NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION

West Virginia University Institute of Technology

Dr. Panta

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West Virginia University INSTITUTE OF TECHNOLOGY

Presentation Outline

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  - Design & Construction
  - Testing & Evaluation
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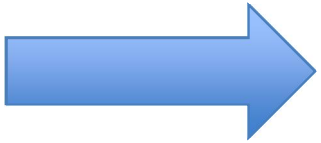
- Sample Calculations

Introduction:
The WVU Tech Team

Left to right: Geoffroy Gauneau, Amr Semmami, Dr. Yogendra Panta (advisor), Matthew Pittman, Manuel Serrano Laguna

Project Statement & Objectives (1/2)

- ✓ Learn hydraulic theories and fluid components
- ✓ Design, Assemble, Test, Analyze, Redesign, and Finalize a well-functioning *human-powered hydraulic vehicle that meets*
  - ❖ *NFPA Fluid Power Vehicle Challenge and fulfills our Capstone Design Project requirements.*



Project Statement & Objectives (2/2)

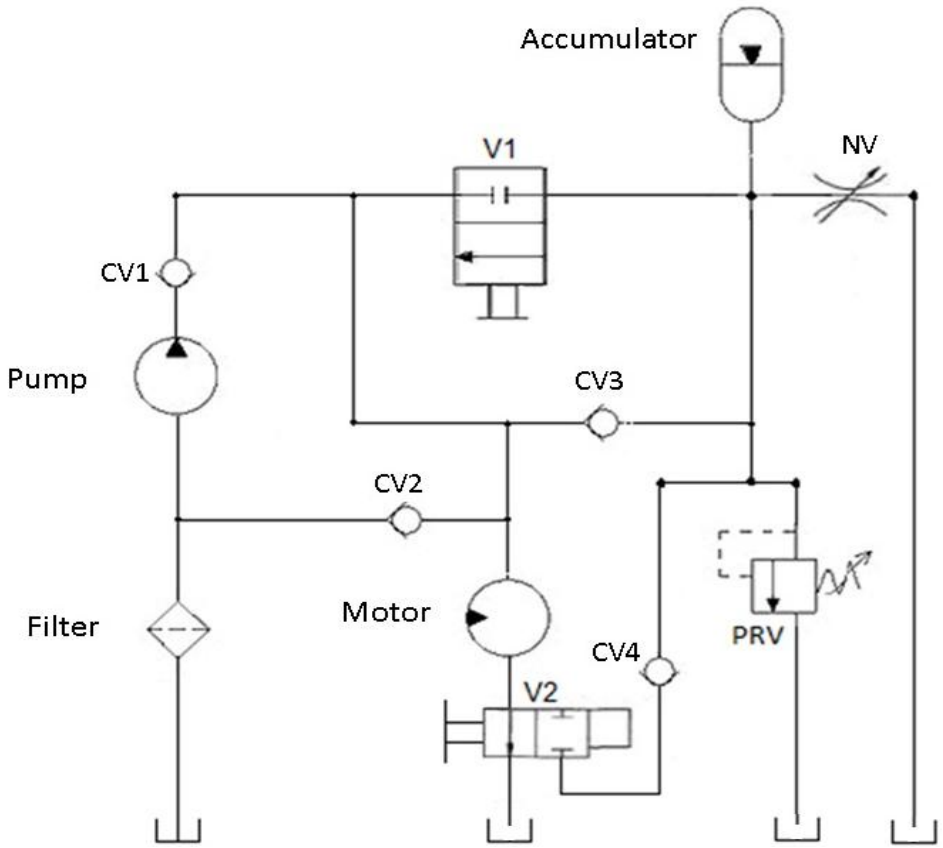
- Safety is our Number 1 Priority
- Understand, build, assemble components, test, and finalize a *Simple Hydraulic Circuit*
- Lightweight yet meets Dynamic Equilibrium while the vehicle in motion

Project Review- Midway

- Presented the progress
- Made schematic improvement (circuit drawing contained some errors)
- More analysis was suggested to be conducted

Project Review- Final (1/5)

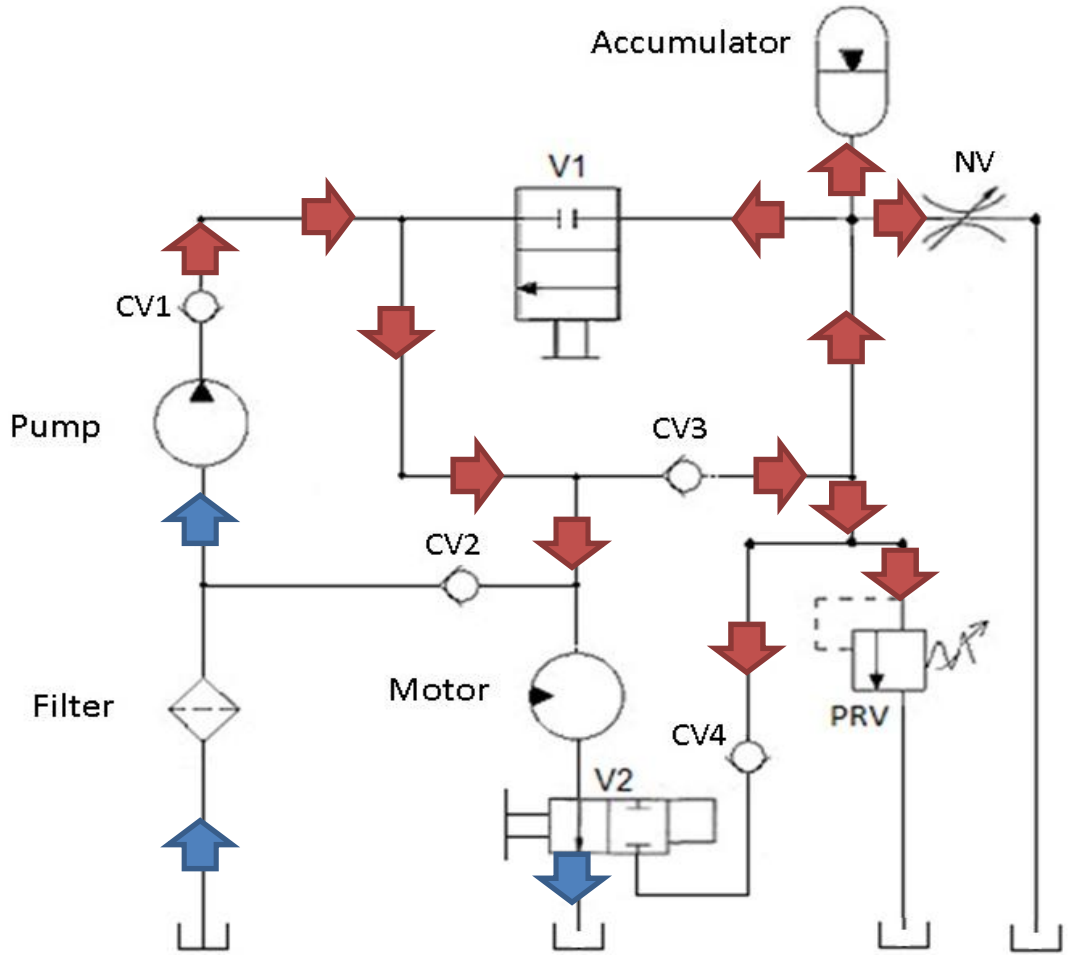
- Hydraulic circuit redesigned based on midway review



CV: Check Valve
NV: Needle Valve
PRV: Pressure Relief Valve
V: Directional Control Valve

Project Review- Final (2/5)

- Hydraulic circuit – Pedaling mode



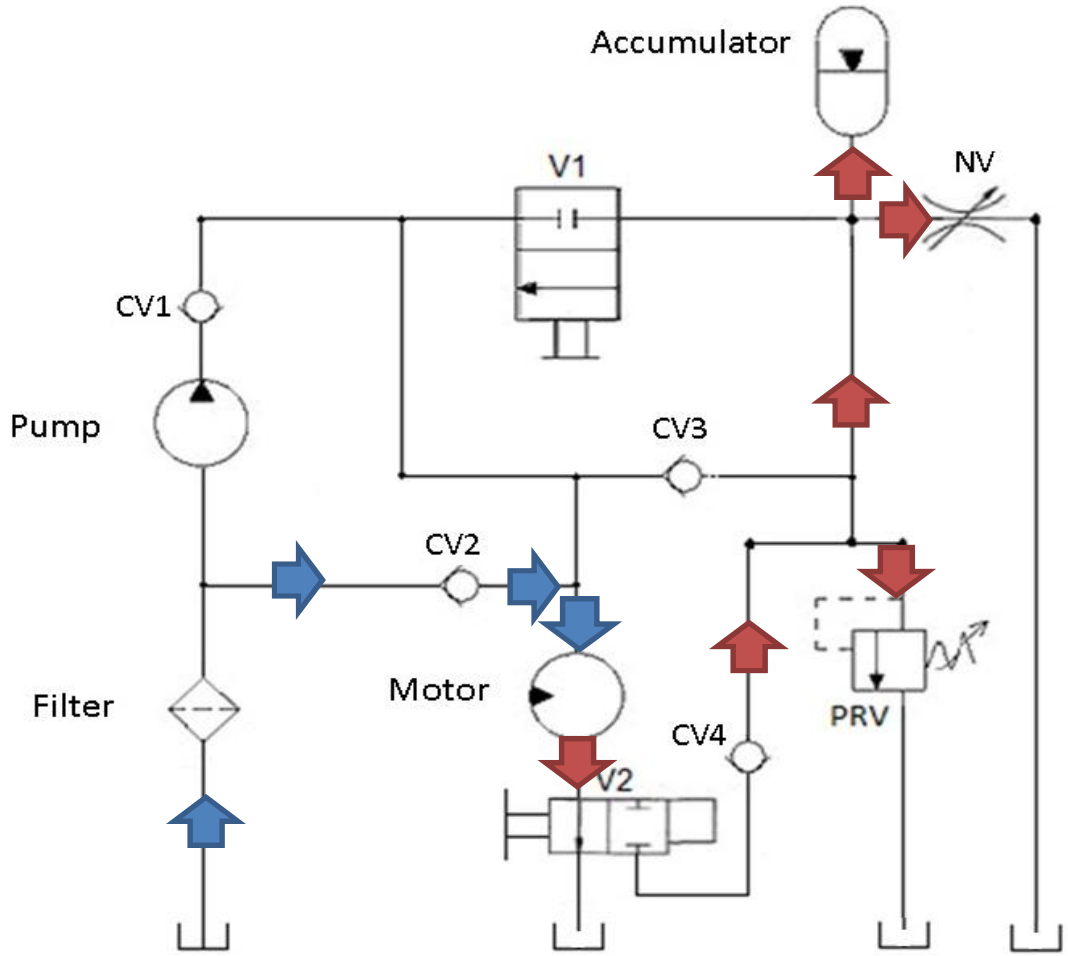
CV: Check Valve
NV: Needle Valve
PRV: Pressure Relief Valve
V: Directional Control Valve

: High pressure flow

: Low pressure flow

Project Review- Final (3/5)

- Hydraulic circuit – Regenerative mode



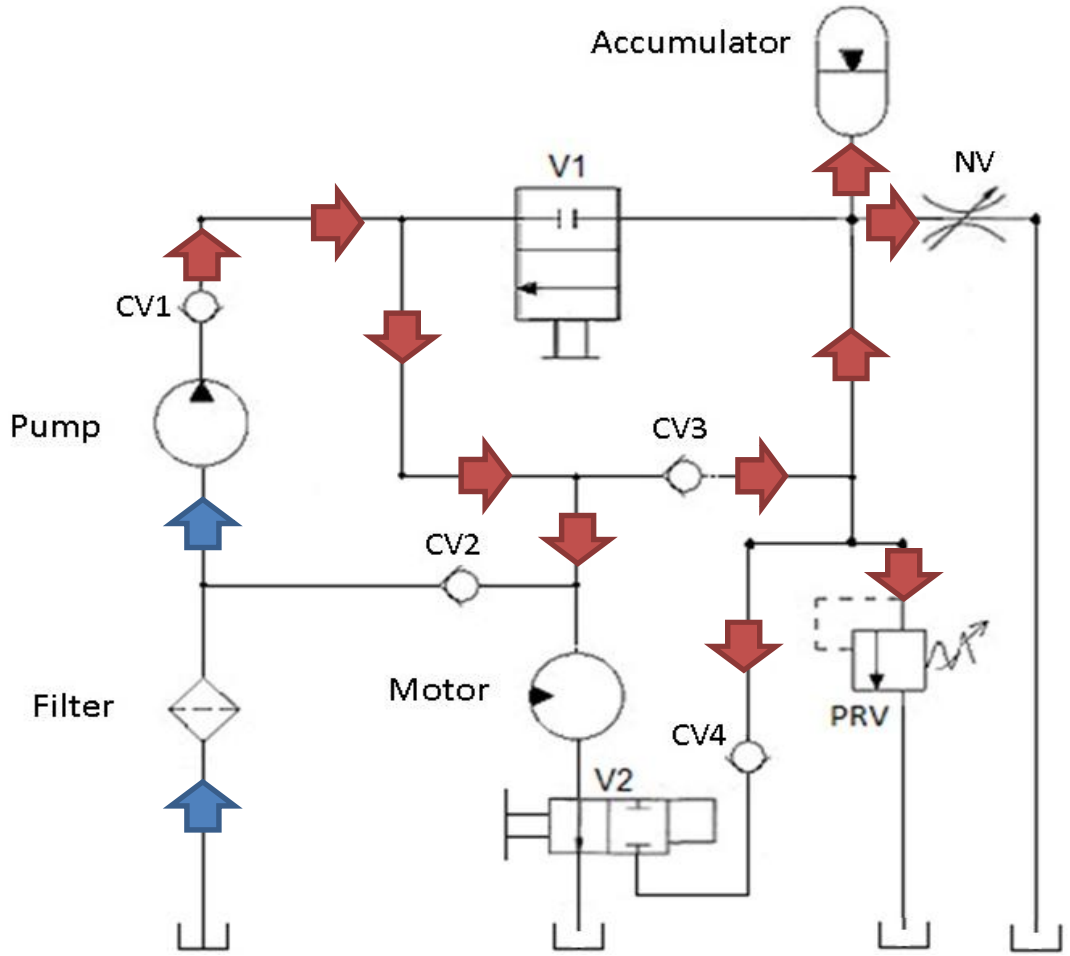
CV: Check Valve
NV: Needle Valve
PRV: Pressure Relief Valve
V: Directional Control Valve

: High pressure flow

: Low pressure flow

Project Review- Final (4/5)

- Hydraulic circuit – Charging mode



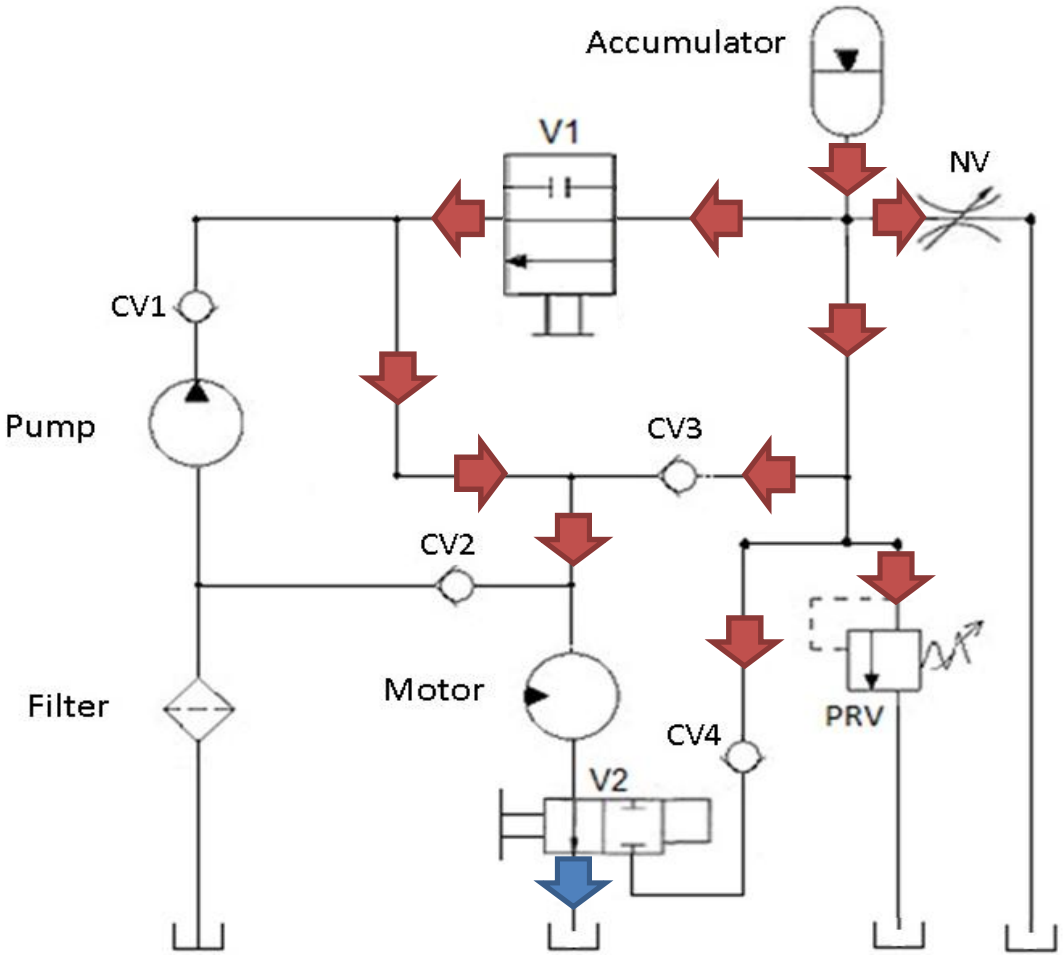
CV: Check Valve
NV: Needle Valve
PRV: Pressure Relief Valve
V: Directional Control Valve

: High pressure flow

: Low pressure flow

Project Review- Final (5/5)

- Hydraulic circuit – Boost mode



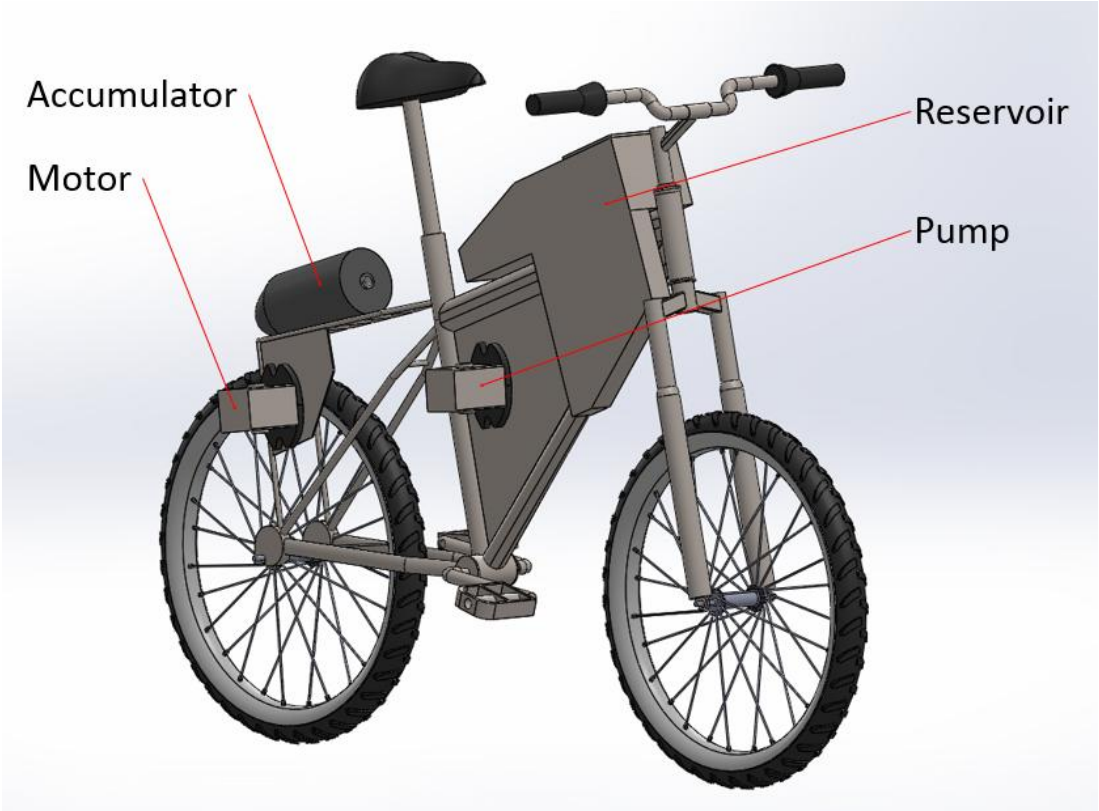
CV: Check Valve
NV: Needle Valve
PRV: Pressure Relief Valve
V: Directional Control Valve

: High pressure flow

: Low pressure flow

Project Review - Final Assembly

- CAD model with major components shown



Fluid Power Vehicle Design & Construction

- Gear Pump

1.22 cu in Hydreco HMP3 20211A1 Hydraulic Pump

Accumulator

A1QT31003 Accumulator
1 quart
Weight- 9.5 lb

Motor

1.21 cu in Dynamic BMM20UBU Hydraulic Motor

Fluid Power Vehicle Design & Construction

Frame

Sprockets

Final Assembly

Reservoir

Fluid Power Vehicle: Testing & Evaluation (1/2)

- First attempt to ride the vehicle failed

Original Calculations	
Motor RPM	687.27
Rear Wheel RPM	229.09
Gear Ratio Pump	10
Gear Ratio Motor	3
Motor Efficiency	0.90
Pump Efficiency	0.95
Volumetric Efficiency	0.95
Pull (lb)	23.18
Torque (lb-ft)	25.11
Wheel RPM	193.85
Motor Size (cu in/rev)	0.55
Flow Rate (gpm)	2.12
Power (HP)	2.78
Pump Size (cu in/rev)	0.6

Updated Calculations	
Bike Weight (lb)	120.00
Up Hill Pull (lb)	13.23
Torque (lb·ft) @ wheel	14.33
Torque of motor (lb*ft)	16.94
Wheel RPM	180.92
Motor Displacement (In^3/rev)	1.21
Motor RPM	190.97
GR 1 (Crank to Pump)	3.43
GR 2 (Motor to Wheel)	0.95
Total Ratios (crank to wheel)	3.22
Flow Rate Motor GPM	1.00
Pump Displacement (CIR)	1.20
Pump Horse power	0.58
Hydraulic ratio (pump/motor)	0.99
Accumulator pre-charge (psi)	800.00

Fluid Power Vehicle: Testing & Evaluation (2/2)

- Updated design allowed the vehicle to fully function

Cost Analysis

Item	Vendor	Quantity	Cost per unit	Total cost	Comment
Gear pump	Sunsource	1	$0.00	$0.00	Donated by competition sponsor
Female hose end - str	Sunsource	30	$0.00	$0.00	Donated by competition sponsor
Female hose end - 45'	Sunsource	15	$0.00	$0.00	Donated by competition sponsor
Female hose end - 90'	Sunsource	15	$0.00	$0.00	Donated by competition sponsor
Tee adapter 1 F to 2 M	Sunsource	6	$0.00	$0.00	Donated by competition sponsor
Accumulator	Sunsource	1	$0.00	$0.00	Donated by competition sponsor
Check valve	Sunsource	3	$0.00	$0.00	Donated by competition sponsor
Pressure relief valve	Sunsource	1	$0.00	$0.00	Donated by competition sponsor
0.61 CI Variable Piston Pump	Burden	1	$116.19	$116.19	N/A
0.5 CI Gerotor Motor	Burden	1	$147.95	$147.95	N/A
1/2" 2500 PSI Hydraulic Hose	Burden	2	$6.95	$13.90	N/A
3/8" 400 PSI Hydraulic Hose	Burden	5	$3.99	$19.95	N/A
5/8 Splines	Grainger	1	$39.89	$39.89	N/A
Rigid Steel Coupling	Grainger	1	$7.72	$7.72	N/A
Sprocket Parts	Control Point	1	$150.00	$150.00	N/A
3' x 3' Sheet Steel	WV Steel Corporation	1	$57.60	$57.60	N/A
Steel Angle Bar	Steel Corporation	1	$8.32	$8.32	N/A
Sprockets	Elevation Sports	1	$59.99	$59.99	N/A
Straight Adapter	Nova Rubber Co.	18	$0.96	$17.28	N/A
90 Elbow Adapter	Nova Rubber Co.	12	$1.00	$12.00	N/A
Tee Adapter	Nova Rubber Co.	11	$2.05	$22.55	N/A
3000 psi Check Valve	Nova Rubber Co.	2	$80.00	$160.00	N/A
10,000 psi Needle Valve	Nova Rubber Co.	1	$80.00	$80.00	N/A
Hydraulic Hose Assemblies	Nova Rubber Co.	1	$261.95	$261.95	N/A
Aluminum 7 Port Manifold	Enerpac	1	$206.23	$206.23	N/A
3/8 Prince Needle Valve	Burden	1	$26.95	$26.95	N/A
3/8 5 PSI Check Valve	Burden	2	$15.95	$31.90	N/A
Filter Mount Kit	Automotive	1	$25.98	$25.98	N/A
Pressure Relief Valve	Burden	1	$55.93	$55.93	N/A
Hydraulic Adapters MJIC #8	Nova Rubber Co.	32	$5.80	$185.60	N/A
1.22 CI Gear Pump	Burden	1	$112.99	$112.99	N/A
1.21 CI Dynamic Motor	Burden	1	$152.95	$152.95	N/A
Miscelaneous Items and Labor		1	$600.00	$600.00	N/A
			Total Cost	$2,573.82	

Experiences/Lessons Learned

- Knowledge of hydraulics
- Account for margin of error during planning
  - Ordering parts ahead of time
  - Building and testing the vehicle
- Do not hesitate to ask for help when needed
  - Advisor(s) & other instructor(s)
  - NFPA

Conclusion

- Grateful to have participated in this challenge. Designing and building a functional, human powered, hydraulic vehicle was challenging and a valuable learning experience.

- Looking forward to competing in this year's Fluid Power Vehicle Challenge

Acknowledgements

- Many thanks to Kenneth Pittman, Lynn Beyer, Ernie Parker, Eric Lanke and everyone from the National Fluid Power Association

- We appreciate Danfoss, Parker Hannifin, SunSource, Eaton Corporation, LubeTech and all other sponsors for the donations

References

- *Vickers mobile hydraulics manual.* (1998). Rochester Hills, MI: Vickers, Inc.
- Hedges, C. S. (1988). *Industrial fluid power: volume 3: advanced text on hydraulics, air & vacuum for industrial and mobile applications.* Texas: Womack.

Thank you for your attention

As Elvis Presley says:

“Thank you, thank you very much.”

Questions & Answers

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