NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION & DESIGN REVIEW

NCAT Fluid Power 5

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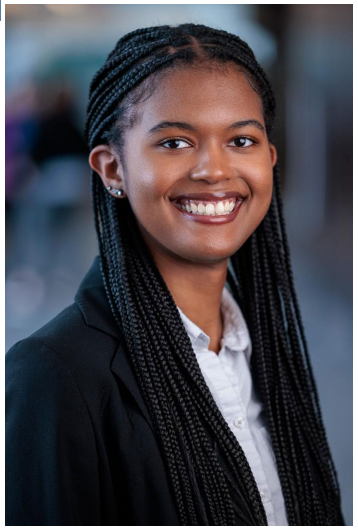
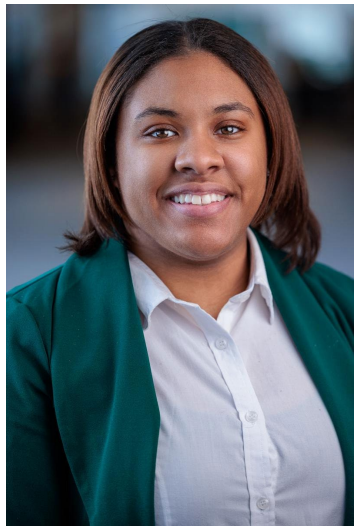
Danfoss Power Solutions, Ames, Iowa

April 23, 2025

Team Introduction



Sidney Jones
Team Lead



Brianna Mitchell
Hydraulics Lead

Wesley Grammer
Pneumatics Lead

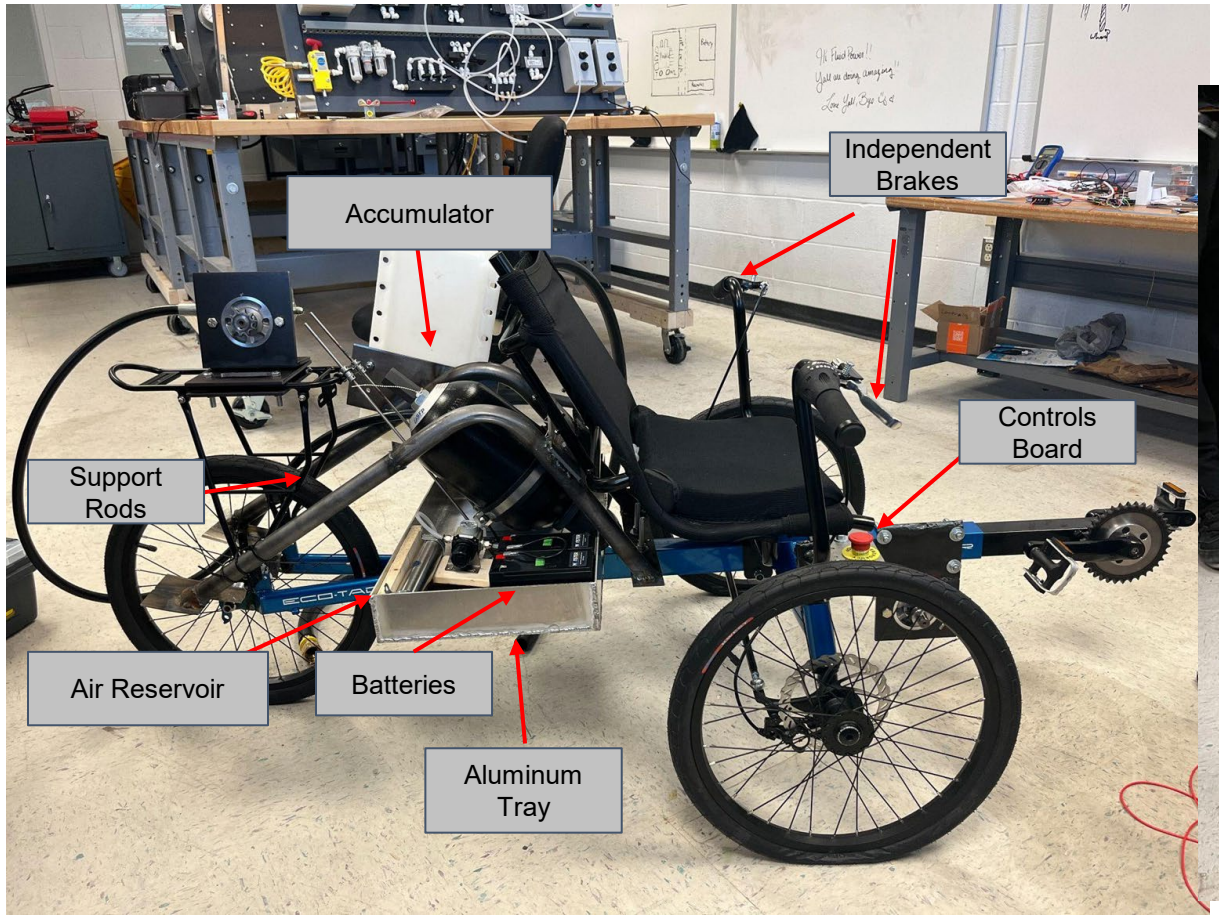
David Deal
Controls Lead

Kenneth Clark
Manufacturing & Integration Lead

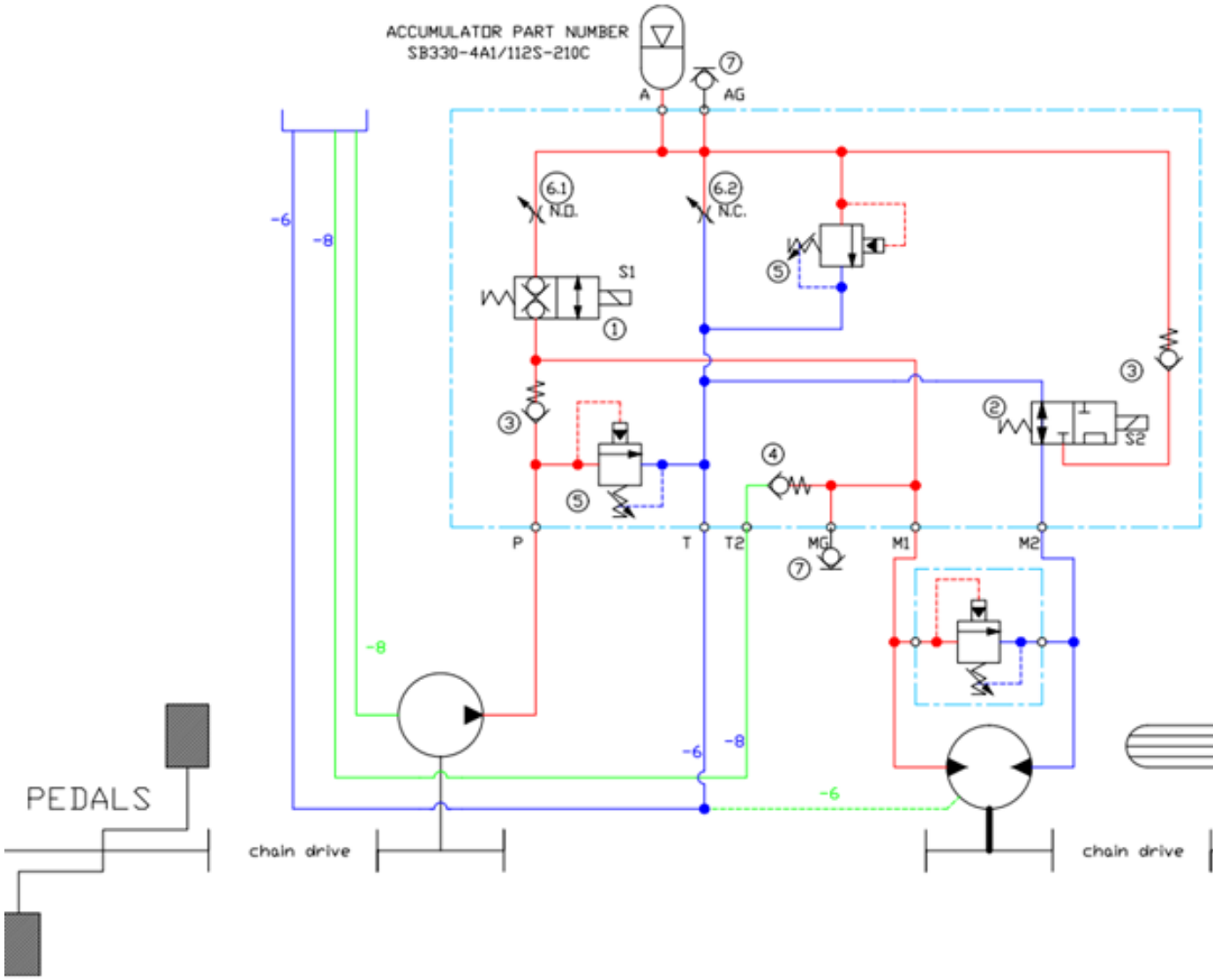
Acknowledgement

We would like to express our sincere gratitude to the NFPA for providing us with this invaluable opportunity. Our heartfelt thanks also goes to Eastman, Cross Company, and Lubrizol for their generous support and sponsorship. We deeply appreciate the exceptional mentorship from Bosch and Cross, which has been instrumental throughout this journey. A special thank you to our technical liaison, Mr. Randy Nobles, for facilitating seamless communication and offering critical insights that were essential to the success of this project.

Vehicle Construction



2024 Hydraulic Circuit



PORT SIZES	
A	-8
AG	-6
P	-6
T	-6
T2	-8
MG	-6
M1	-6
M2	-6

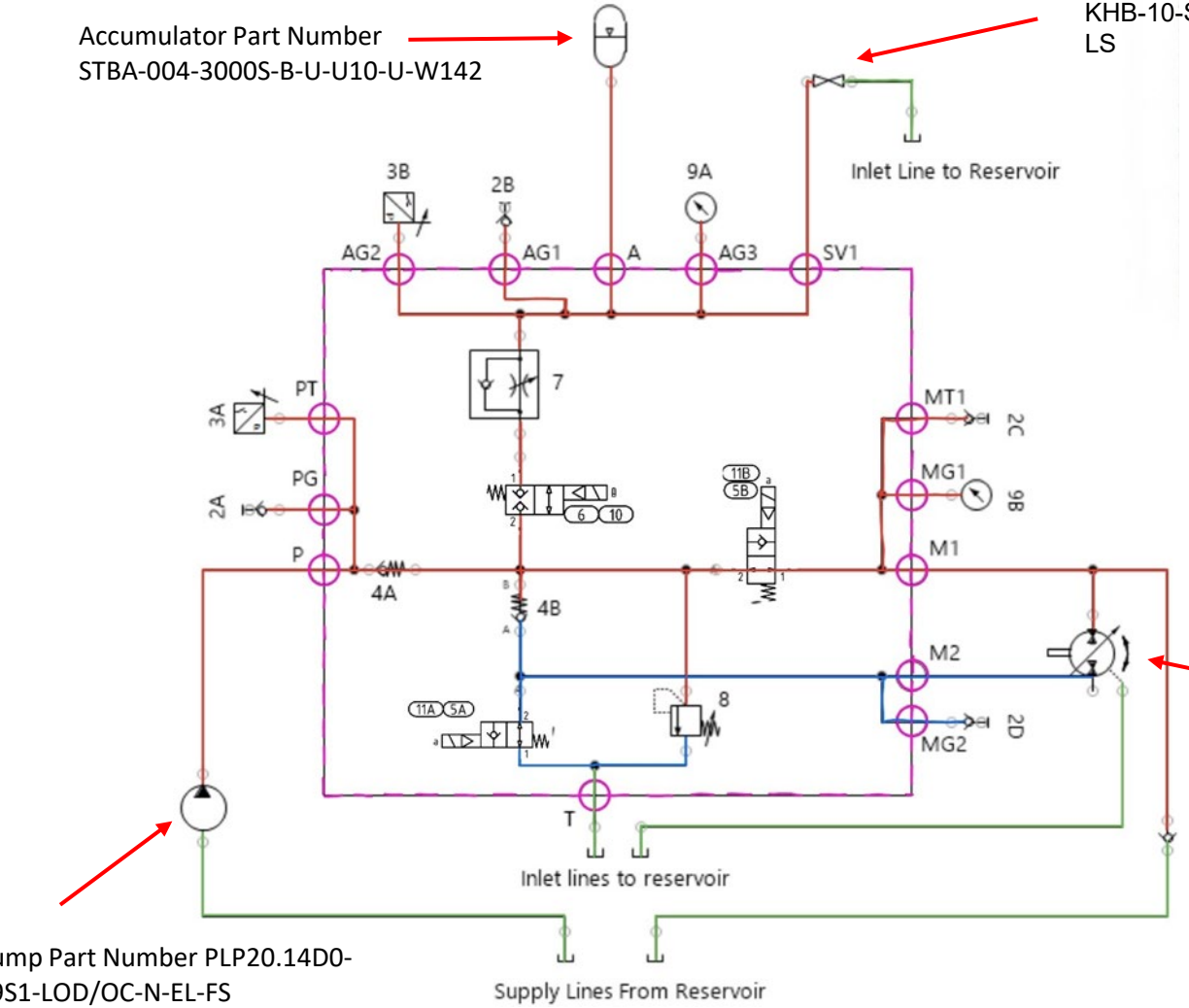
	S1	S2
DRIVE		
COAST		
CHARGE	X	X
ACC DIS	X	
REGEN		X

BILL OF MATERIAL		QTY
1	SBV11-10-C-0-00	1
2	SV1-10-3-0-00	1
3	CV10-NP-0.3-B-00	2
4	CP102-1-B-0-005	1
5	RV1-10-S-0-36	2
6.1	FCV7-10-S-0-NV	1
6.2	FCV7-10-S-0-NV	1
7	D1620-01-06SAE	2
S1	300AA00141A	1
S2	300AA00101A	1

2025 Hydraulic Circuit

Accumulator Part Number
STBA-004-3000S-B-U-U10-U-W142

Shut-off Valve Part Number
KHB-10-SAE-1114-11x-A-LS



Item	Qty	Model Code	Description	Manufacturer
1	1	FV-14424-M1	Manifold body	Source Fluid Power
2	4	D1620-01-06SAE	Test Point Fitting, M16 x 2	Dynamic
3	2	11044547	Pressure Transducer 0-3626 PSI SAE #6	Danfoss
4	2	CV10-NP-0.3-B-00	Check 1 to 2	Danfoss ICS
5	2	SVP10-NOR-R00-00-B-00	Solenoid 2 pos. 2 way	Danfoss ICS
6	1	SBV11-8-C-0-00	Solenoid 2 pos. 2 way	Legacy-Eaton
7	1	FCV7-10-S-0-FF	Flow Control	Legacy-Eaton
8	1	RV1-10-S-0-36	Relief Direct Acting	Danfoss
9	2	CF-1P-210-A-SAE	Pressure Gauge, 0 - 3000 PSI, Stem Mounted	Dynamic
10	1	300AA00062A	Coil 24VDC, Deutsch	Legacy-Eaton
11	2	R16-24D-20W-DE	Coil 24VDC, Deutsch	Danfoss ICS

Motor Part Number
121.20.045.00

Check Valve Part Number
CXBAXZN

Pump Part Number PLP20.14D0-49S1-LOD/OC-N-EL-FS

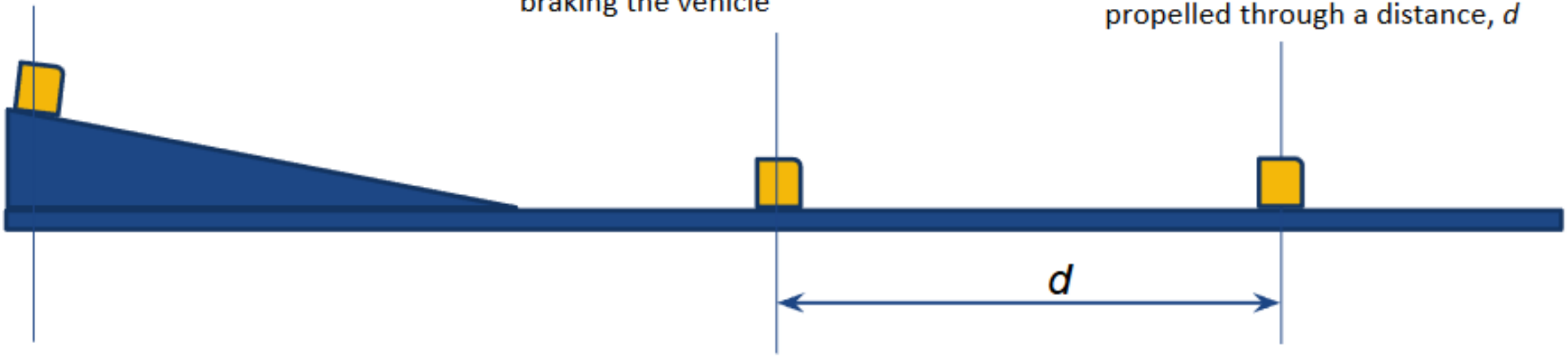
Regenerative Braking Demonstration

Regenerative braking demonstrates the vehicle's ability to store energy through regenerative braking and use the stored energy for propulsion.

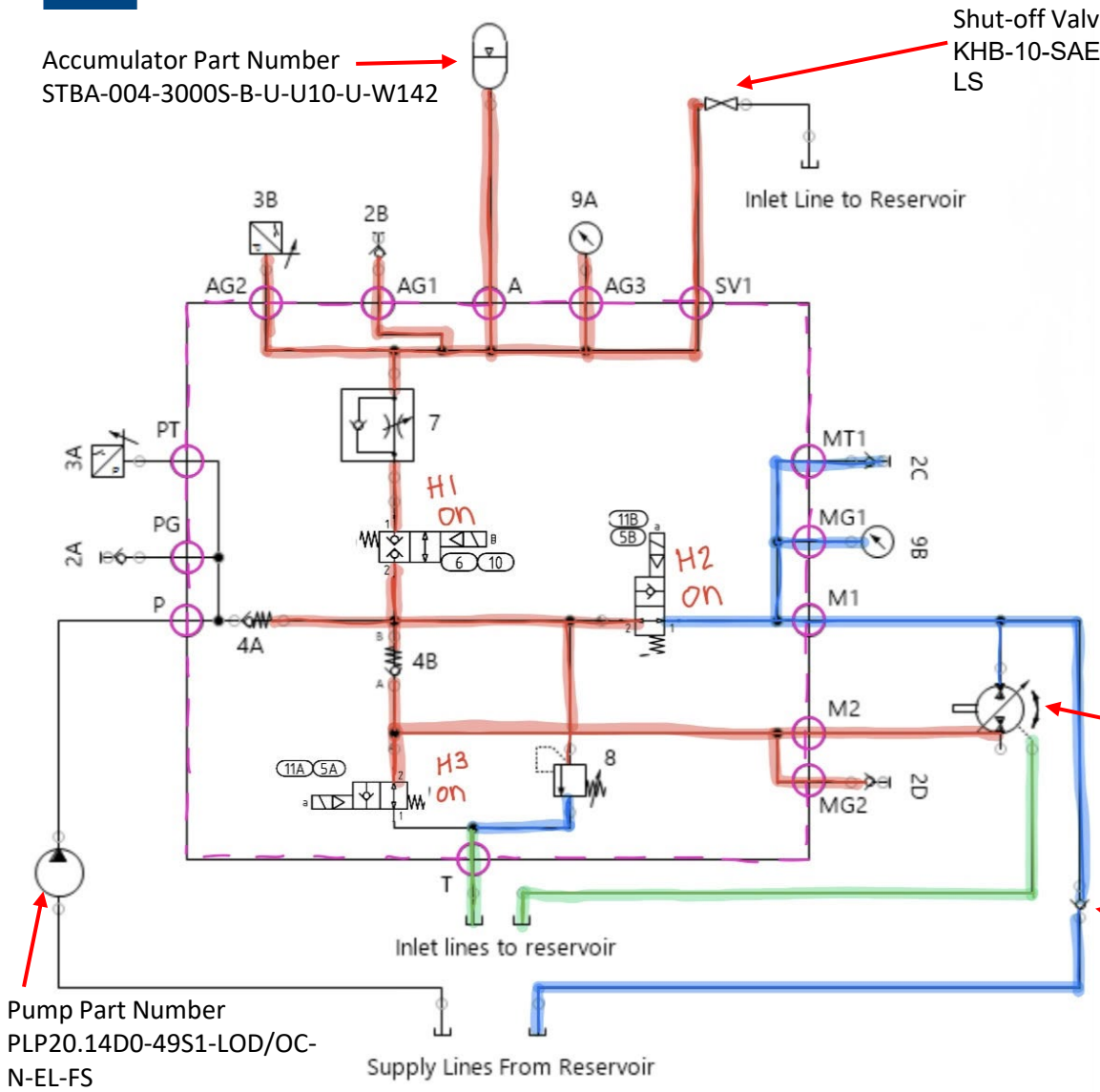
STAGE 1:
Vehicle starts under no accumulator charge. No human propulsion.

STAGE 2:
The vehicle is propelled under gravitational potential energy, which is stored in the accumulator, effectively braking the vehicle

STATE 3:
Using the stored energy in the accumulator, the vehicle is propelled through a distance, *d*



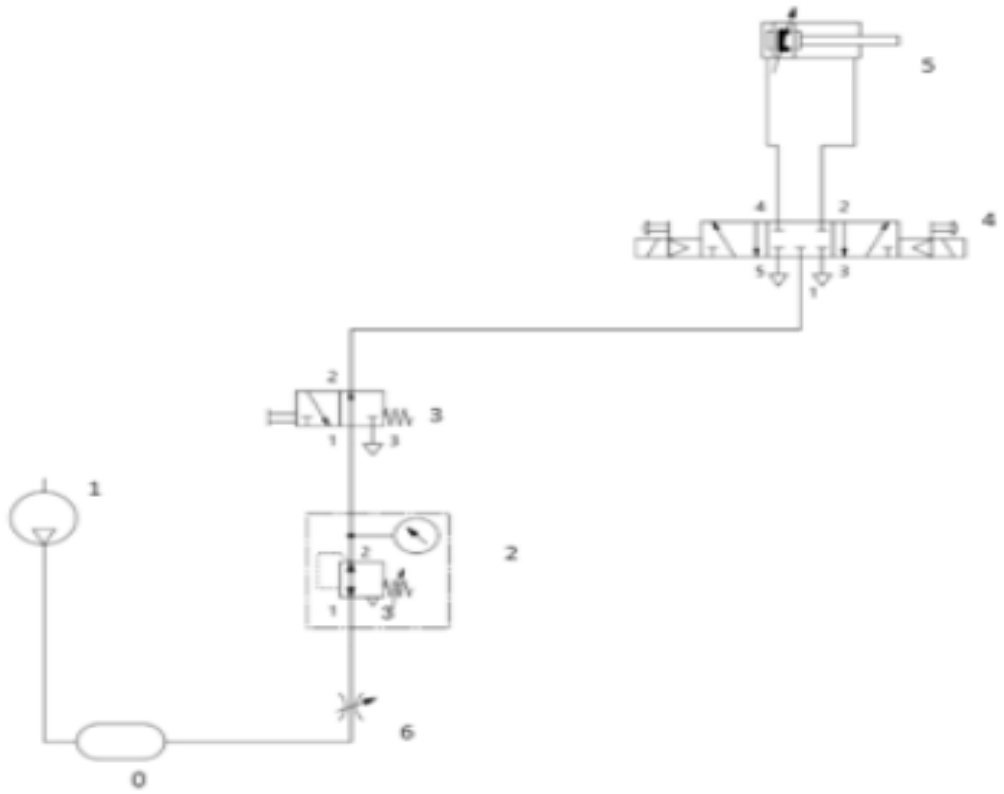
Regen Braking Circuit



During Regen Mode, the bi-directional hydraulic motor will be acting as a pump.

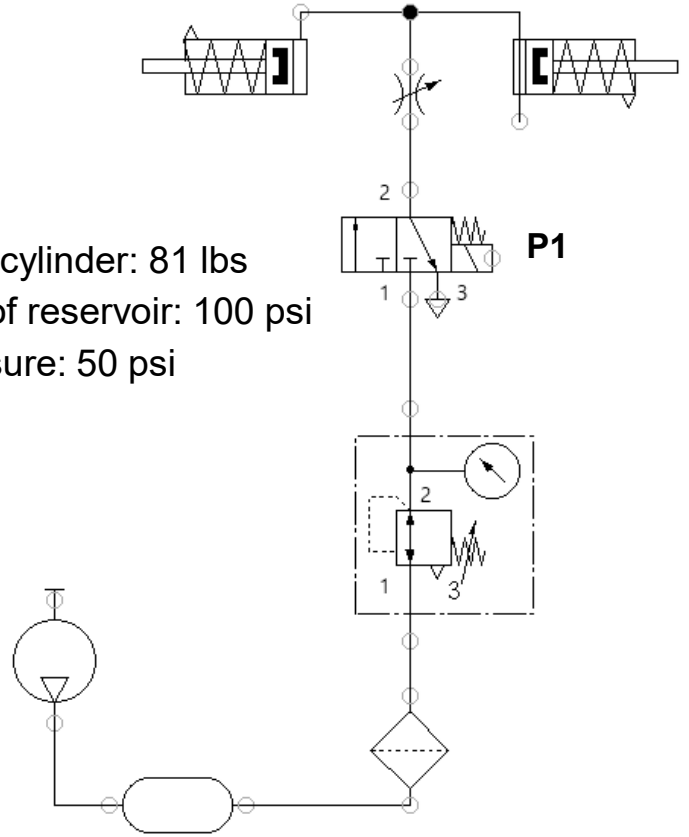
	Directional Control Valves (DCVs)-state of solenoids			
Drive Mode	H1	H2	H3	Manual Shut-off Valve
Regen Braking	ON	ON	ON	Closed

2024 vs 2025 Pneumatic Circuit



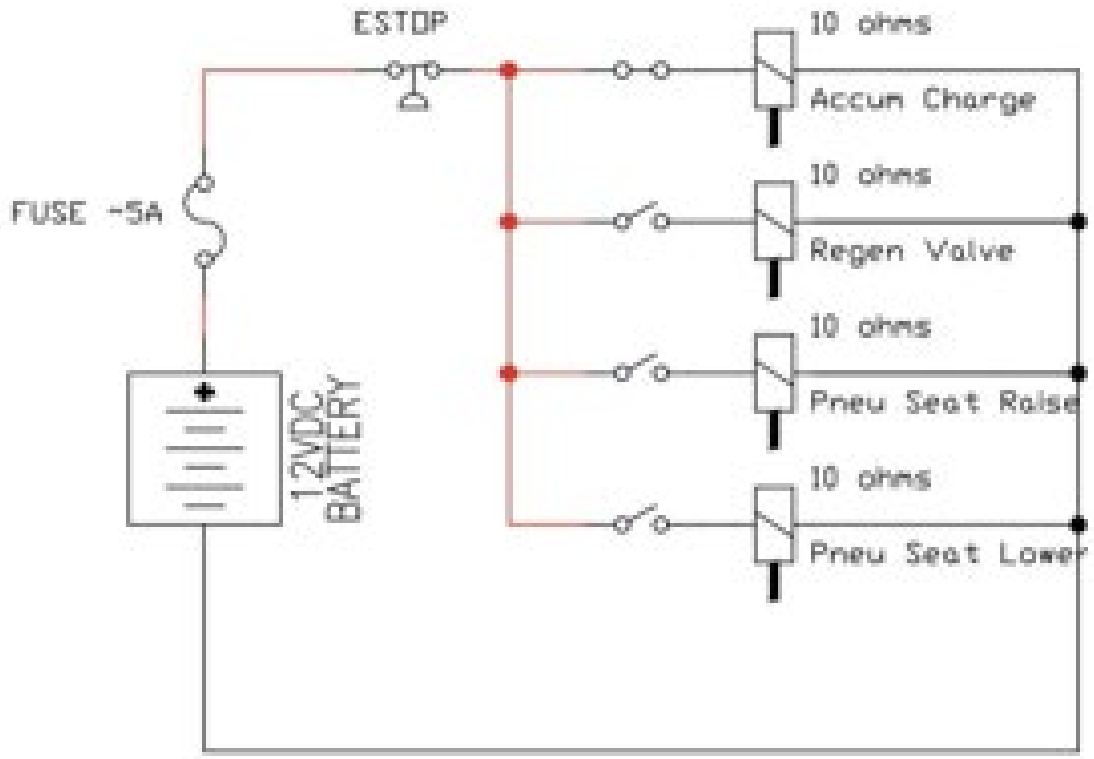
2024

Force per cylinder: 81 lbs
Capacity of reservoir: 100 psi
Line pressure: 50 psi

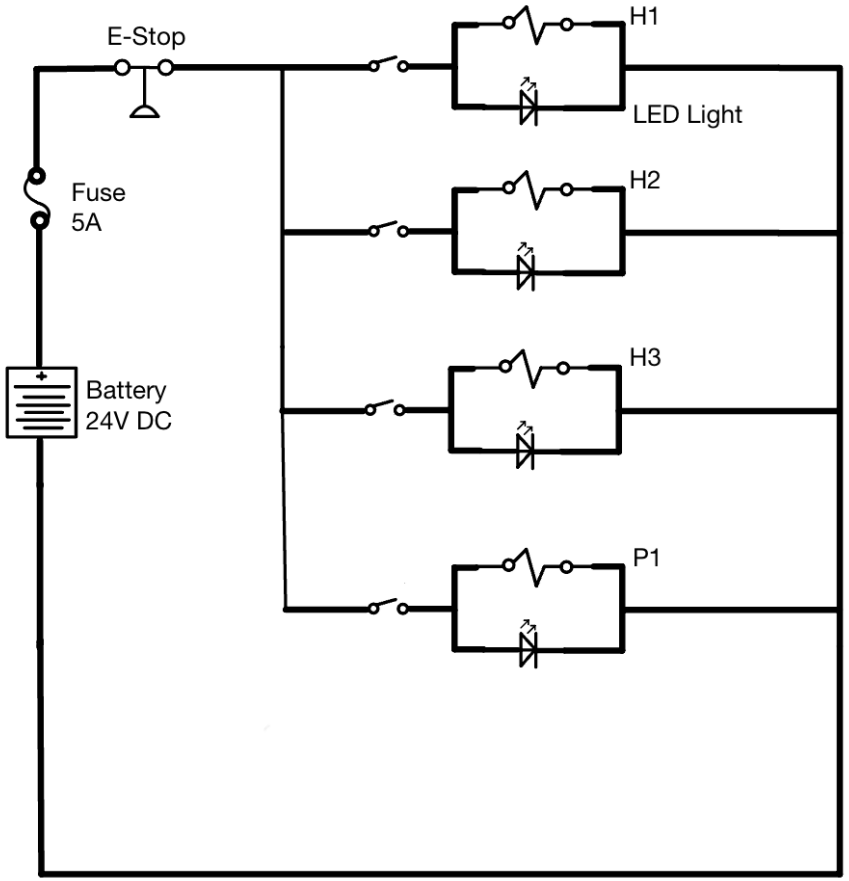


2025

2024 vs 2025 Controls Circuit



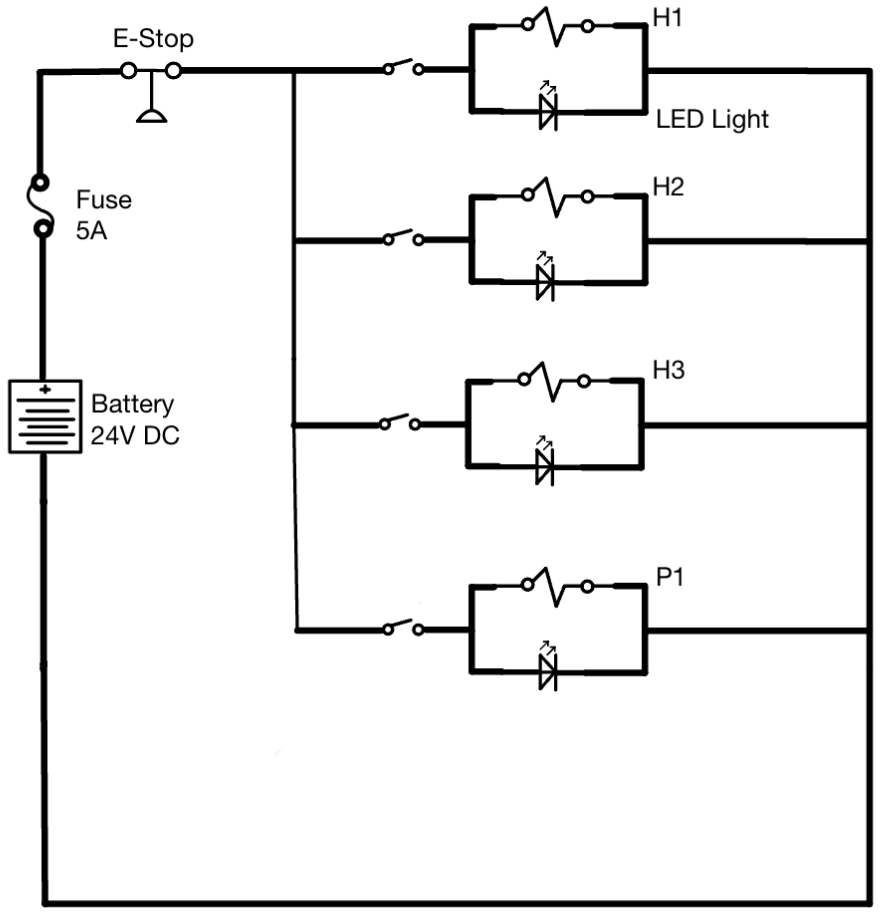
2024



2025

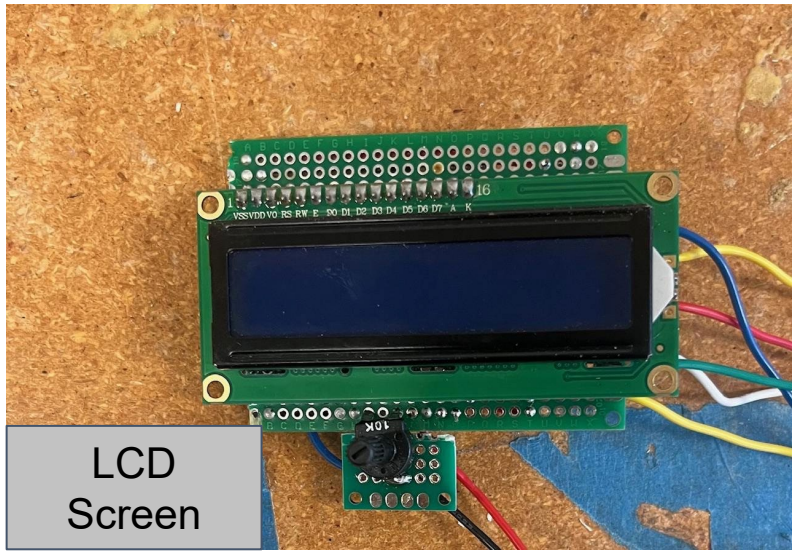
Controls Logic and Circuit

Drive Modes	Directional Control Valves (DCVs)-state of solenoids			
	H1	H2	H3	Manual Shut-off Valve
Direct Drive	OFF	OFF	OFF	Closed
Accumulator Charge	ON	ON	OFF	Closed
Regen Braking	ON	ON	ON	Closed
Accumulator Discharge	ON	OFF	OFF	Closed
Coast Mode	OFF	OFF	OFF	Open
System Dump	OFF	ON	OFF	Open



Arduino Integration

The Pressure Transducer is wired to the Arduino to display the pressure reading on the LCD Screen.



LCD Screen

Pressure_Transducer_Code

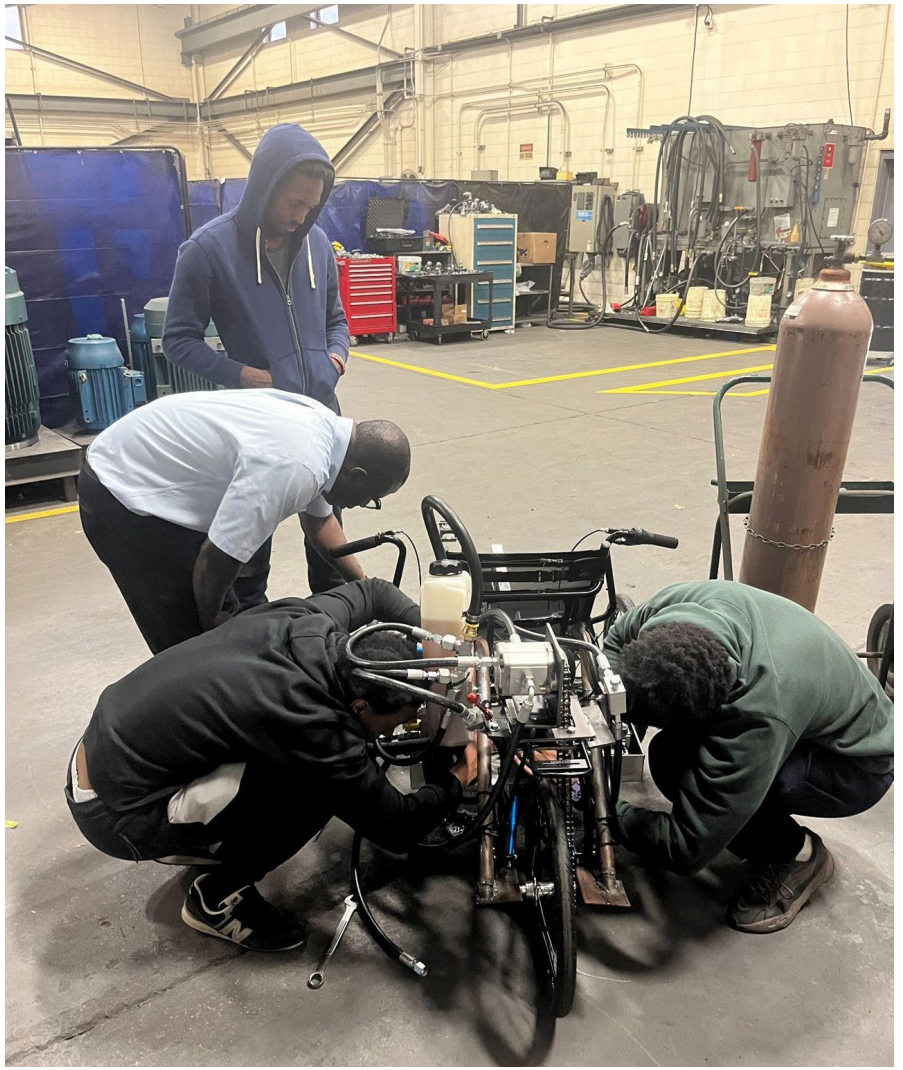
```
#include <LiquidCrystal.h>
const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);


const int pressureInput = A0;
const int pressureZero = 102.4; //analog reading of pressure transducer at 0psi
const int pressureMax = 921.6; //analog reading of pressure transducer at 100psi
const int pressuretransducermaxPSI = 100; //psi value of transducer being used

float pressureValue = 0; //variable to store the value coming from the pressure transducer

void setup() {
  // put your setup code here, to run once:
    Serial.begin(9600);
    lcd.begin(16,2);
}

void loop() {
  // put your main code here, to run repeatedly:
    pressureValue = analogRead(pressureInput); //reads value from input pin and assigns to variable
    pressureValue = ((pressureValue-pressureZero)*pressuretransducermaxPSI)/(pressureMax-pressureZero); //conversion equation to convert analog reading to psi
    Serial.print(pressureValue,1);
    Serial.println(" psi");
    lcd.setCursor(0, 0);
    lcd.print("Pressure:");
    lcd.print(pressureValue, 1);
    lcd.print("psi");
    lcd.print("  ");
    delay(400);
}
```

Arduino Code

Pressure Transducer

Vehicle Testing

- Final Weight: 168 lbs
- Accumulator Pressure: 1500 psi
- Distance Traveled: 200-500ft



Vehicle Testing

- Pressure Transducer Test

Lessons Learned

- Controls: When supplying a specific voltage to a circuit, it is important to ensure that everything within the circuit, at minimum, can withstand the maximum output of that voltage.
- Hydraulics: Develop and test multiple circuits in appropriate software. Start planning for the hoses and fittings as soon as you have a solid layout of components on the bike.
- Pneumatics: Figure out what physical circuit will look like to order the appropriate fittings
- Manufacturing: Start the manufacturing process in the Fall Semester to prepare for any potential modifications and adjustments that may be needed in the spring. Agree on overall vehicle design early.

Thank you for your attention!

Questions?