NFPA Fluid Power Vehicle Challenge

Braden Keown
Caleb Jackson
Caleb Barley

West Virginia University
INSTITUTE OF TECHNOLOGY

Outline

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- References

Meet the Team

Braden Keown

Caleb Jackson

Caleb Barley

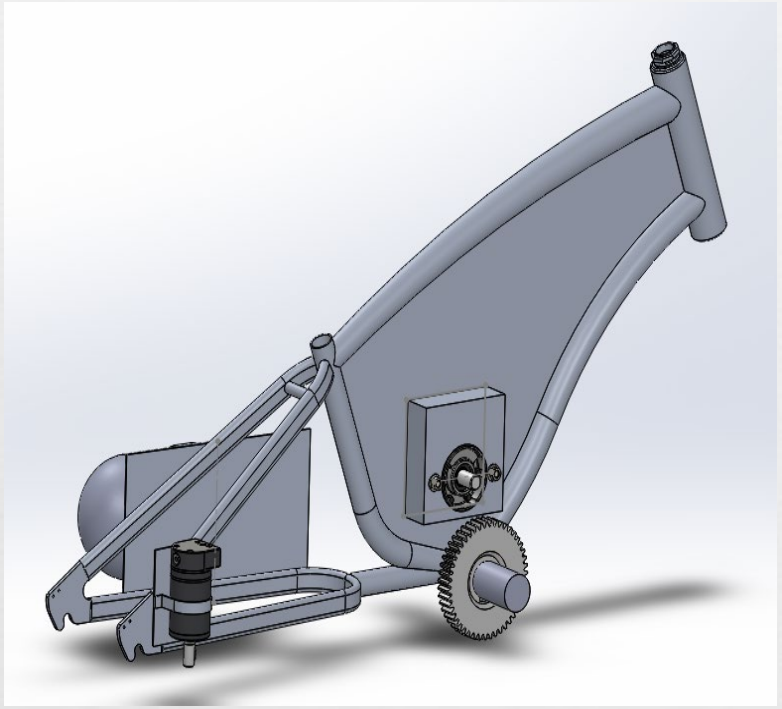
Dr. Yogendra Panta

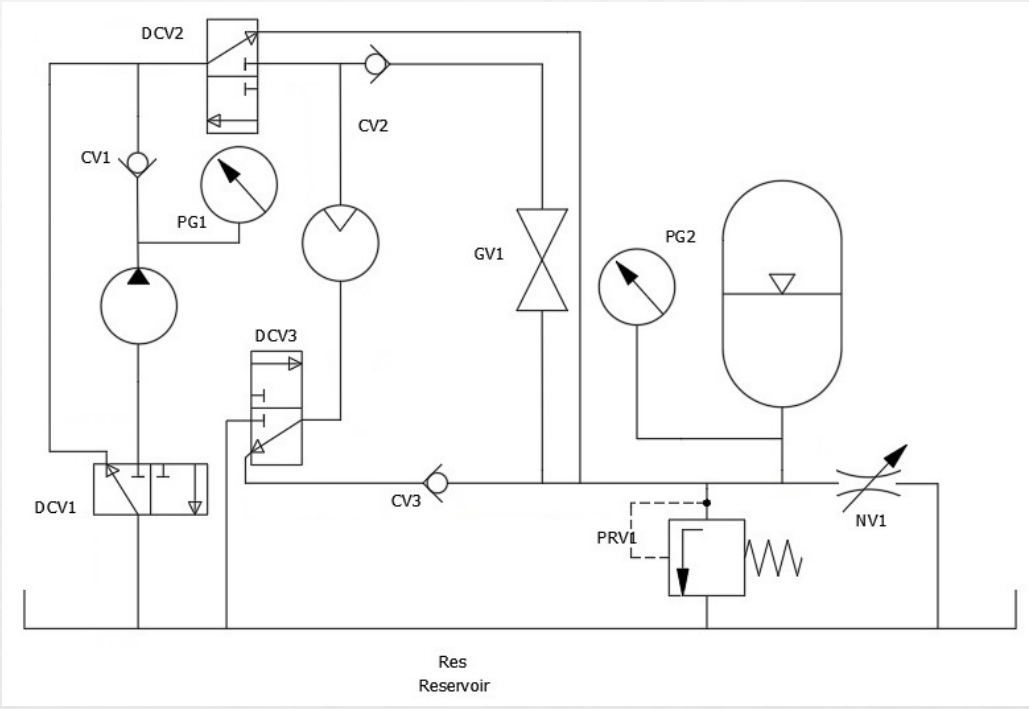
West Virginia University
INSTITUTE OF TECHNOLOGY

Problem Statement and Objectives

- Improve on the previous years design
- Make it more ergonomic
- Learn more about hydraulics and its application
- Learn more about the design process

Initial Design & Calculations





Initial layout of components and Circuit Diagram

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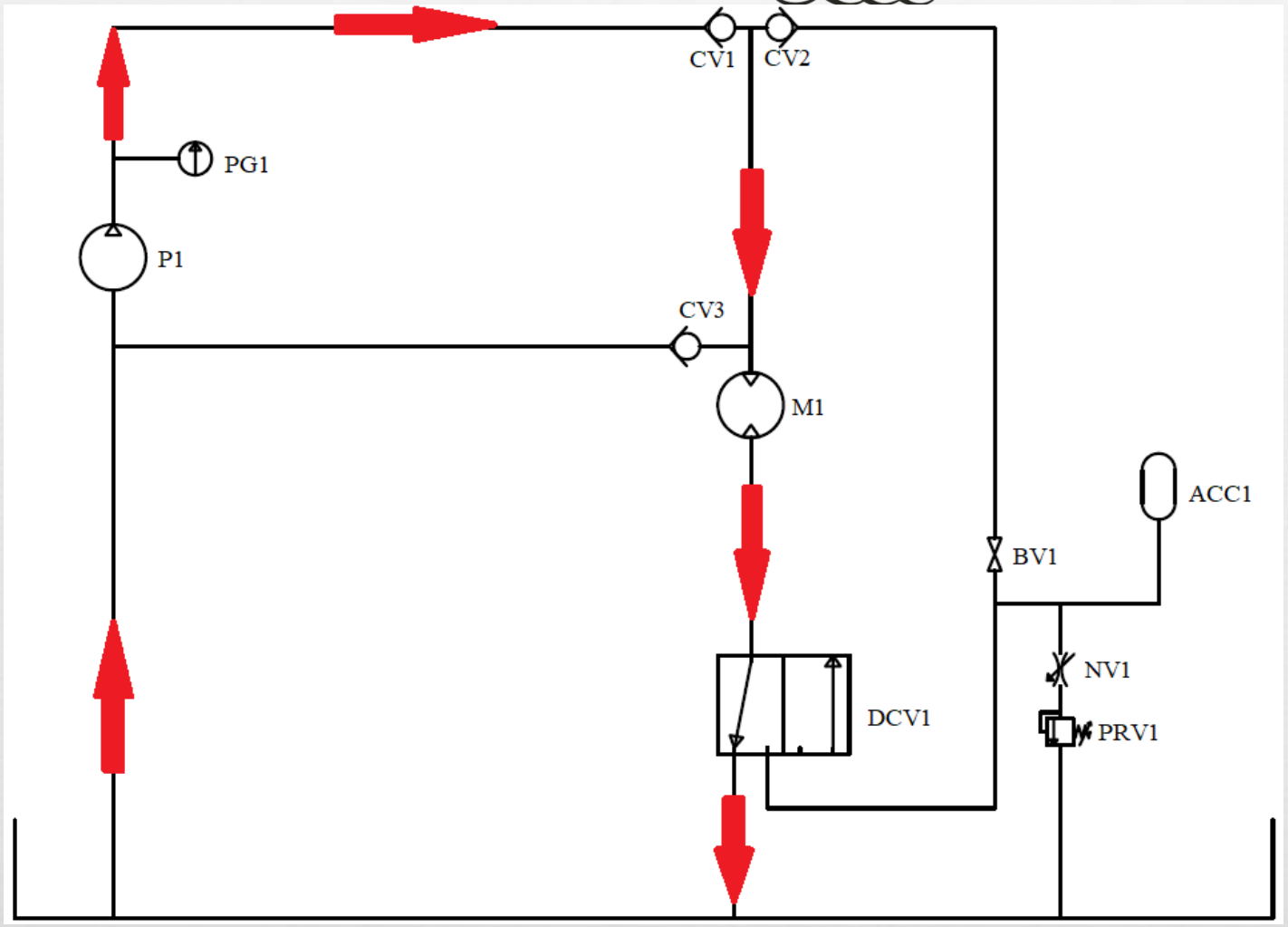
Initial Design & Calculations

Pull [lb]	8.995
Wheel Torque [in lb]	233.9
GR1	1.05556
Wheel [RPM]	193.846
Motor [CIR]	1.551
Flow Rate [GPM]	1.3
HP	0.758
GR2	4
Pump [RPM]	240
Pump [CIR]	1.25

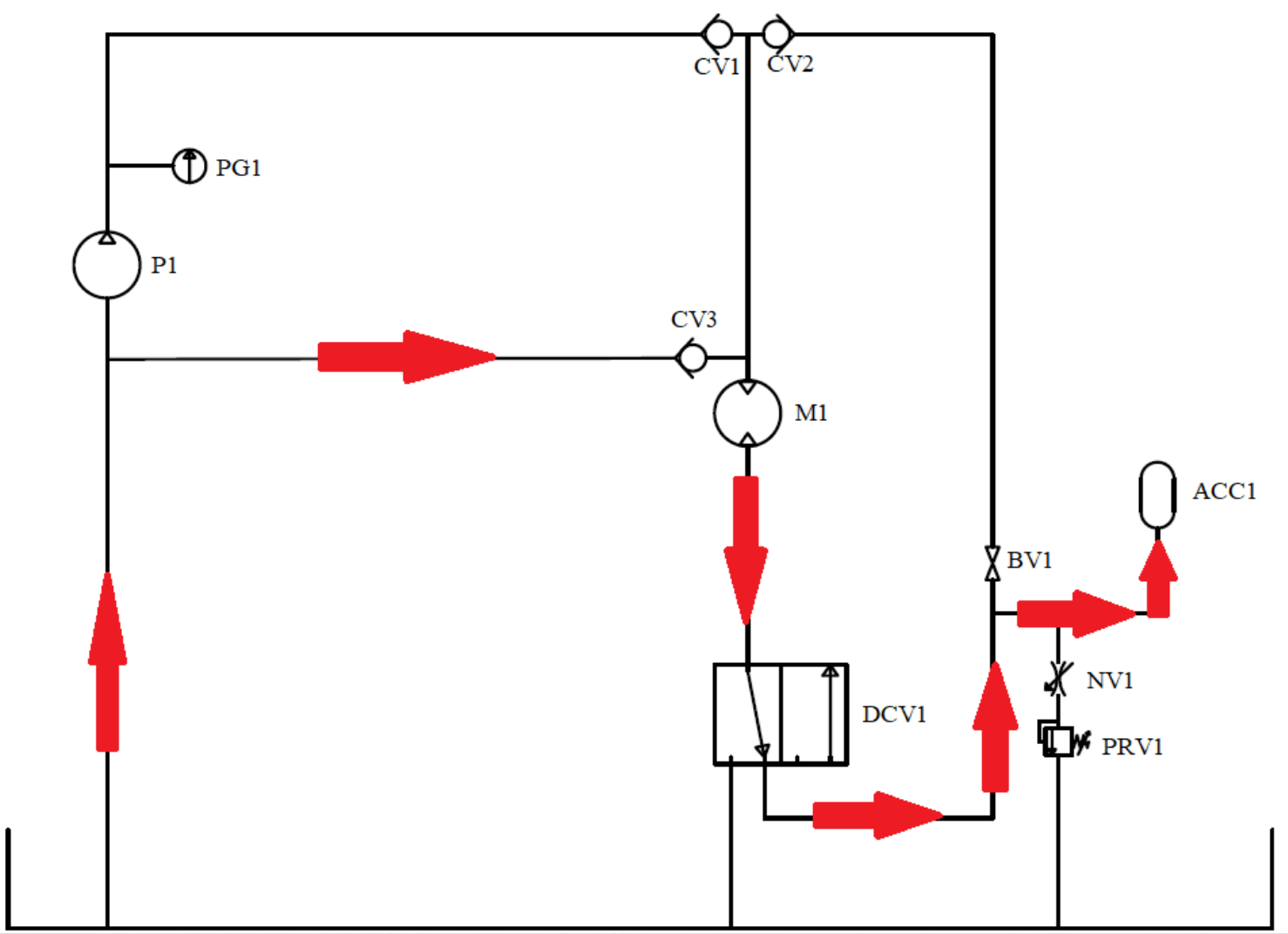
Initial Calculations

Changes to Design & Construction



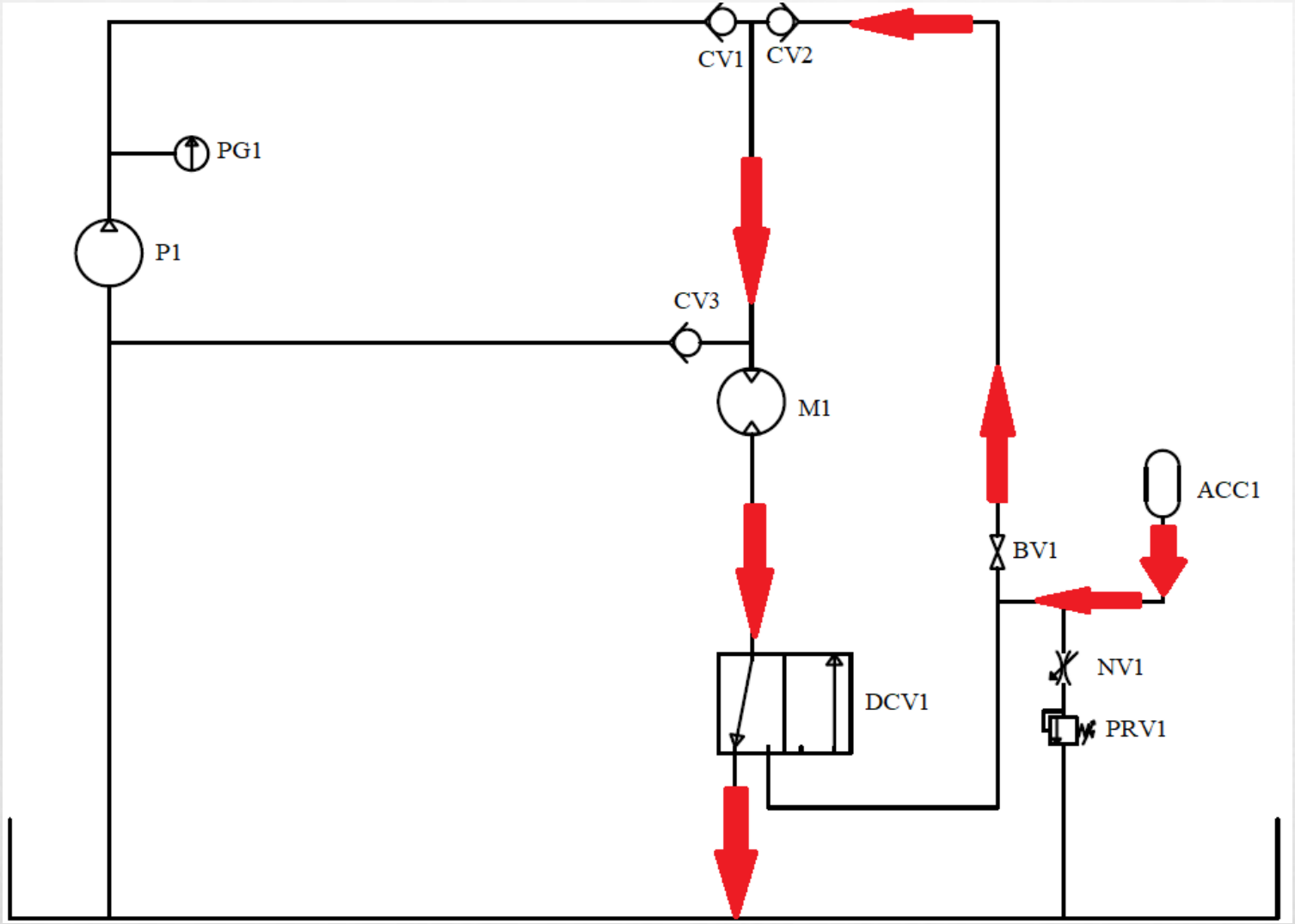
Direct Drive Circuit Design

Changes to Design & Construction



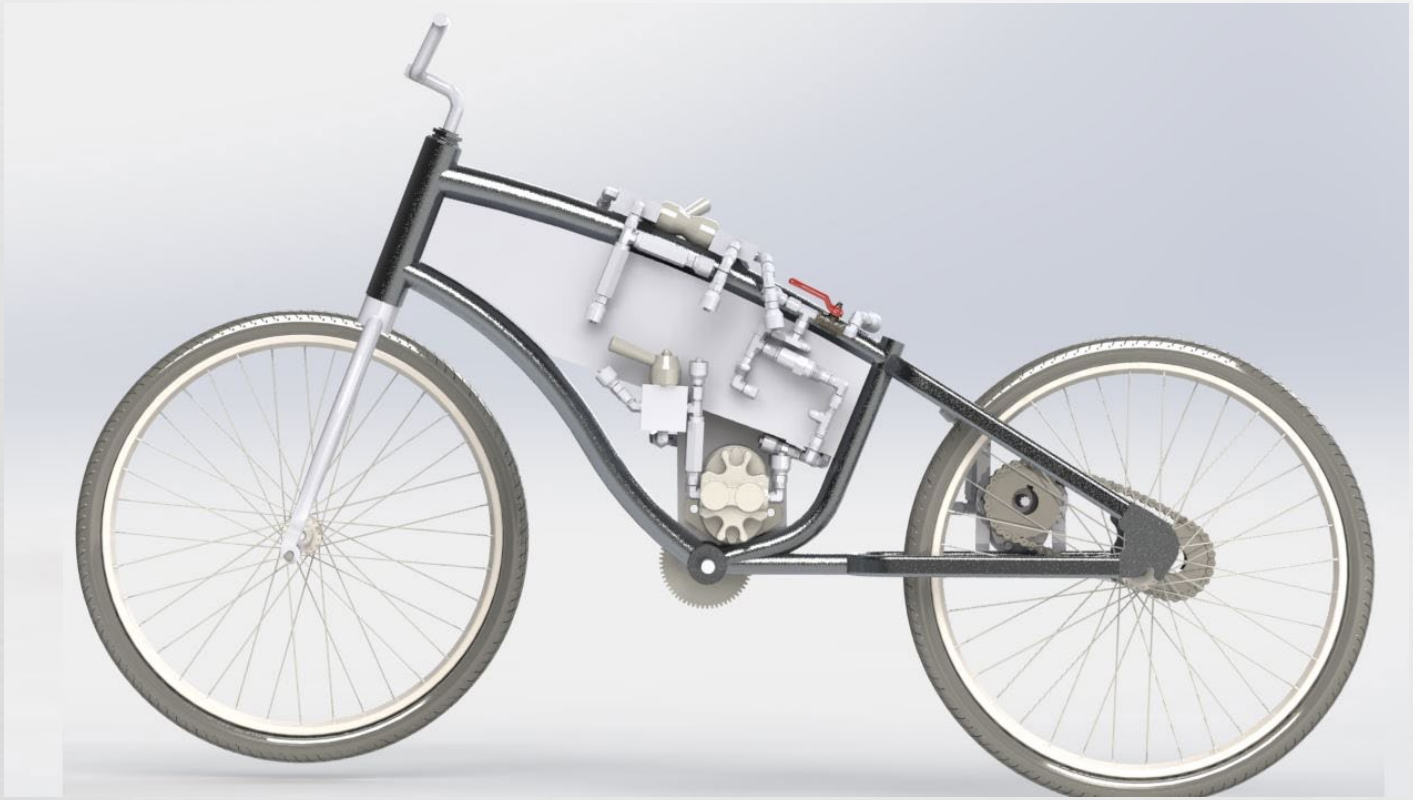
Regenerative Braking Circuit Design

Changes to Design & Construction



Boost Mode Circuit Design

Changes to Design & Construction



Bicycle Design:

From the initial design we changed how the pump and motor are mounted, the size of the reservoir. Originally the pump was to sit in the centre of the bike by offset from centre plate, our final design uses two tabs welded from the centre (4th picture, next page). The motor uses two structural members welded to the frame instead of a plate. The volume of the reservoir is smaller as after volume calculations it didn't need to be so big.

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Changes to Design & Bicycle Construction

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Changes to Design & Construction

Caleb Jackson grinding off the misaligned gear so we can put the new water jet cut gears on.

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Changes to Design & Bicycle Construction

Final Product

Performance & Evaluation

Standard Data	
GR1	3
Pump [CIR]	0.58
Motor [CIR]	0.62

Minimum input (60 RPM)			
Gear System 1		Gear System 2	
System Pressure [psi]	1000	System Pressure [psi]	1000
Pump Min [RPM]	210	Pump Min [RPM]	210
Flow Rate [GPM]	0.527	Flow Rate [GPM]	0.527
HP	0.308	HP	0.308
GR2	1.0556	GR2	0.5
Motor [RPM]	196.35	Motor [RPM]	196.35
Wheel [RPM]	207.3	Wheel [RPM]	98.175
Wheel Torque [in lb]	93.5	Wheel Torque [in lb]	197.45
Pull [lb]	3.6	Pull [lb]	7.6
Speed (MPH)	16.04	Speed (MPH)	7.6
Weight [lb]	90	Weight [lb]	90

Maximum input (≈125 RPM)			
Gear System 1		Gear System 2	
Pump Max [RPM]	375	Pump Max [RPM]	375
Flow Rate [GPM]	0.9415	Flow Rate [GPM]	0.9415
HP	0.61	HP	0.61
Motor [RPM]	350	Motor [RPM]	350
Wheel [RPM]	370	Wheel [RPM]	175
Wheel Torque [in lb]	93.5	Wheel Torque [in lb]	197.45
Pull [lb]	3.6	Pull [lb]	7.6
Speed (MPH)	28.62	Speed (MPH)	14.31

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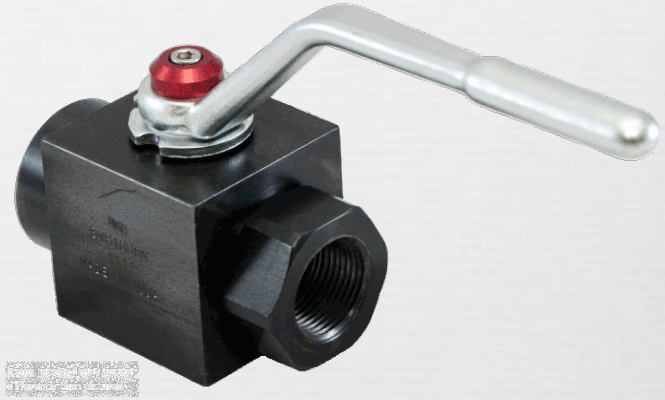
Hardware Used

Eaton Gear Motor 0.62
CIR 26703-DAA

Eaton Gear Pump 0.58
CIR 26003-RZJ



SunSource Ball valve, 2 way, 2000 PSI, -6 SAE port

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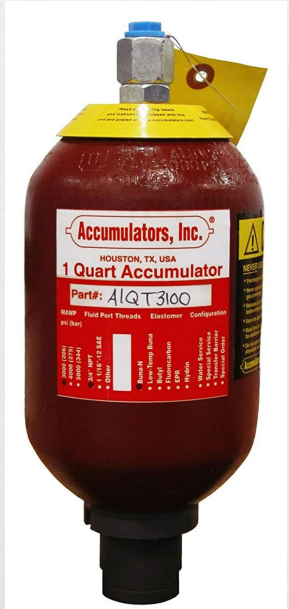
Hardware Used

SunSource Ball valve, 3 way, 3000 PSI, -6 SAE port

3000 psi, 1 quart Accumulator



18 & 19 tooth sprockets (respectively)

Hardware Used

Relief Valve, 1000 to 2500 psi, 1/2" NPT, 16.0 GPM, Steel

In-Line Needle Valve, 3/8" FNPT Port

16 & 48 tooth gears (respectively) made by water jet cutting

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Cost Evaluation

Bill of Materials								
	Part Name	Schematic Name	Vendor	Part Number	Quantity	Cost Per Unit	Total Cost	
1	1 Quart Accumulator 3000psi	ACC	McMaster	59595K18	1	$ 676.96	$ 676.96	
3	Gear Motor, 0.62 CID, Keyed Shaft .625", Bi-rotatoin, internal drain	M	Eaton	26703-DAA	1	$ 274.69	$ -	
4	HP Ball Valve 3/8" SAE 3 Way	BV	SunSource	BV3D-0375SA-1111	1	$ 51.43	$ 51.43	
4	HP Ball Valve 3/8" SAE	BV	SunSource	BVH-0375S-1111	1	$ 54.72	$ -	
5	Gear Pump, 0.58 CID, 9 tooth spline, CW rotation	P	Eaton	26003-RZJ	1	$ 178.87	$ -	
7	Relief, Direct Acting	PRV	Grainger	RD1850H	1	$ 75.19	$ -	
8	Flow Control, Needle Valve	NV	Zoro	WNV-600	1	$ 36.43	$ -	
9	Fitting, -6 JIC male "T"	MMMTJ6	Eaton	2033-6-6S	5	$ 1.84	$ 9.20	
10	Fitting, -6 JIC, male to female swivel with male branch	MMFTJ6	Eaton	203101-6-6S	2	$ 2.59	$ 5.18	
11	Fitting, -6 JIC male to -6 JIC female swivel, 45 degree	FF45J6	Eaton	2070-6-6S	10	$ 1.74	$ 17.40	
12	Fitting, -6 JIC male to -6 JIC female swivel, 90 degree	MF90J6	Eaton	2071-6-6S	16	$ 1.98	$ 31.68	
13	M/M 90 Joint SAE 6	MM90J6	Eaton	2039-6-6S	3	$ 3.09	$ 9.27	
14	M/M Connectors SAE 6	MMC6	Eaton	202702-6-6S	2	$ 2.12	$ 4.24	
15	Adapter M/M Straight SAE 12 - SAE 6	MFC6	Eaton	202702-12-6S	2	$ 9.13	$ 18.26	
16	Adapter M/F Straight SAE 12 - SAE 6	AS126	Eaton	FF1010-1206S	3	$ 7.27	$ 21.81	
17	Female Tube Fittings SAE 6	FTF6	Eaton	1AA6FJ6	10	$ 3.00	$ 30.00	
18	Male Tube Fittings SAE 6	MTF6	Eaton	1AA6MJ6	15	$ 3.00	$ 45.00	
19	FF 90 Joint SAE 6	FF90J6	Eaton	C3509X6	2	$ 3.74	$ 7.48	
20	Tube SAE 6	T6	Eaton	GH663-6	14	$ 5.09	$ 71.26	
21	Pressure Gage SAE 6	PG	McMaster	4089K61	1	$ 10.25	$ 10.25	
22	Metal Gear - 14-1/2 Degree Pressure Angle 15	G1	McMaster	6325K79	1	$ 28.62	$ 28.62	
23	Metal Gear - 14-1/2 Degree Pressure Angle 60	G2	McMaster	6325K4	1	$ 90.10	$ 90.10	
25	Aluminum Sheet 3mm 3ftx 3ft	AL	Mc Master	89015K75	1	$ 160.73	$ 160.73	
							$ 1,288.87	

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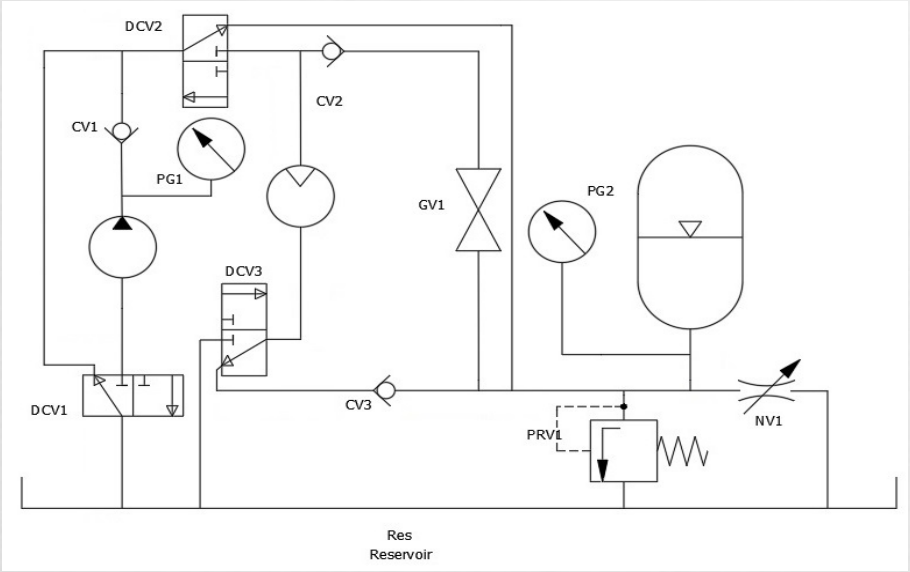
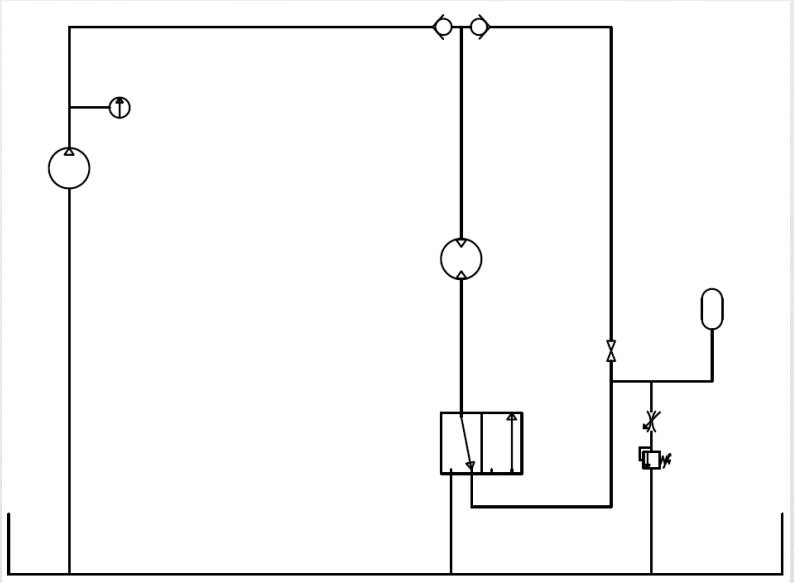
Occurred Problems, Mitigation & Lessons Learned

We had to machine our gears to allow them to fit between the pedals, the problem is our milling machine is 3 degrees unbalanced so the face at which the pedal sits against is misaligned, causing the gears to mesh incorrectly. Consequently, causing pedaling issues. Therefore we had to instead machine new gears from our water cutting jet.

Occurred Problems, Mitigation & Lessons Learned

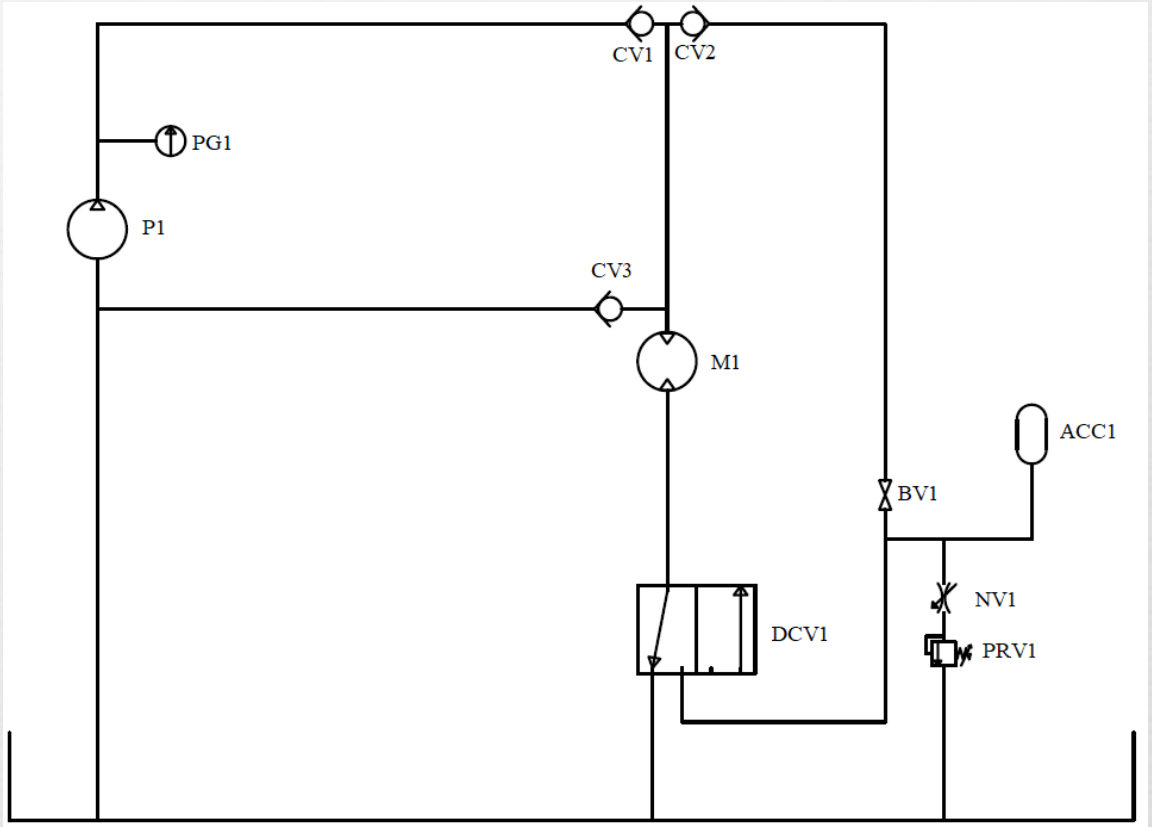
We also had problems with our parts, we ordered SAE 6 fitting control valves and check valve, but the vendor ended up sending us SAE 8 fitting valves instead. The solution was to use last years check valves and directional control valve, and consequently making a new circuit diagram (right), as we only have one directional control valve instead of three.





Occurred Problems, Mitigation & Lessons Learned

The last problem we faced was with our regenerative braking not working, the first part was having a free spinning back wheel, we fixed this by welding it together. The second part was to do with the new developed circuit. We did not add in a way for the circuit to bypass the pump and flow oil into the accumulator through the motor, the solution involved adding a check valve to the pump.



Conclusion

This experience taught us that your design is not always the right approach. Sometimes you need to step back and use a simpler, better solution.

Through the many problems that occurred throughout the construction process, with the help of others insight to our problems we were able to mitigate the issues that arose as a team.

From this we have become better engineers and learned what to expect in the working world.

Acknowledgements

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to Bernie Parker,
to our advisor Yogendra Panta,
to Gary Duffield,
to the WVU Tech lab assistants,
all for helping us through this process.

References

Berendsen Fluid Power, Inc. (2001). *Fluid power designers' lightning reference handbook*. Tulsa, OK: Berendsen Fluid Power.

Thank you for Your Time

Are there any questions?