NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

Midway Review & Update
Tennessee State University
Dr. Habibi Mohammad
January 19th, 2024

TSU Tennessee State University

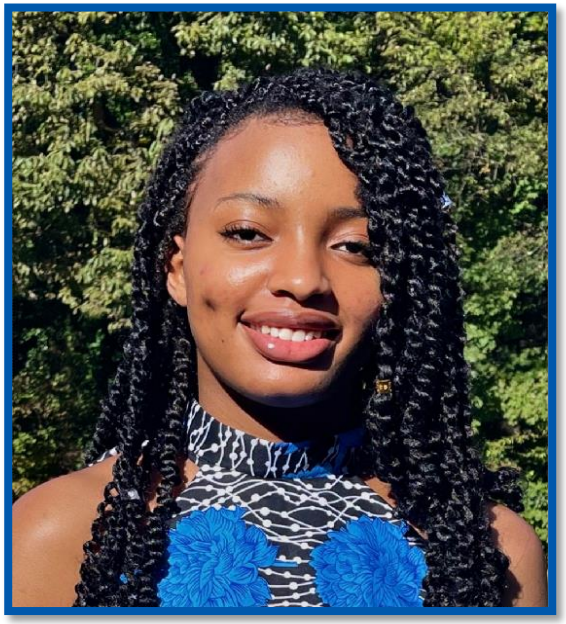
AGENDA

- Team Introductions
- Project Goals and Objectives
- Design Progress
- Hydraulic Calculation
- Vehicle Assembly
- FEA Analysis
- Challenges Faced
- Thank you
- Questions

MEET THE TEAM

ANTHONY WHEELER
Senior, Mechanical Engineering

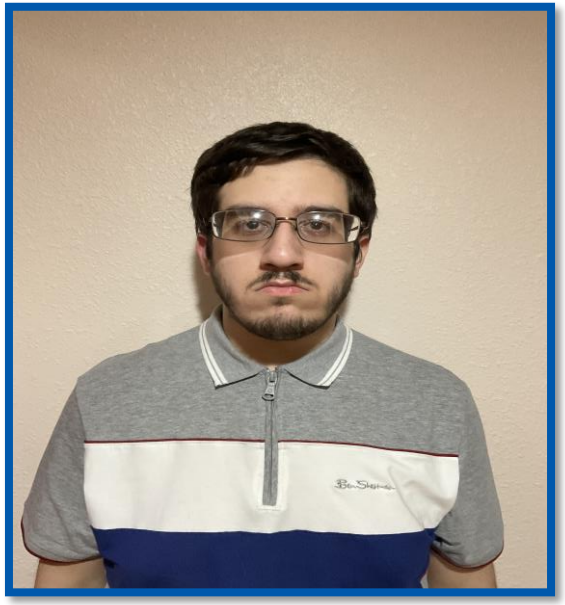
KAYLEN ESSIX
Senior, Mechanical Engineering



HAVILAH AKACHUKWU
Senior, Mechanical Engineering

MEET THE TEAM

DONOVAN DAVIS
Sophomore, Mechanical Engineering



AVRAZ TOVI
Senior, Mechanical Engineering

Dr. Mohammad Habibi
FACULTY ADVISOR
Assistant Professor
Mechanical Engineering Dept.

MEET THE MENTORS

ERNIE PARKER, CFPA
Fluid Power Hall of Fame Inductee

DEAN EBERHARDT, CFPS
IFP Motion solutions

AND

BRIAN TRITLE
IFP Motion Solutions

Project Goals and Objectives

❑ Competition's Goals and Objectives

- ✓ Stimulate education in fluid power components, circuits, and systems, incorporating them into a systems engineering experience.
- ✓ Provide students with experience in real-world engineering under a strict timeline of designing, simulating, ordering, building, testing, and demonstrating their designs.
- ✓ Stimulate innovative thinking for designing and testing potential new fluid power technologies or concepts integrated into a vehicle platform.
- ✓ Provide an industry recruitment opportunity for high-potential engineering seniors by engaging directly with practitioners in the fluid power industry.

Project Goals and Objectives

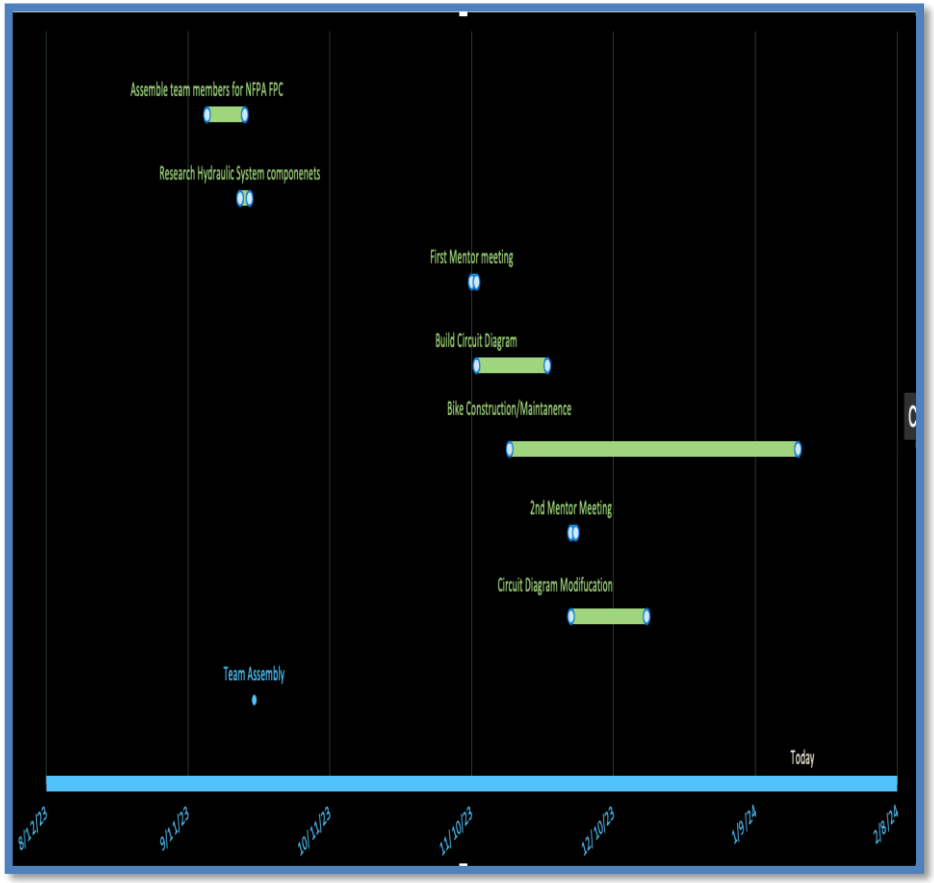
❑ Team's Goals and Objectives

- ✓ Vehicle should be able to qualify for all races.
- ✓ Vehicle's must meet the weight requirement by not exceeding 200 lbs.
- ✓ Vehicle must meet all safety requirements; injury to driver cannot occur.
- ✓ Participating students must finish the project having learned more about fluid power and the product manufacturing process.

Project Goals and Objectives

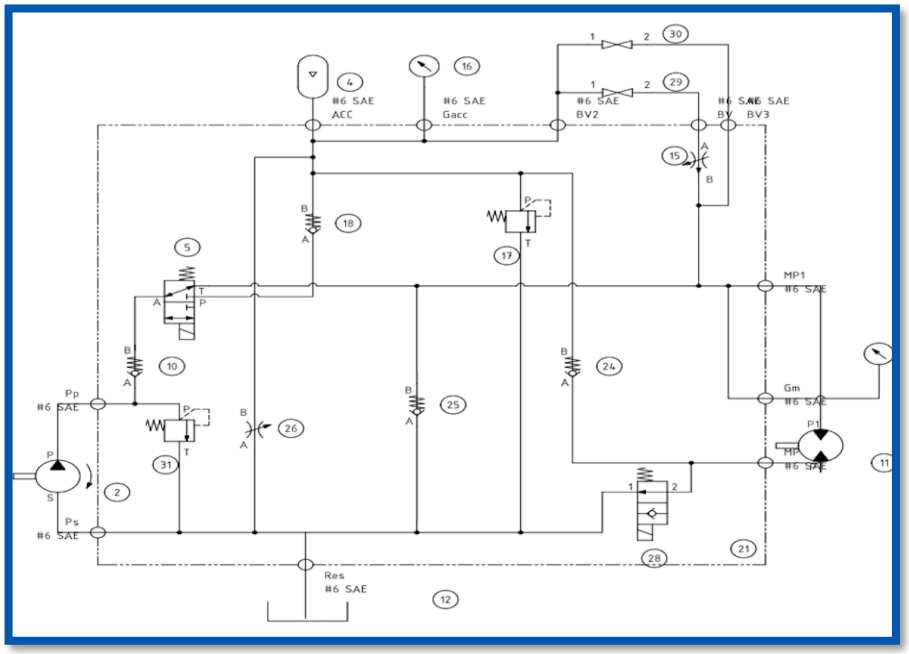
- Project Management

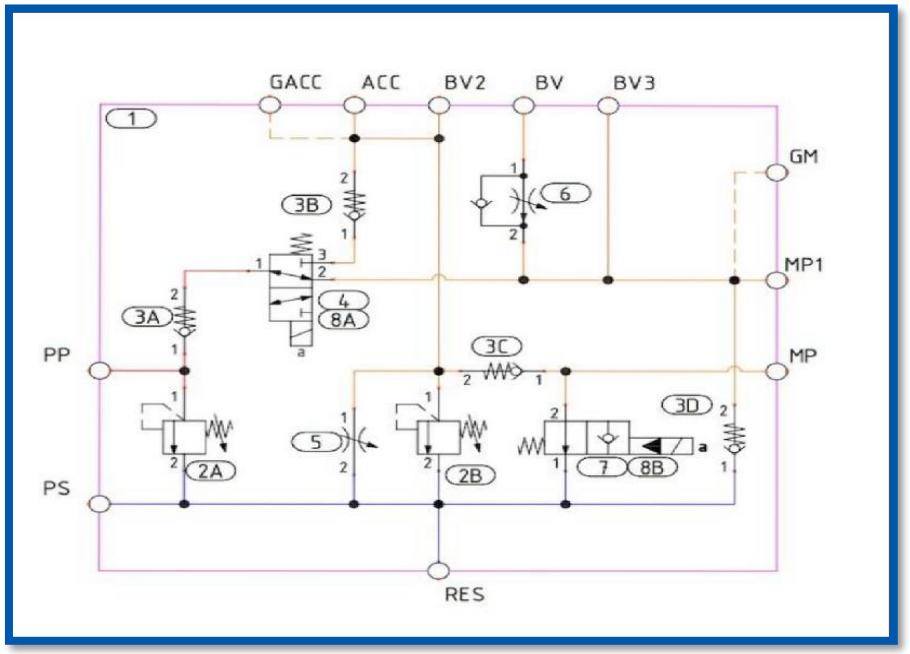
No.	Start Date	End Date	Task
1	9/15/23	9/22/23	Assemble team members for NFPA FPC
2	9/22/23	9/23/23	Research Hydraulic System componenets
3	11/10/23	11/10/23	First Mentor meeting
4	11/11/23	11/25/23	Build Circuit Diagram
5	11/18/23	1/17/24	Bike Construction/Maintanence
6	12/1/23	12/1/23	2nd Mentor Meeting
7	12/1/23	12/16/23	Circuit Diagram Modifucation
8	12/16/23	1/15/24	Design of Hyrdaulic component houisng
9	11/10/23	1/26/24	Material Allocation
10	1/19/24	1/19/23	Midway Review
11	1/22/24	1/29/23	Component Mounting
12	1/29/24	2/29/24	Hydraulic component housing construction



DESIGN PROGRESS

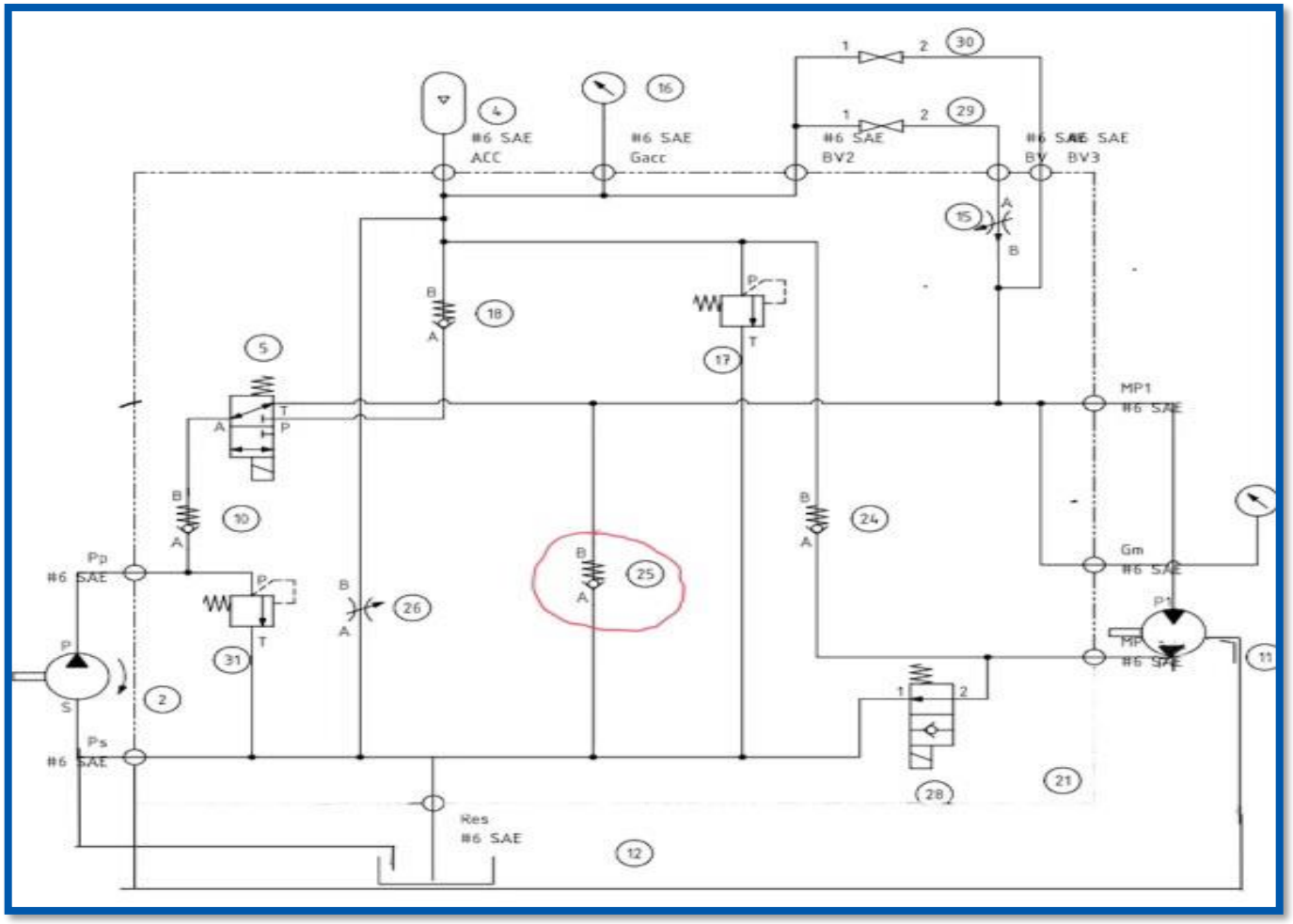
- Hydraulic Circuit Stage 1





DESIGN PROGRESS

- Hydraulic Circuit Final

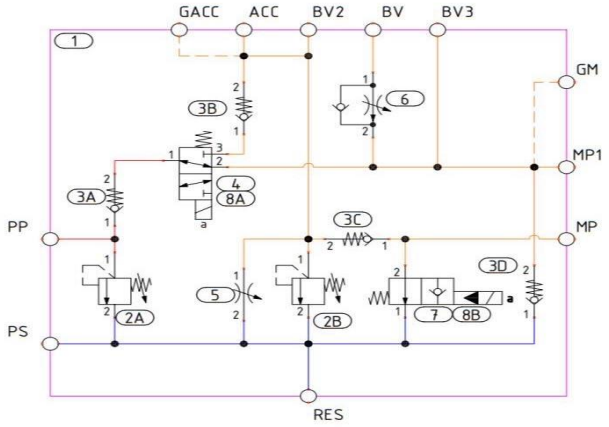


DESIGN PROGRESS

- Manifold Design

ITEM ID	PORT TYPE	PORT SIZE
ACC, BV, BV2, BV3, GACC, GM, MP, MP1, PP, PS, RES	SAE O-RING	#6 SAE

Item	Qty	Model Code	Description	Manufacturer
1	1	FV-14057-M1	Manifold body	Source Fluid Power
2	2	RV1-10-S-0-36	Relief Direct Acting	Eaton
3	4	CV08-NP-0.3-B-00	Check 1 to 2	Danfoss ICS
4	1	SV1-10-3-0-00	Solenoid 2 pos. 3 way	Eaton
5	1	NV1-8-S-0	Needle Valve, Screw Adj	Eaton
6	1	FAR1-10-S-0	Flow Control Compensated, Screw Adjust	Eaton
7	1	SV3-10-0-0-00	Solenoid 2 pos. 2 way	Eaton
8	2	300AA00081A	Coil 12VDC, DIN	Eaton



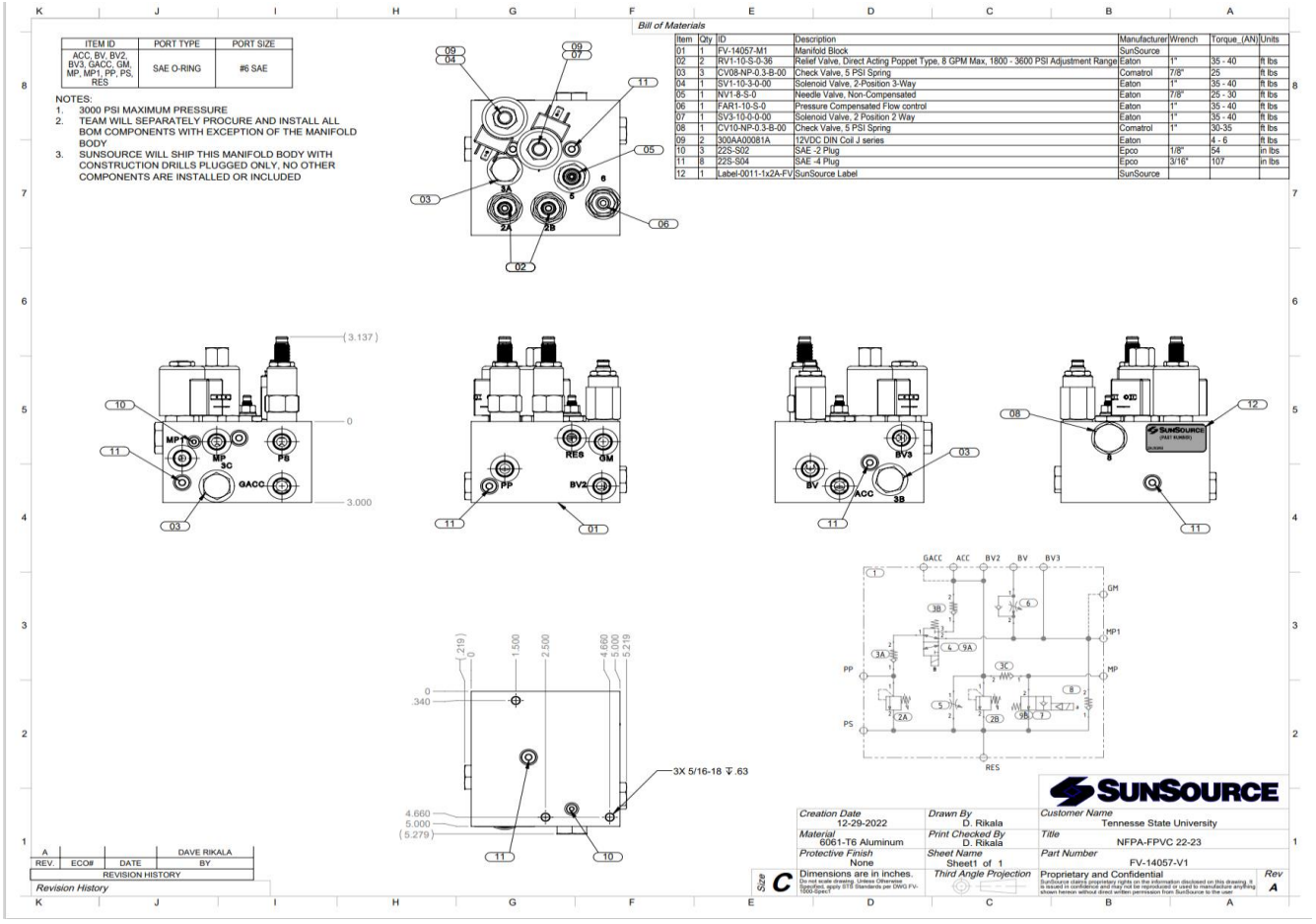
Notes:
-3000 PSI max

SUNSOURCE

Creation Date 12/19/2022	Drawn By J. McCarthy	Customer Name Tennessee State University
Material Aluminum	Print Checked By (Team)	Title NFPA-FPVC 22-23 manifold
Protective Finish None	Sheet Name Sheet 1 of 1	Part Number FV-14057-V1 schem
Size B — Dimensions are in inches. Do not scale drawing. Unless otherwise specified, apply standards per FV-1000-Spec1	Third Angle Projection	Proprietary and Confidential. SunSource claims proprietary rights on the information disclosed on this drawing. It is issued in confidence and may not be reproduced or used to manufacture anything shown hereon without direct written permission from SunSource to the user. Rev A

DESIGN PROGRESS

- Manifold Design



ITEM ID	PORT TYPE	PORT SIZE
ACC, BV, BV2, BV3, GACC, GM, MP, MP1, PP, PS, RES	SAE O-RING	#6 SAE

NOTES:
1. 3000 PSI MAXIMUM PRESSURE
2. TEAM WILL SEPARATELY PROCURE AND INSTALL ALL BOM COMPONENTS WITH EXCEPTION OF THE MANIFOLD BODY
3. SUNSOURCE WILL SHIP THIS MANIFOLD BODY WITH CONSTRUCTION DRILLS PLUGGED ONLY, NO OTHER COMPONENTS ARE INSTALLED OR INCLUDED

Bill of Materials

Item	Qty	ID	Description	Manufacturer	Wrench	Torque_(AN)	Units
01	1	FV-14057-M1	Manifold Block	SunSource			
02	2	RV1-10-S-0-36	Relief Valve, Direct Acting Poppet Type, 8 GPM Max, 1800 - 3600 PSI Adjustment Range	Eaton	1"	35 - 40	ft lbs
03	3	CV08-NP-0.3-B-00	Check Valve, 5 PSI Spring	Comatrol	7/8"	25	ft lbs
04	1	SV1-10-3-0-00	Solenoid Valve, 2-Position 3-Way	Eaton	1"	35 - 40	ft lbs
05	1	NV1-8-S-0	Needle Valve, Non-Compensated	Eaton	7/8"	25 - 30	ft lbs
06	1	FAR1-10-S-0	Pressure Compensated Flow control	Eaton	1"	35 - 40	ft lbs
07	1	SV3-10-0-0-00	Solenoid Valve, 2 Position 2 Way	Eaton	1"	35 - 40	ft lbs
08	1	CV10-NP-0.3-B-00	Check Valve, 5 PSI Spring	Comatrol	1"	30-35	ft lbs
09	2	300AA00081A	12VDC DIN Coil J series	Eaton		4 - 6	ft lbs
10	3	22S-S02	SAE -2 Plug	Epco	1/8"	54	in lbs
11	8	22S-S04	SAE -4 Plug	Epco	3/16"	107	in lbs
12	1	Label-0011-1x2A-FV	SunSource Label	SunSource			

3X 5/16-18 ↧.63

REV.	ECO#	DATE	BY
A			DAVE RIKALA

REVISION HISTORY

Revision History

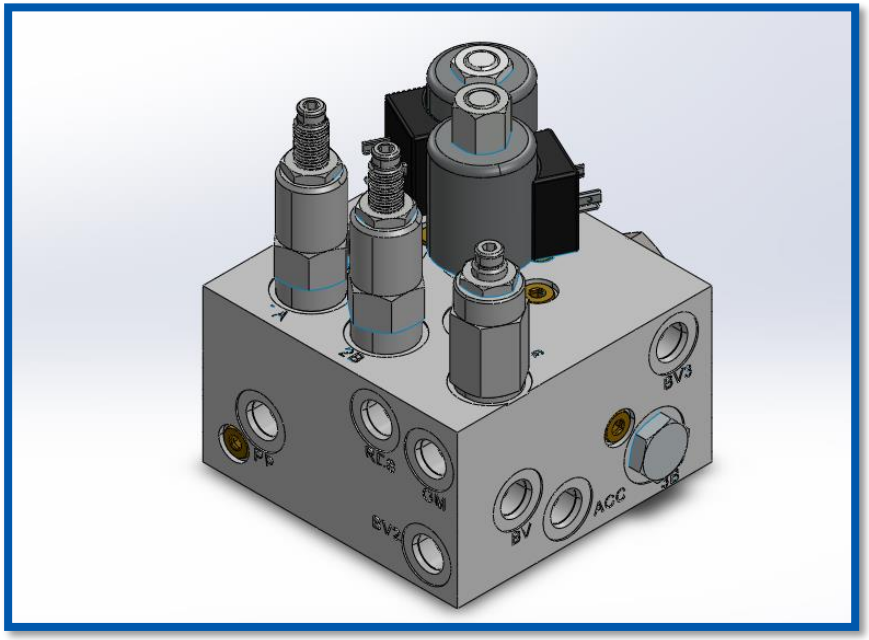
Creation Date 12-29-2022	Drawn By D. Rikala	Customer Name Tennesse State University
Material 6061-T6 Aluminum	Print Checked By D. Rikala	Title NFPA-FPVC 22-23
Protective Finish None	Sheet Name Sheet1 of 1	Part Number FV-14057-V1
Dimensions are in inches.	Third Angle Projection	Proprietary and Confidential

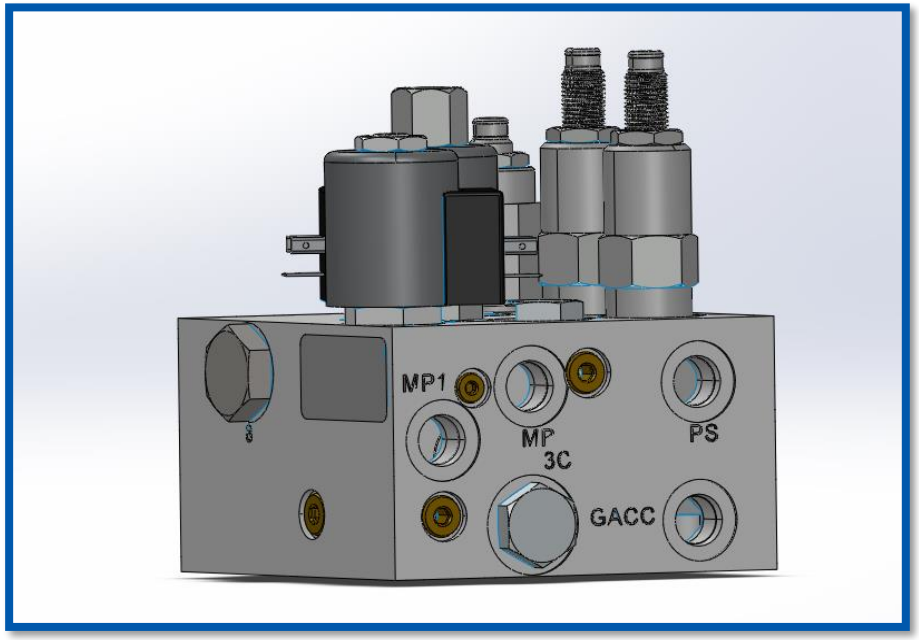
Size C — Rev A

SUNSOURCE

DESIGN PROGRESS

- Manifold design – 3D





DESIGN PROGRESS

- Manifold design – Physical Model

DESIGN PROGRESS

- Manifold design – Physical Model

Hydraulic Calculations

- Vehicle Hardware

Current Gross Weight of Vehicle	
Accumulator	32 lbs.
Check Valve (x4)	0.09 lbs.
Electrical Connector (x2)	0.04375 lbs.
Flow Regulator	0.44 lbs.
Needle Valve (x2)	0.15 lbs.
Gear Motor	7 lbs.
Gear Pump	6 lbs.
2W/2P Poppet	0.87 lbs.
3W/2P Spool	0.93 lbs.
Ball Valve (x2)	1.55 lbs.
Bike	66 lbs.
Total	118.0875 lbs.

Estimated Weight of components: 52.0875 lbs.

Estimated Weight of vehicle with Rider: 286.0875lbs.

Hydraulic Calculations

RPM = **(336/diameter of the wheel * mph).**

[Focus on a minimum of 10 mph]

= [(336/23)*10]

= 0.4348 hp (Estimated)

Gear Ratio

- Pump: 34/15 = GR = 2.267
- Motor: 24/15 = GR = 1.6

Vehicle Assembly

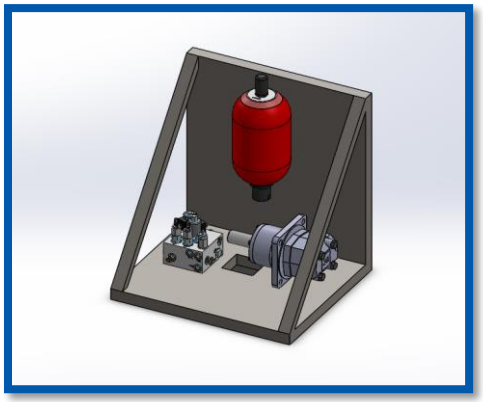
- Bare Frame

Vehicle Assembly

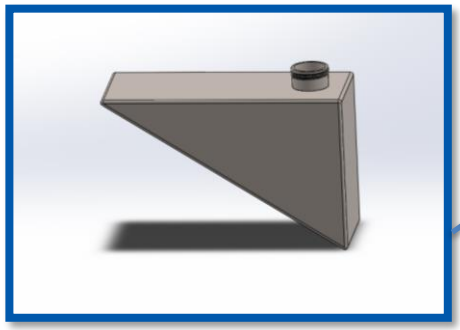
- Initial Set-up Idea

Vehicle Assembly

FRAME DESIGN 1



Rear Frame Design

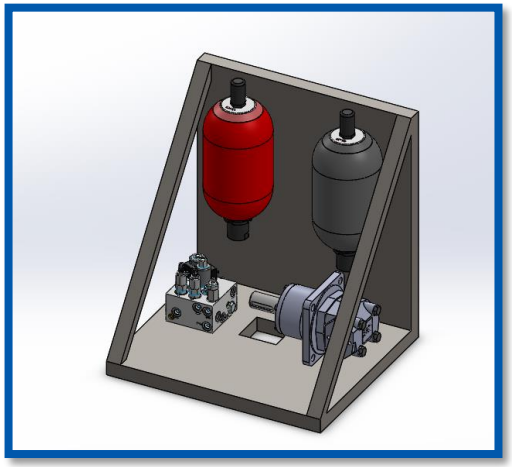


Reservoir

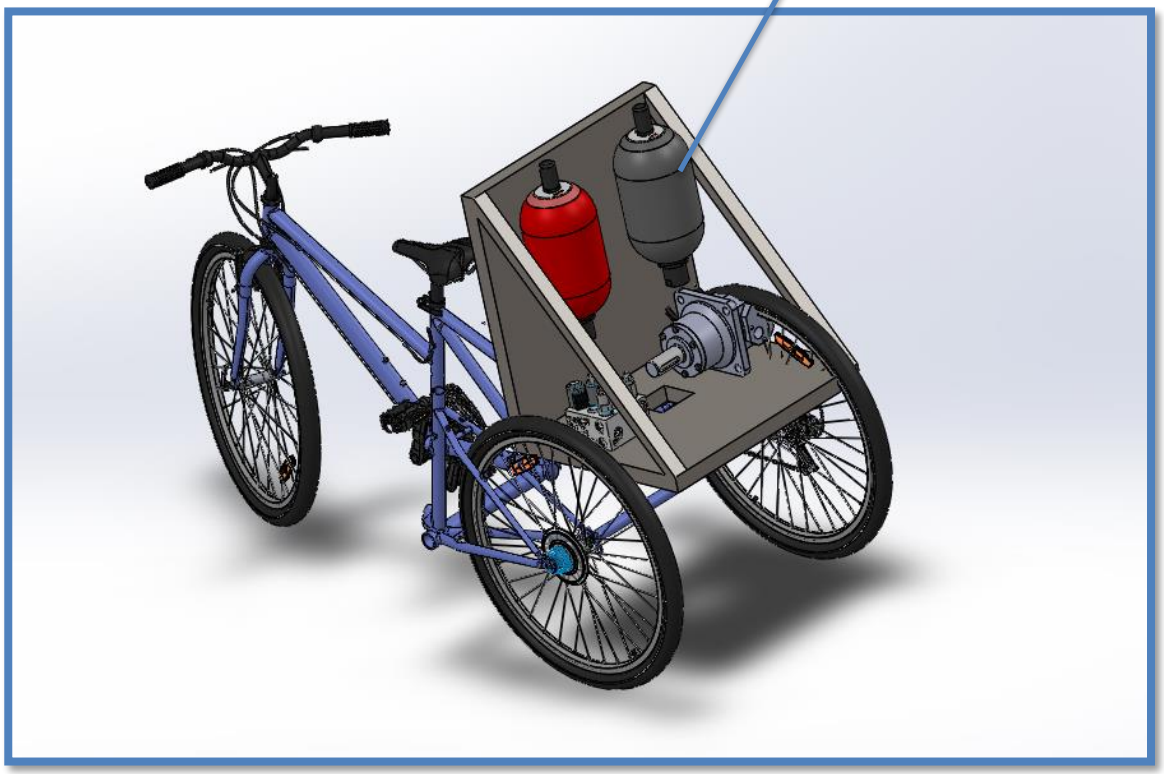
Frame TYPE 1 Layout

Vehicle Assembly

FRAME DESIGN 2



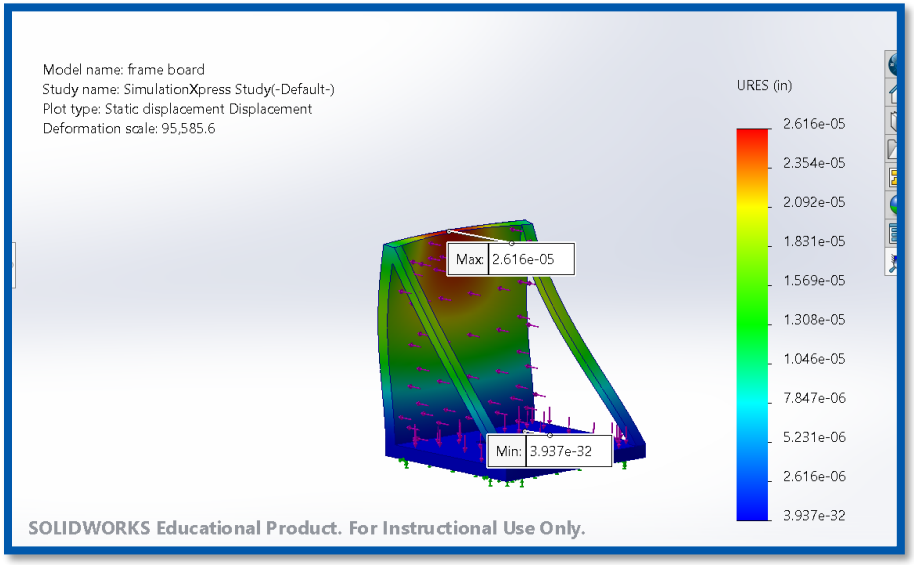
Rear Frame Design



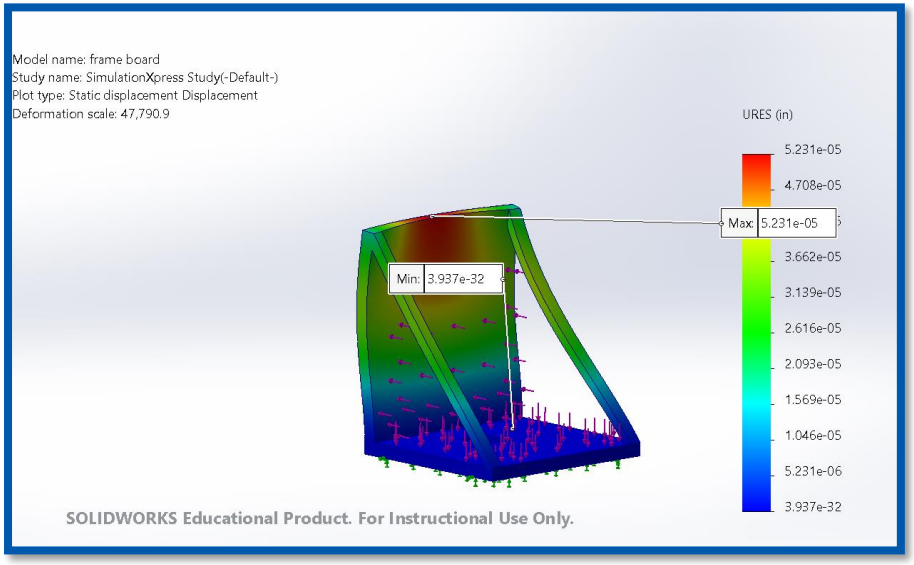
Frame TYPE 2 Layout

FEA ANALYSIS

- FRAME LAYOUT 1



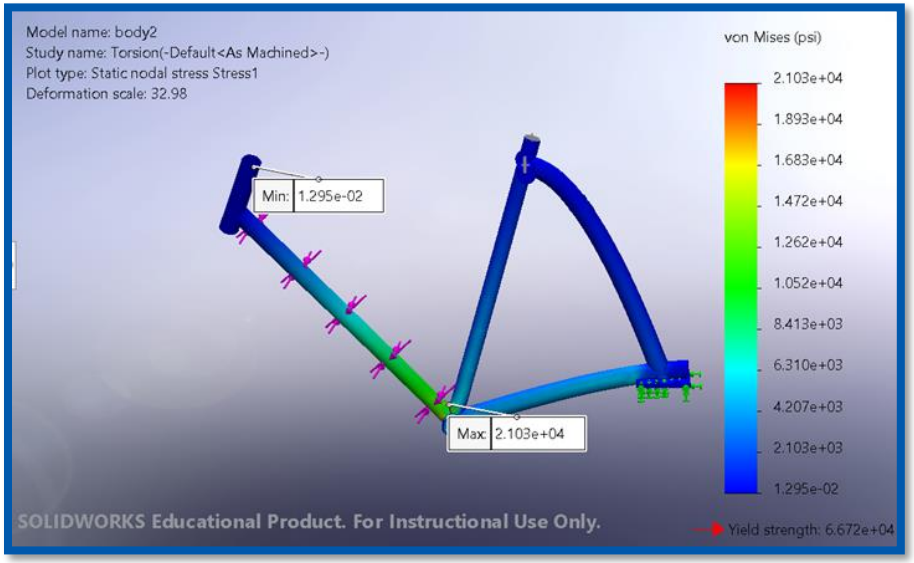
Static Displacement on rear frame 1



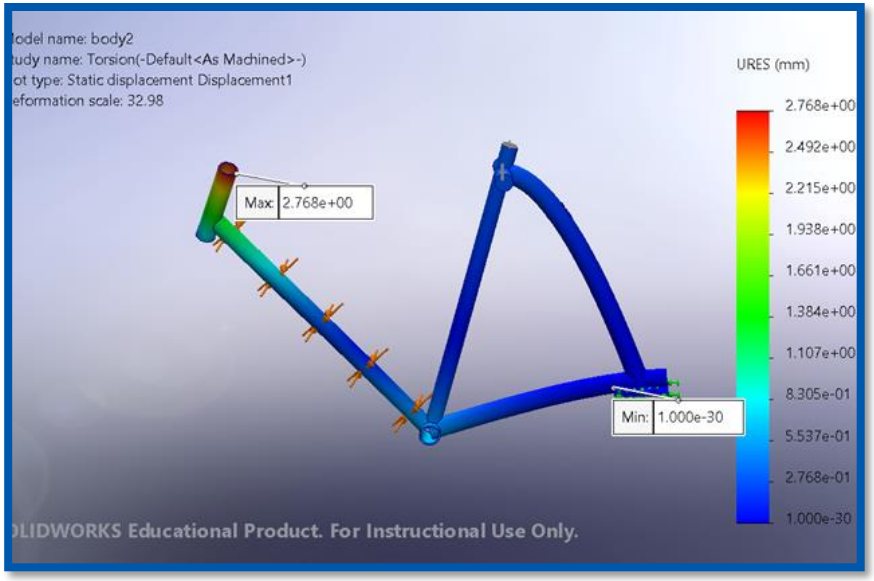
Static Displacement on rear frame 2

FEA ANALYSIS

- Torsional Analysis of vehicle frame



Static stress distribution on frame

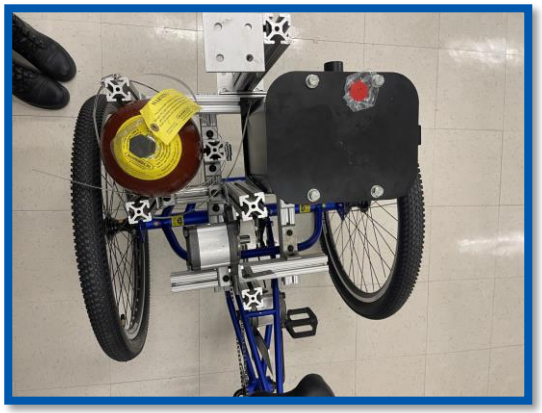


Static displacement on frame

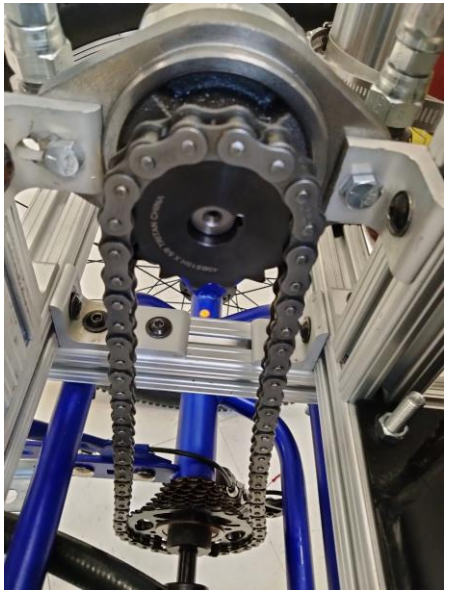
Frame to be redesigned and tested again

Vehicle Assembly

- Final Frame Set-up progress



Significant Assembly Stages



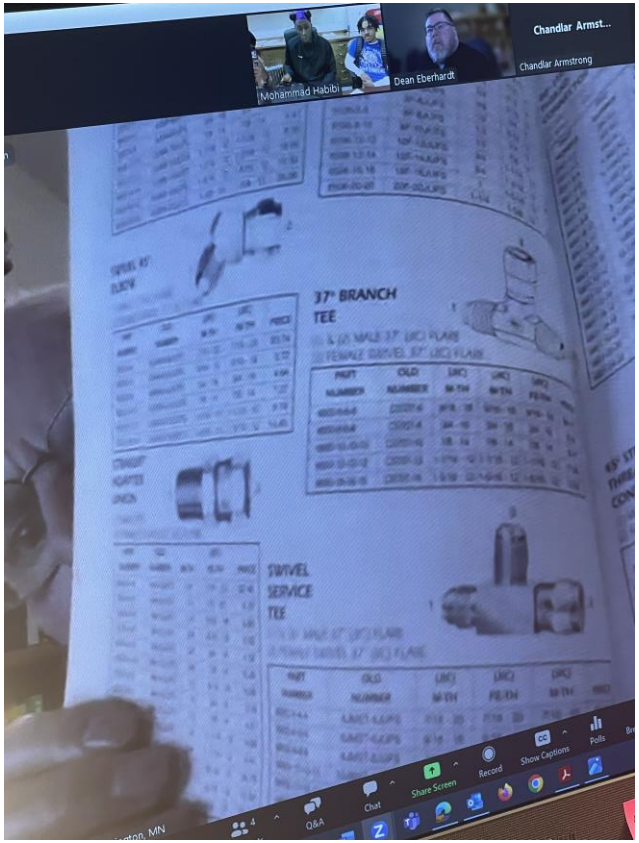
Challenges Faced

- Bike Maintenance
  - Locating Bike shop
  - Broken rear brake (repaired)
  - Handlebars (repaired)
  - Access to sufficient welding tools/welder

- Material allocation in Nashville area
  - Hydraulic hosing
  - K-string
  - Reservoir
  - Switch-Valve

Challenges Faced

❑ Mentor Meeting Topics



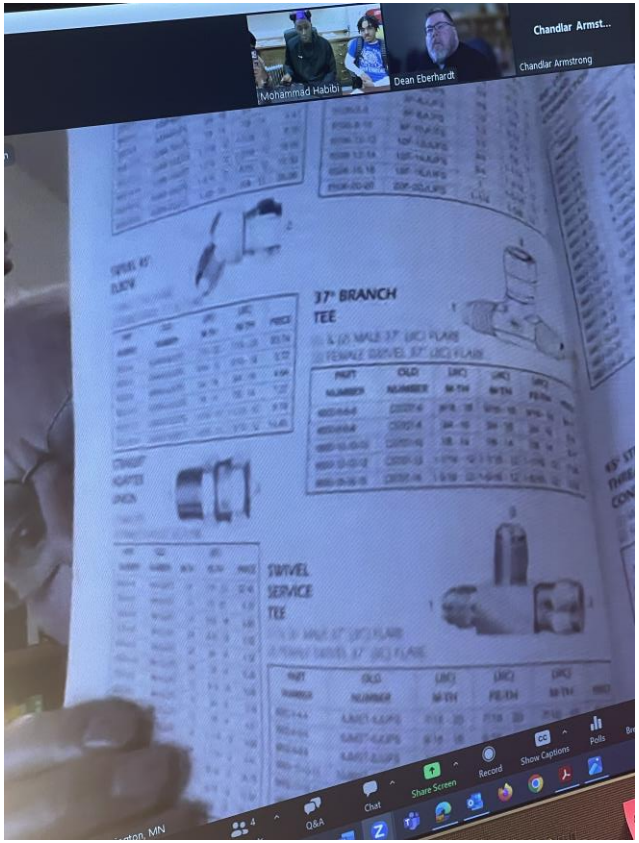
- **11/10/23 (Introduction)**
  - **Introduce team members**
  - **Importance of mounting Components**
  - **Sprocket**
  - **Outline of different NFPA competitions**

- **12/01/23**
  - **Manifold alteration**
  - **Circuit Diagram Stage 2**

- **12/12/23**
  - **90 degree elbows effect pressure drop**
  - **Explore adding cavity for 1psi check valve into manifold**
  - **Adding k-string to connect motor**
  - **Rotating pump in circuit diagram to show 1-directional**

Challenges Faced

❑ Mentor Meeting Topics



- **01/22/24**
  - **Gear Ratio & complete Hydraulic Calculation**
  - **Problems with material allocation for F.D 1**

- **02/19/24**
  - **Hydraulic system Frame Design Option 4 begins**
  - **Extruded Aluminum was chosen as material for FD**

- **03/18/24**
  - **Mentor visit to TSU Campus as students faced challenges with Hosing allocation**
  - **Frame design was 65% complete.**
  - **Motor had to be remounted**

- **03/25/24**
  - **Accumulator Pre-charging**
  - **Ball valves to be incorporated into system upon arrival.**

THANK YOU

QUESTIONS?