - Had to Redesign circuit to allow for pump and motor change
  - Final Drive Ratio was changed to achieve higher speeds
  - Added a pressure relief valve between the rotary pump and motor
- Electronics
  - Redesigned the electronic circuits to utilize a cheaper and more durable microcontroller
  - Redesigned the circuit to utilize 4 and 6 channel relays instead of single channel and automotive relays
- Pneumatics
  - Changed the design to use an off the shelf bicycle disk brake
  - Added a mechanical linkage to apply brake and get more mechanical advantage
- Frame
  - Rear bracket support was built taller than original
  - Added a flat mounting platform to house hydraulics, electronics, and pneumatics
  - Added reservoir to hold 2.5 gallons of hydraulic oil

Drivetrain Calculations

Gear Ratios	Output/Input	Reduction Factor		RPM
Pedal to Pump	1:5	0.2	Pedal	80.0
Hydraulic	1.5:1	1.5	Hydraulic	400.0
Rear Diff	2:1	2	motor output	266.7
Overall		0.6	Axle	133.3

Diameter	24	in	0.6	m
mass	309	lbs	140.1	kg
accel	1	m/s^2		pedal
				acc
Force	140.14	N		
Tire	42.71	N-m		
motor output	21.36	N-m		
pump input	14.23785	N-m		
pedals	71.18926	N-m		
Accumulator				
6.256	N-m			

Circuit Hardware

Gear Pump
Manufacturer: DFC Inc.
Model: GP-F10-34-P-C
Displacement: 3.4cc/Rev
Inlet Port: SAE 8
Outlet Port: SAE 6

Gear Motor
Manufacturer: Casappa
Model: PLM10.5S0-30S0-LOA
Displacement: 5.34cc/rev
Inlet Port: SAE 6
Outlet Port: SAE 6

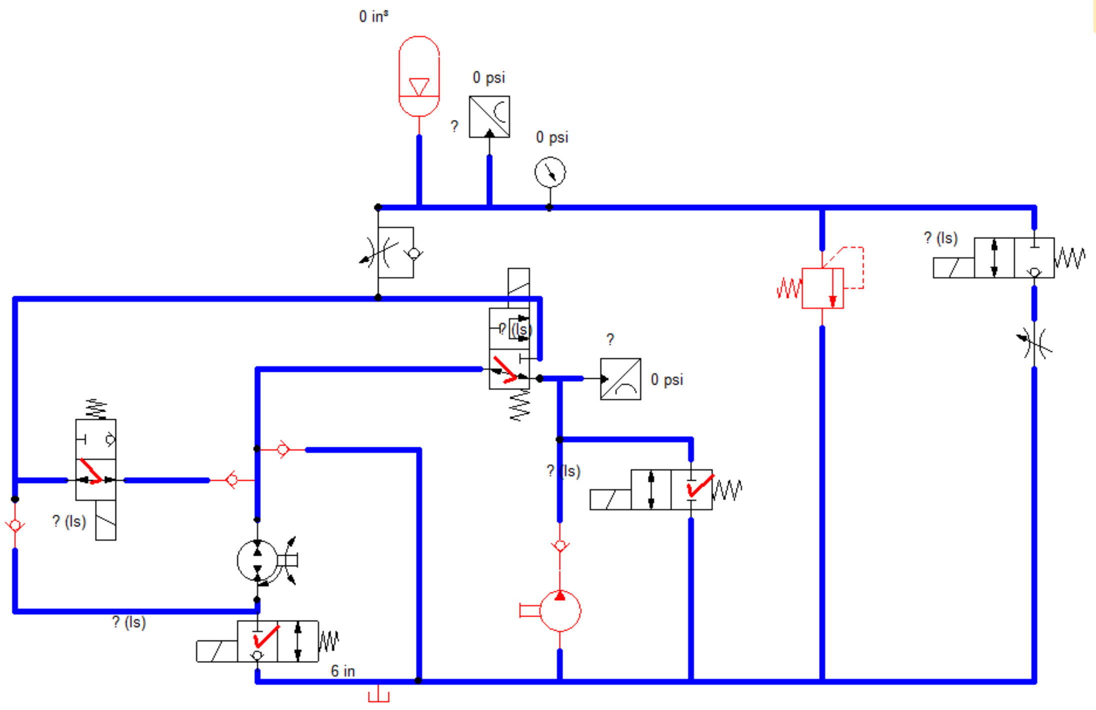
Steel Hydraulic Tubing

Pressure Lines
1/4-.035 JIC Steel Tubing
3,950 psi rating

Vaccuum/Return Lines
3/8-.035 JIC Steel Tubing
2,550 psi rating

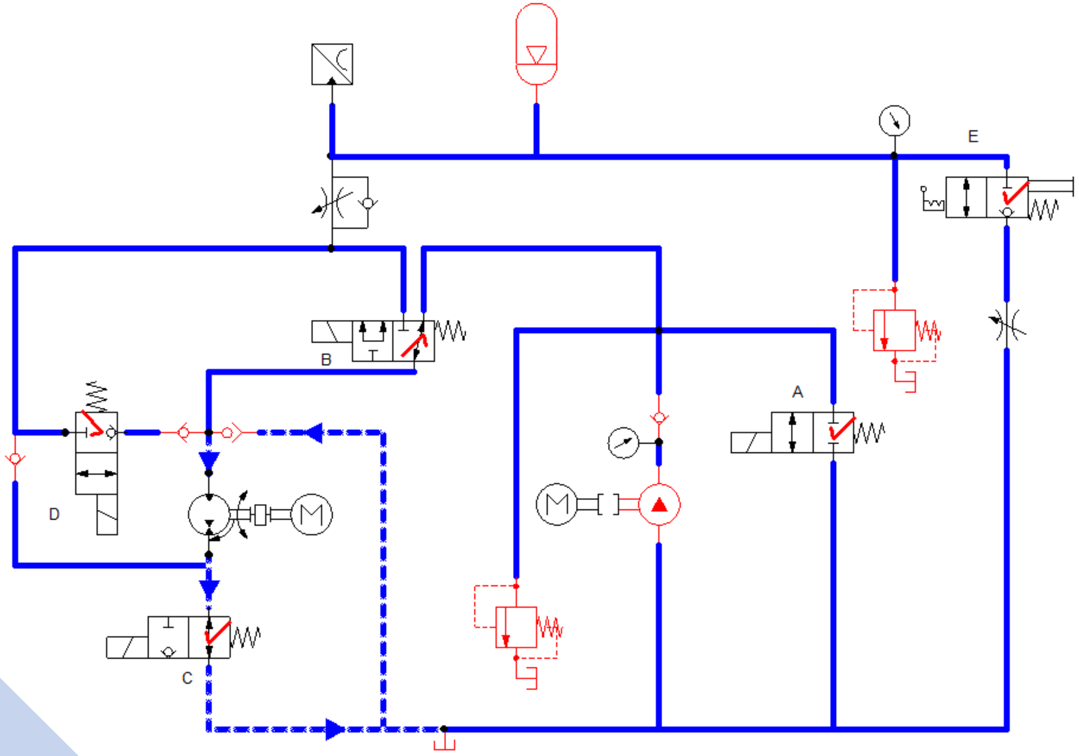
Hydraulic Design

- Hydraulic Circuit
  - Uses a 3.4cc/rev gear pump and a 5.1cc/rev gear motor
  - Uses 3 2/2way solenoids and a 3/2way solenoid for mode operations
  - Uses a 2/2way solenoid for a dump valve and includes a pressure relief valve

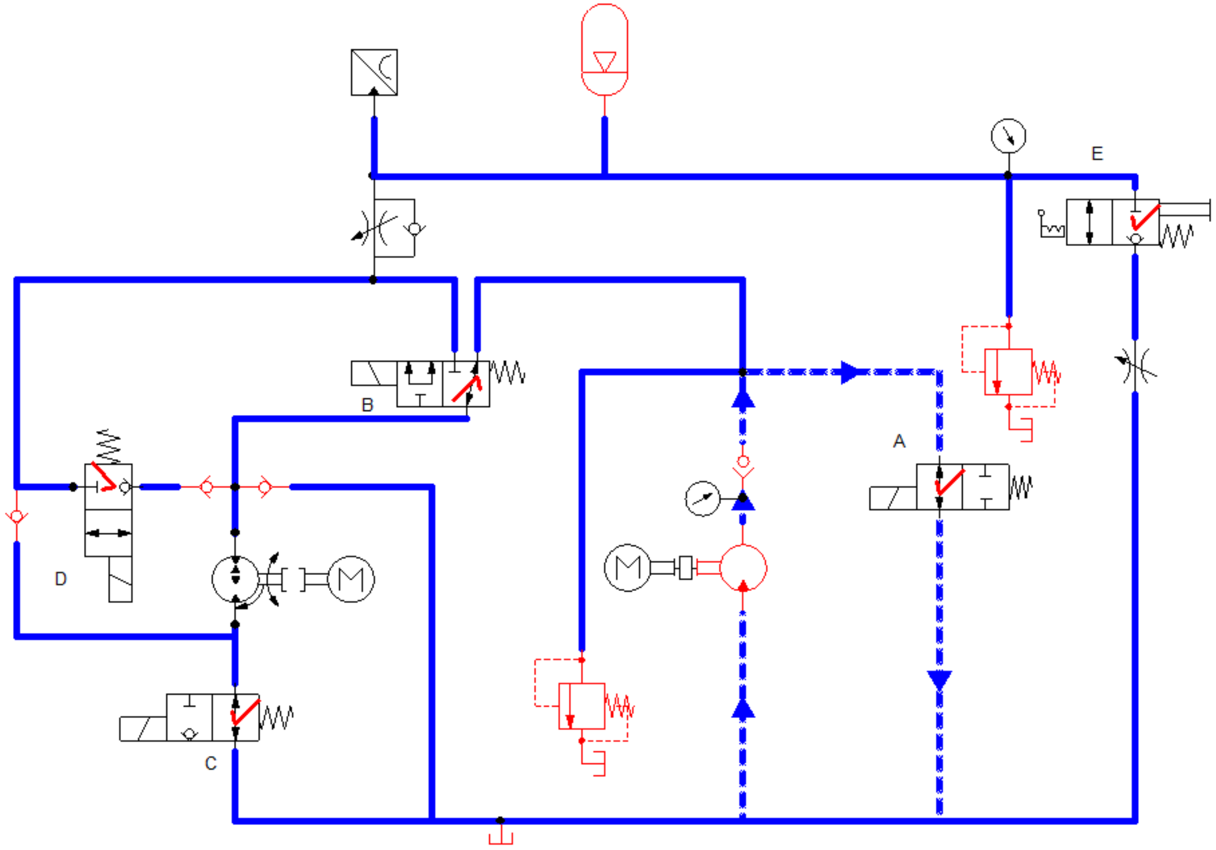


Driving Mode – Neutral

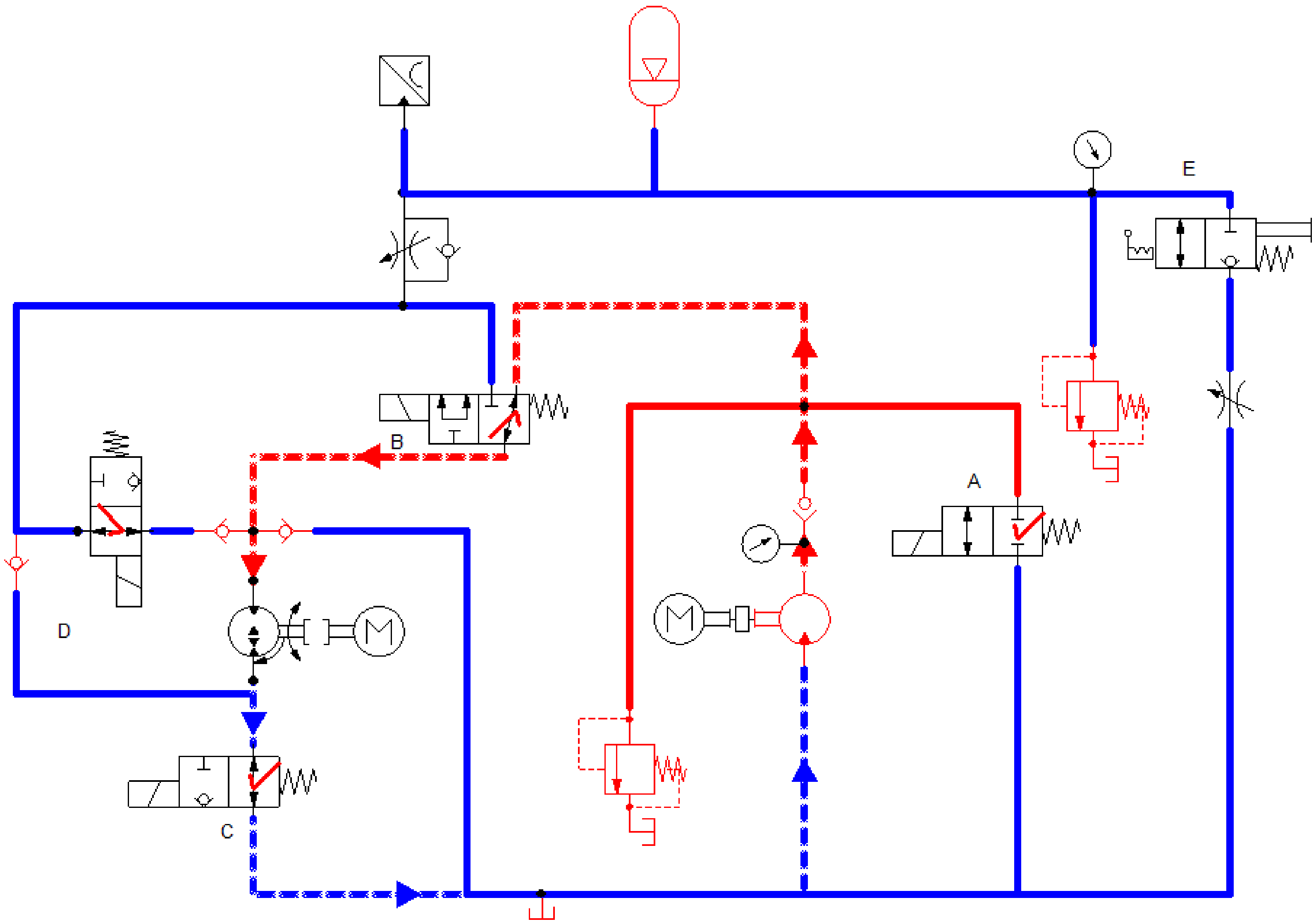
Motor



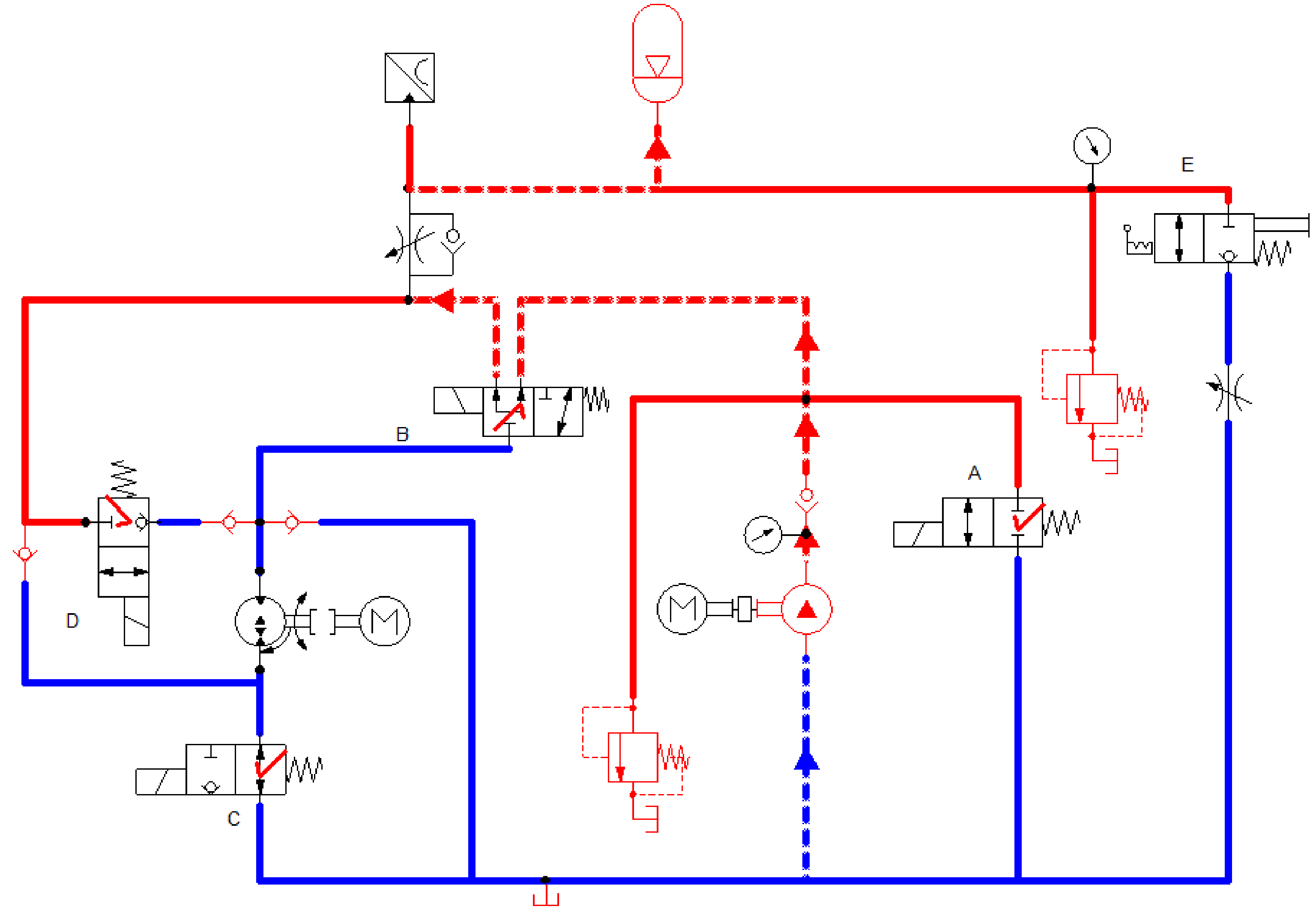
Pump



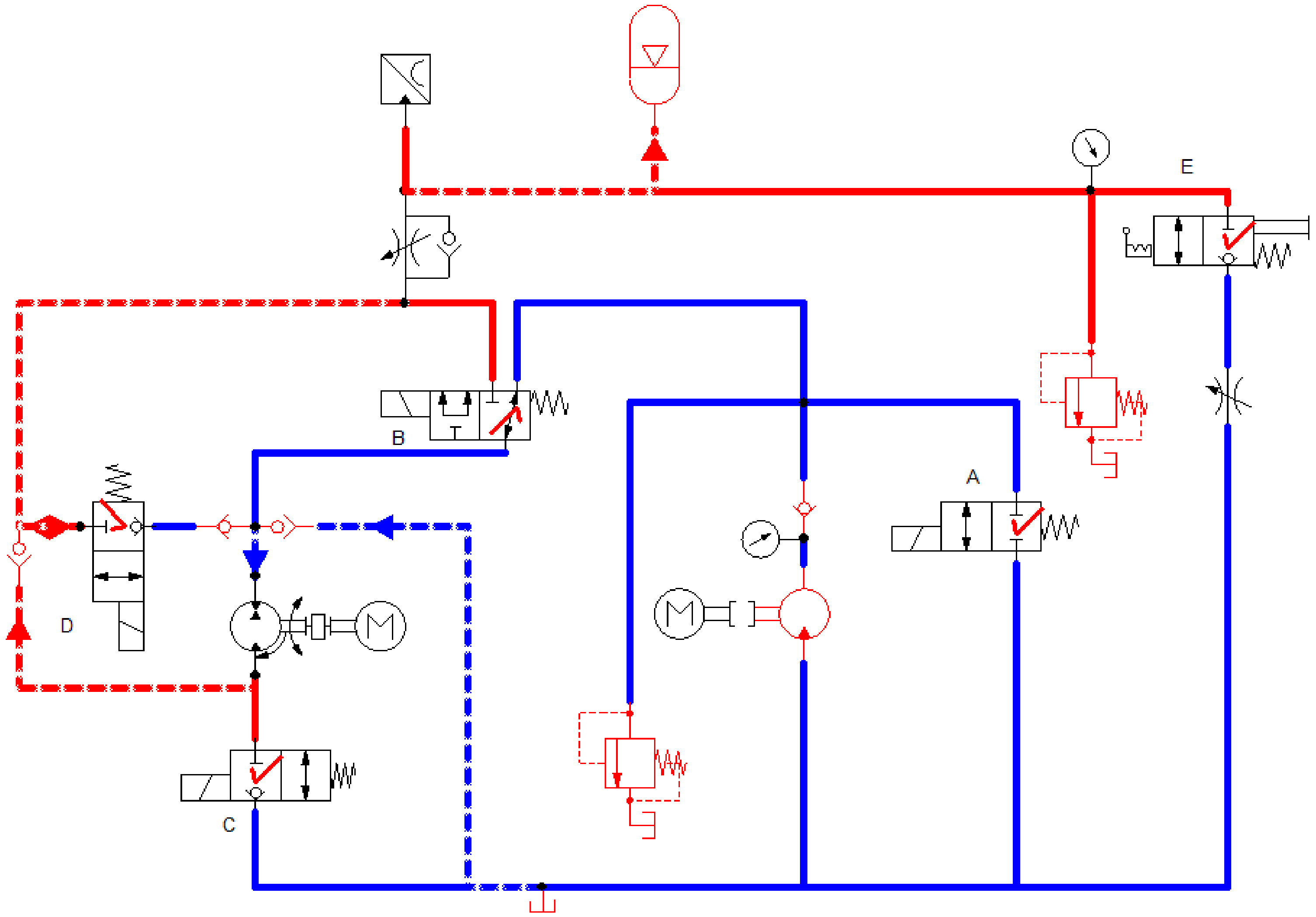
Driving Mode – Pedal to Power



Driving Modes – Accumulator Charge



Driving Modes – Regenerative Braking

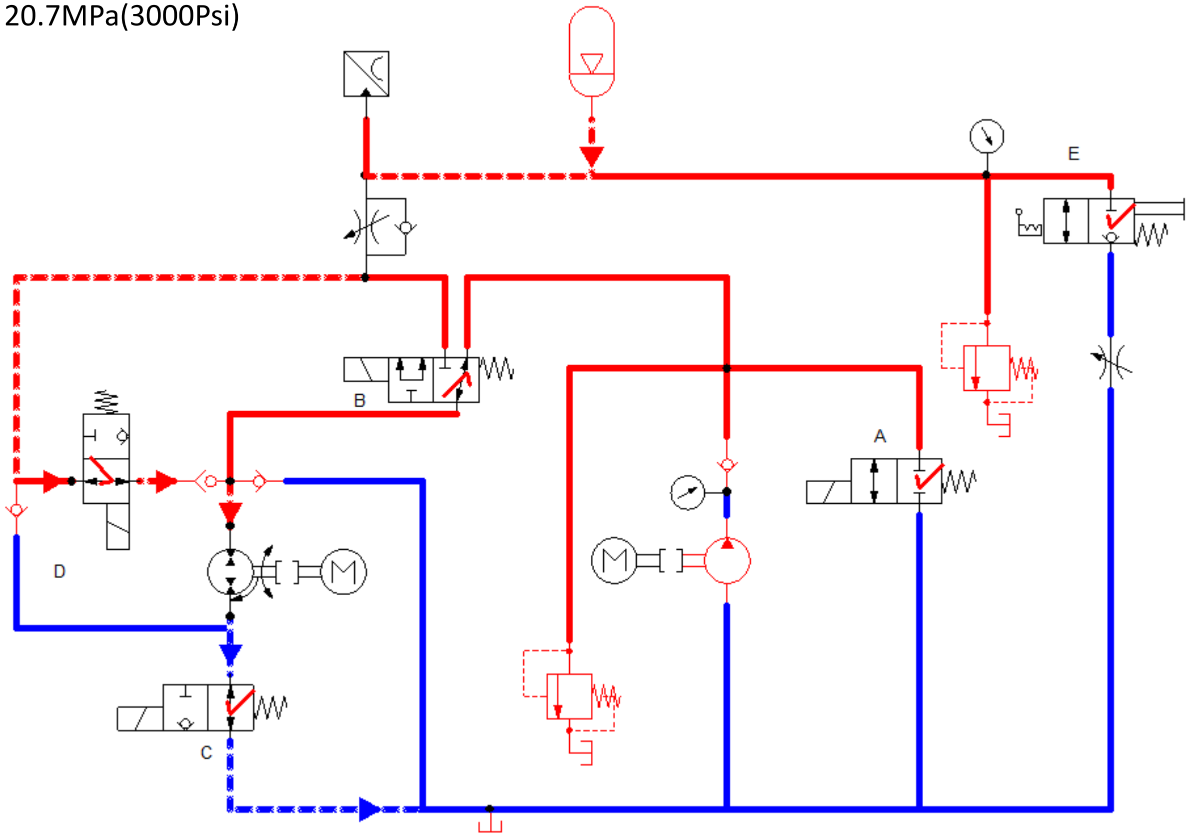


Driving Modes

Accumulator Discharge

$$T_m(N-m) = \Delta P(Pa) * V_m\left(\frac{m^3}{rev}\right) * \eta_{tm} * \frac{1rev}{2\pi}$$

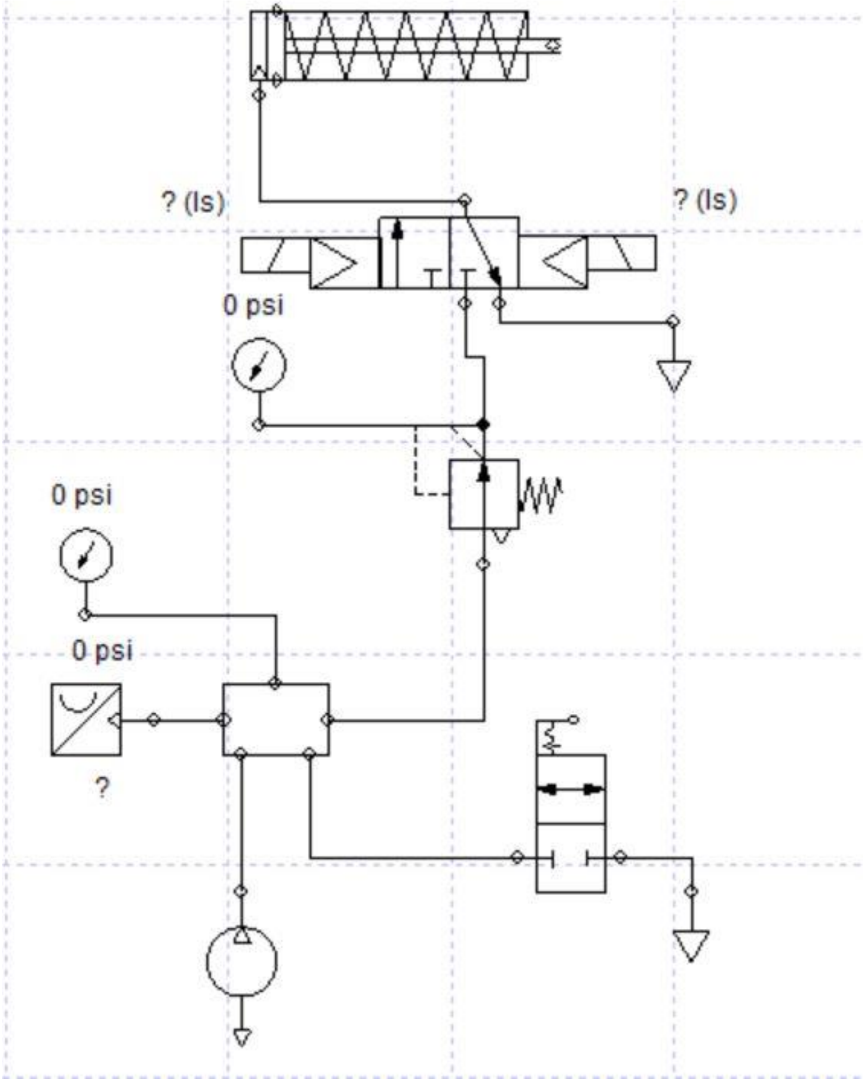
accumulator			9.463529	L/min	4.68020575	N-m	7.750738	kW	6.2Mpa(900Psi)
					15.62584823	N-m			20.7MPa(3000Psi)



Pneumatic Design

- Pneumatic Parking Brake
  - Air cylinder with disc brake
  - Double solenoid 3/2 valve used to actuate single acting cylinder
  - Allows us to use toggle switches to control the brake
  - Brake can be left on without the need for power

Pneumatic Circuit



Pneumatic Design

- Pneumatic System

Pneumatic Design

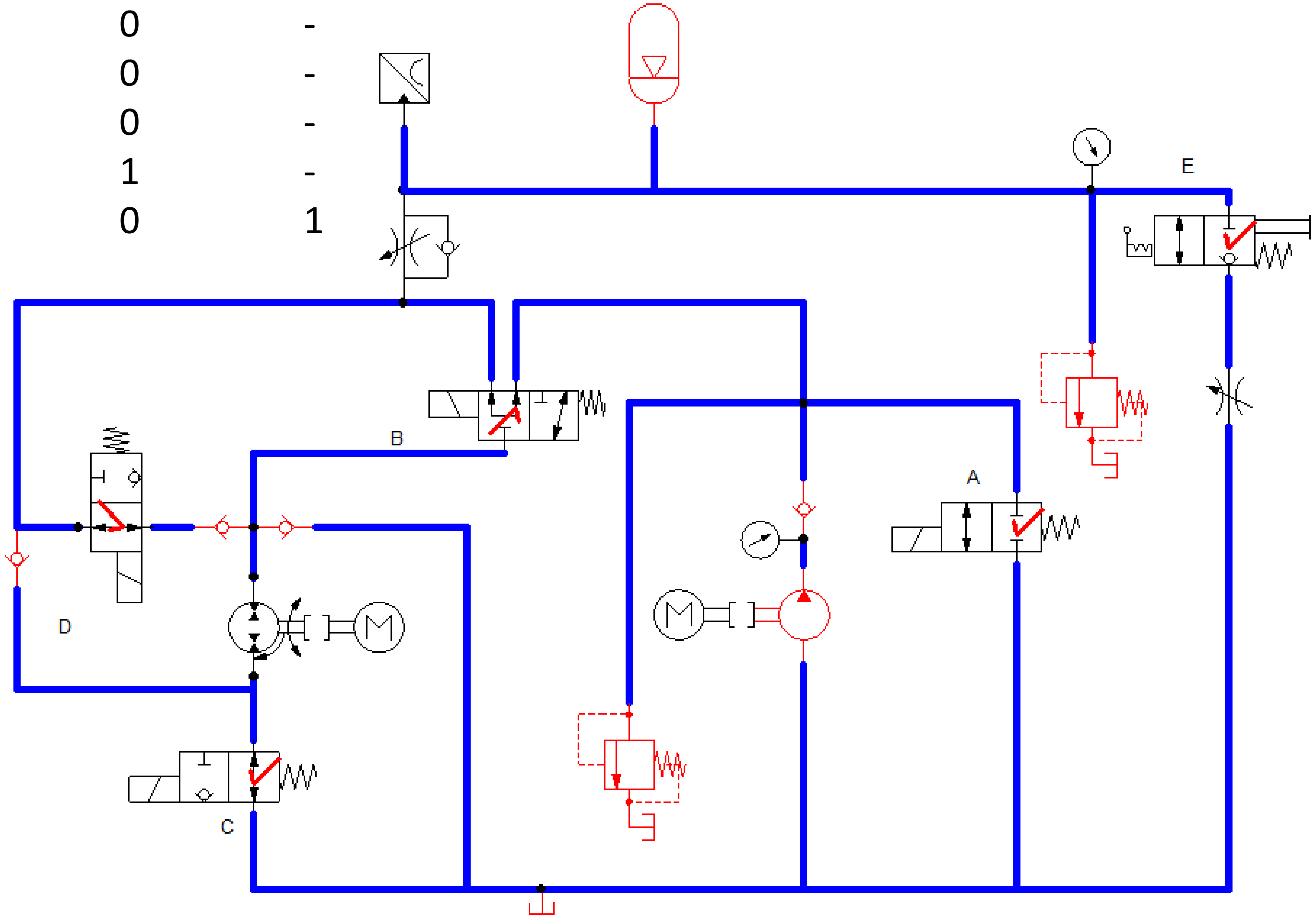
- Mechanical System
  - Piston Pushes on lever to pull cable and apply brake

Electronic Design- Switch Box

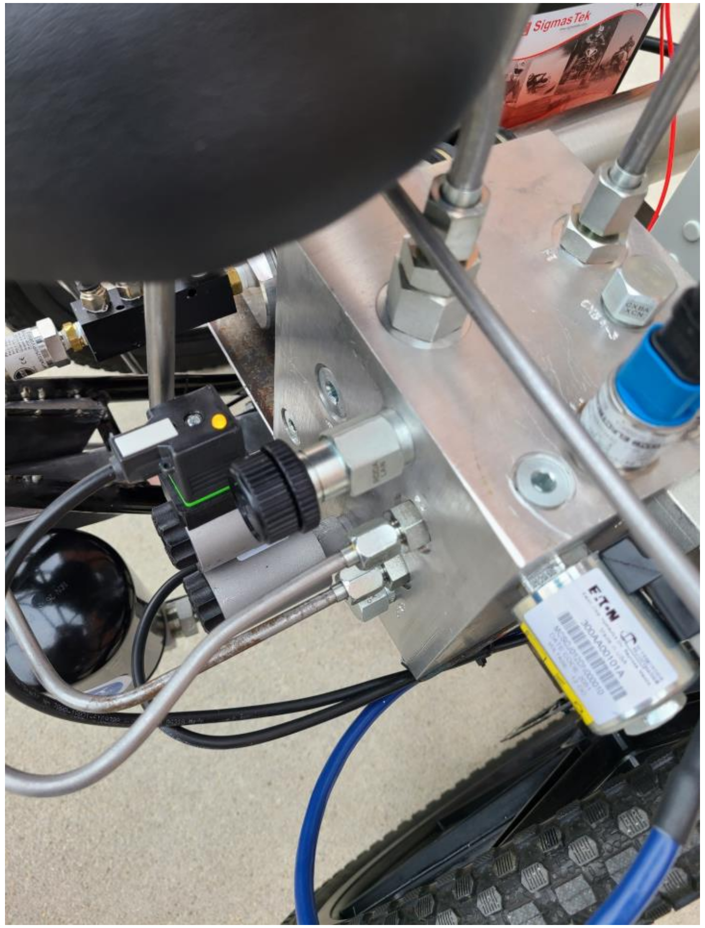
- A- Hydraulic Neutral
- B- Accumulator Charge
- C- Regenerative Brake
- D- Accumulator Discharge
- E- 12V Power Socket
- F- 5V USB Ports
- G- Digital Voltmeter
- H- Power Master
- I- Air Compressor Lockout
- J- Pneumatic Brake Engage/Disengage
- K, L, M- Extra/Diagnostic Switches

Electronic Design- Logic Tables

		Valve				
		A	B	C	D	E
Mode	Drive	0	0	0	0	-
	Neutral	1	0	0	0	-
	Charge	0	1	0	0	-
	Regen	0	0	1	0	-
	Discharge	0	0	0	1	-
	Dump	0	0	0	0	1



Electronic Design



Electronic Design

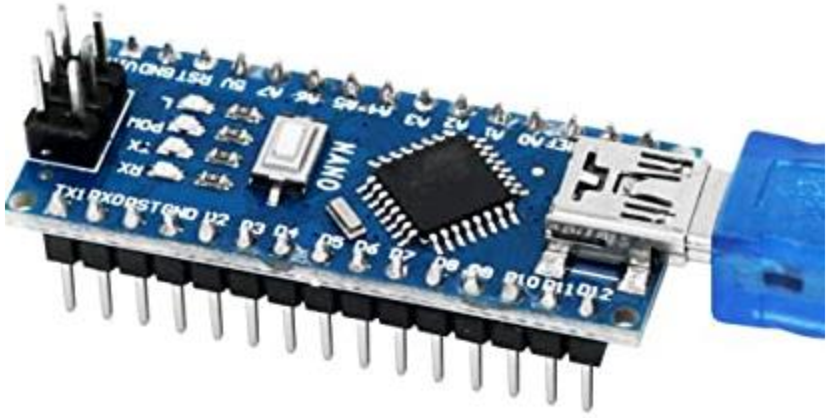
1x Arduino Nano

2x 4-channel Relay Board

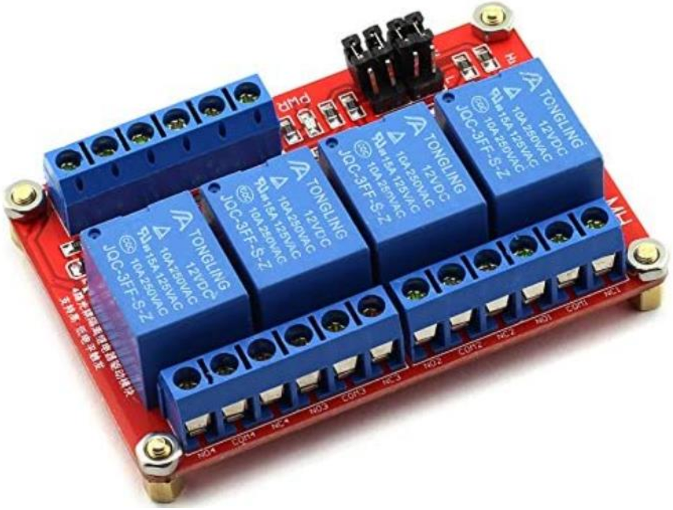
1x 6-channel Relay Board

1x Voltage Regulator

1x Switch Panel



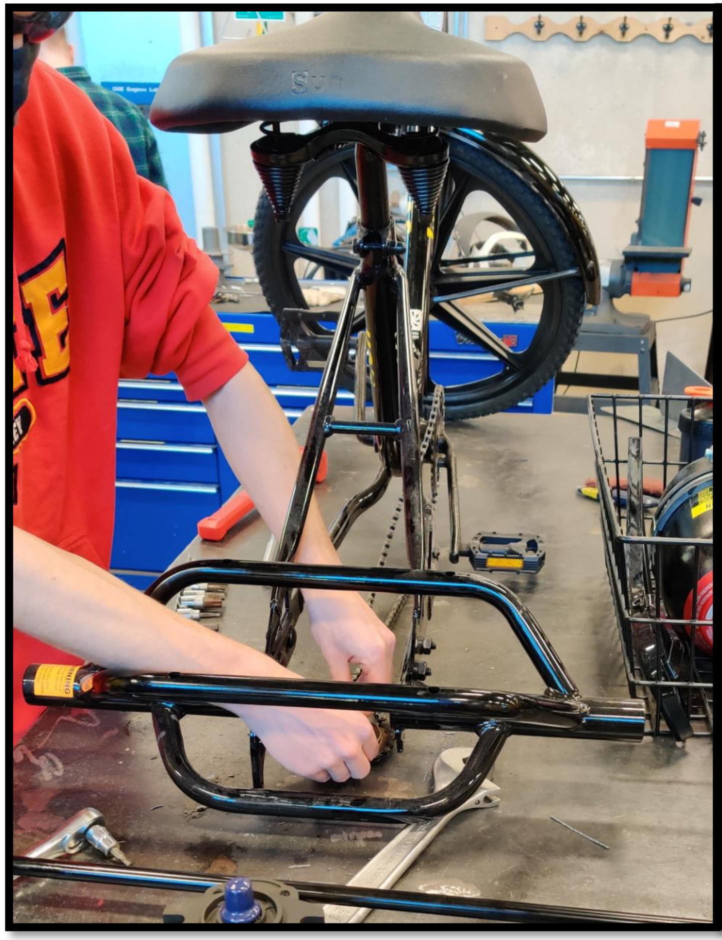
Arduino Nano

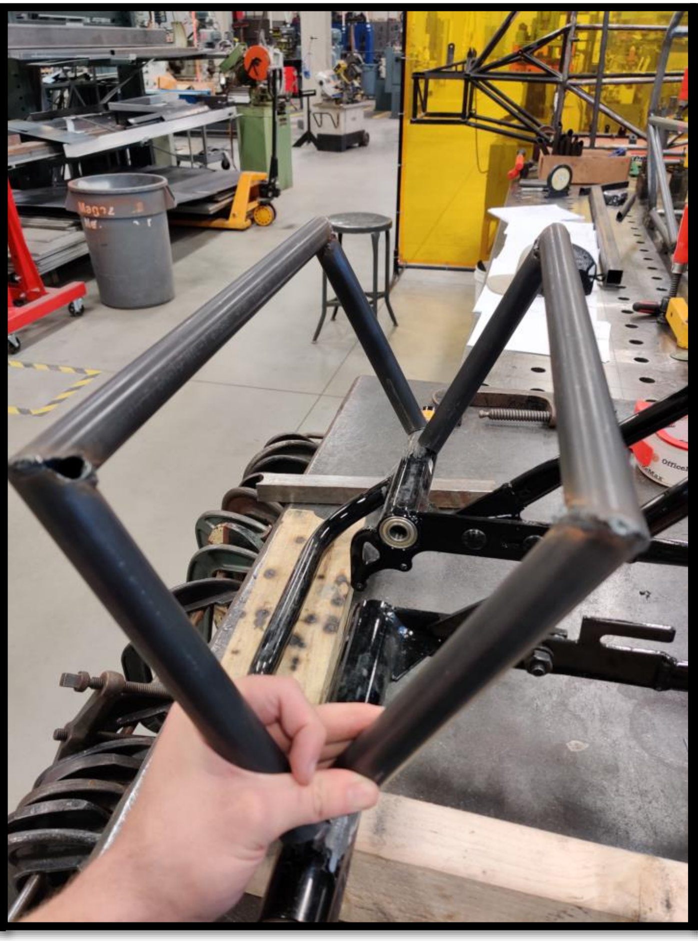


4-Channel Relay Board

Voltage Regulator

Frame Design





Frame Design

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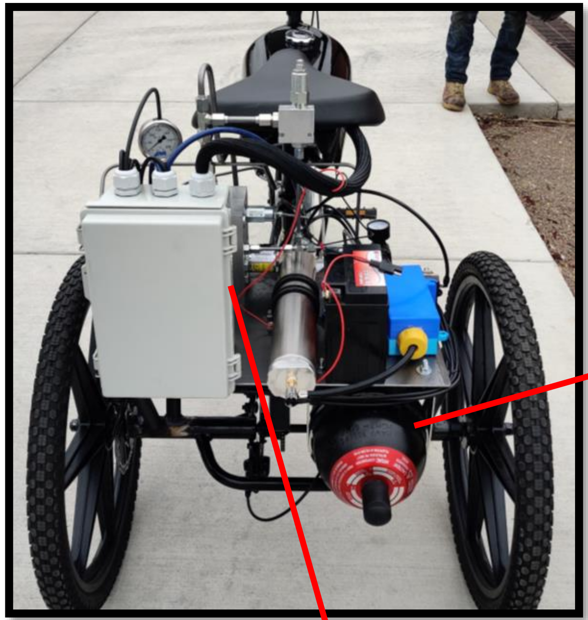
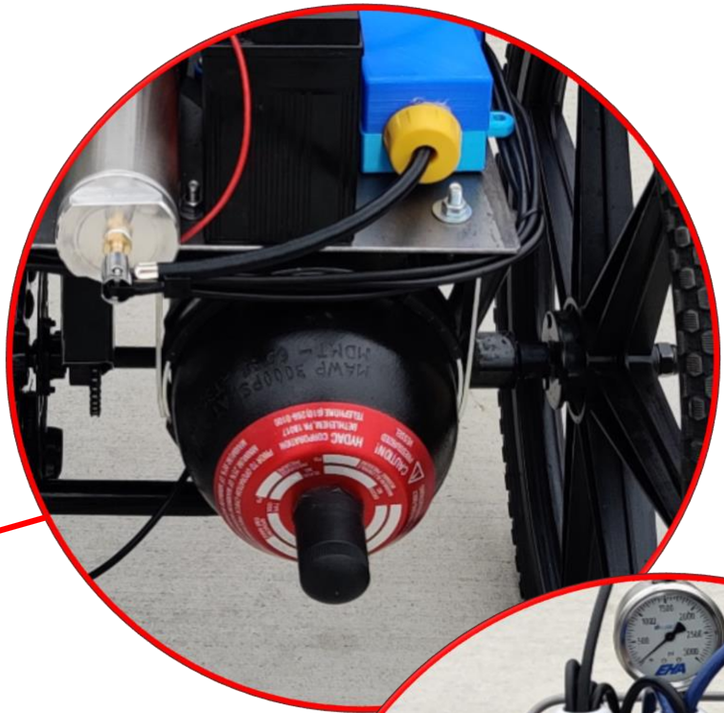
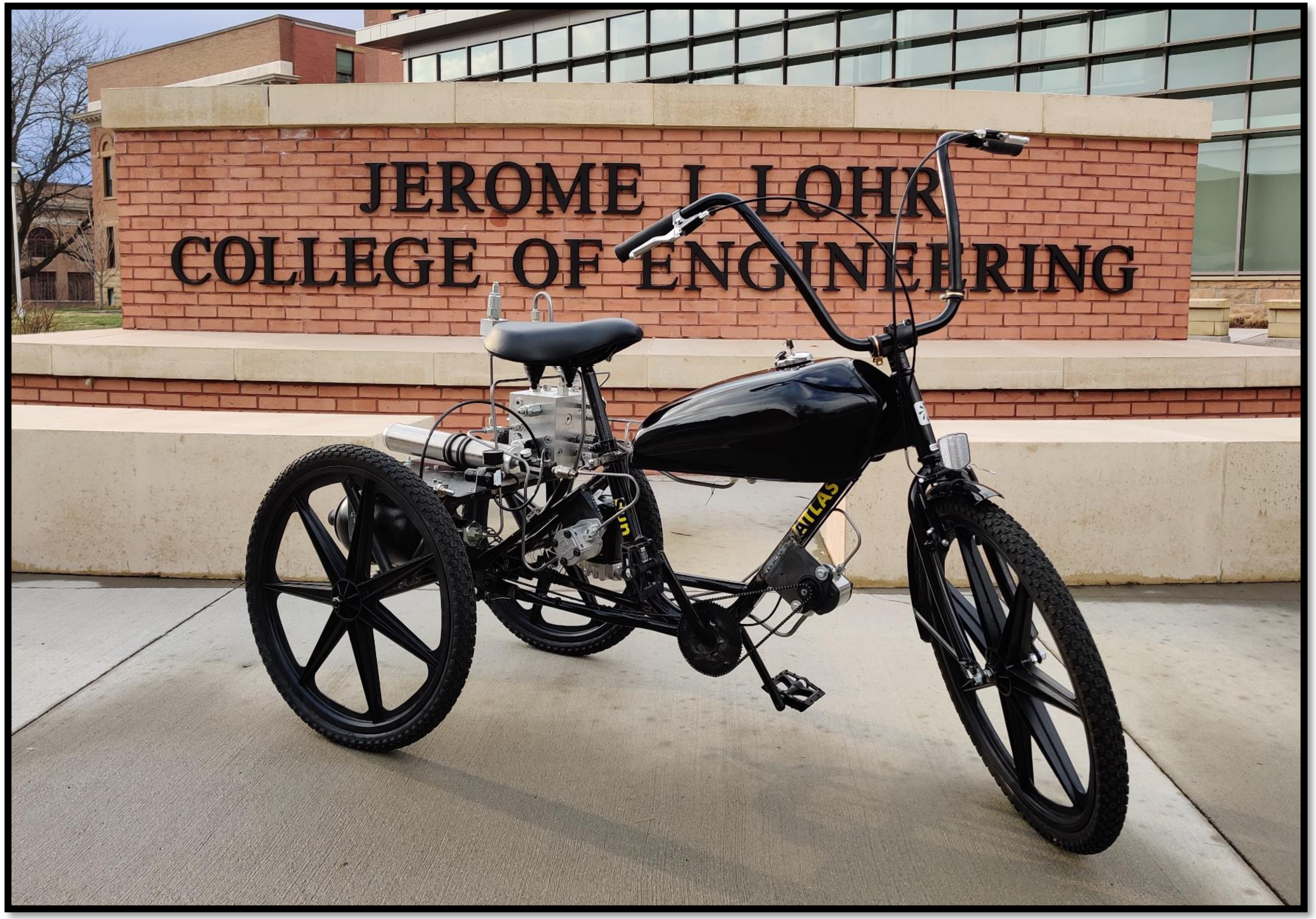




Frame Design



Lessons Learned

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- Hydraulic systems can be very complicated and need to be well designed in order to work as intended
- It is important to properly design and assemble your hydraulic system to minimize the amount of air in the system
- As a first-year team, it is important to design "simple" backup circuits in case more ambitious concepts are too difficult to execute quickly.