CAPSTONE/SENIOR DESIGN EXPERIENCE 2019

NFPA Fluid Power Vehicle Challenge

PURDUE UNIVERSITY — Agricultural & Biological ENGINEERING

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FLUID FOLKS — CHAINS NOT INCLUDED

Problem Statement

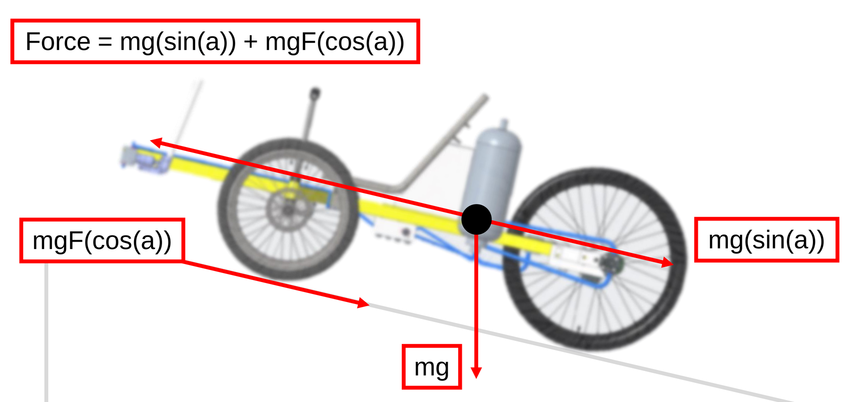
There is a need to design and build a human powered vehicle that uses fluid power to transfer and store energy using novel approaches and innovative technology.

Background

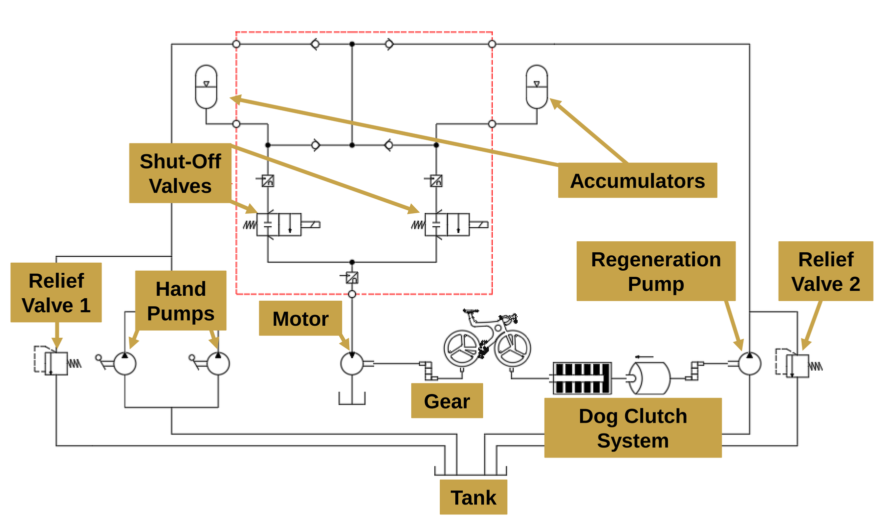
The Fluid Power Vehicle Challenge (FPVC) is a competition that challenges students to develop fluid power vehicles without the direct use of chains or belts.

Hydraulic System Design

Preliminary Calculations



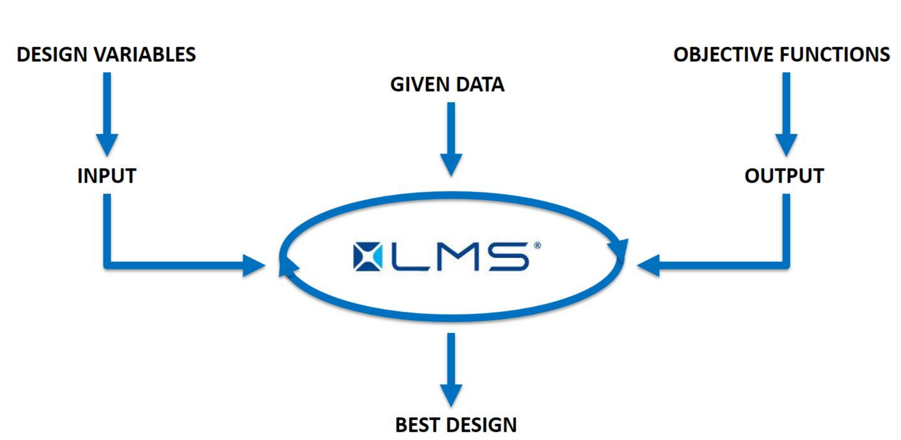
Hydraulic Circuit Layout



Layout of Hydraulic Circuit with Manifold

AMESim Simulation Process

- Further Calculation Estimation
- Simulation Models
  - Model 1: Optimization Test
  - Model 2: Performance Estimation
- Simulation Result

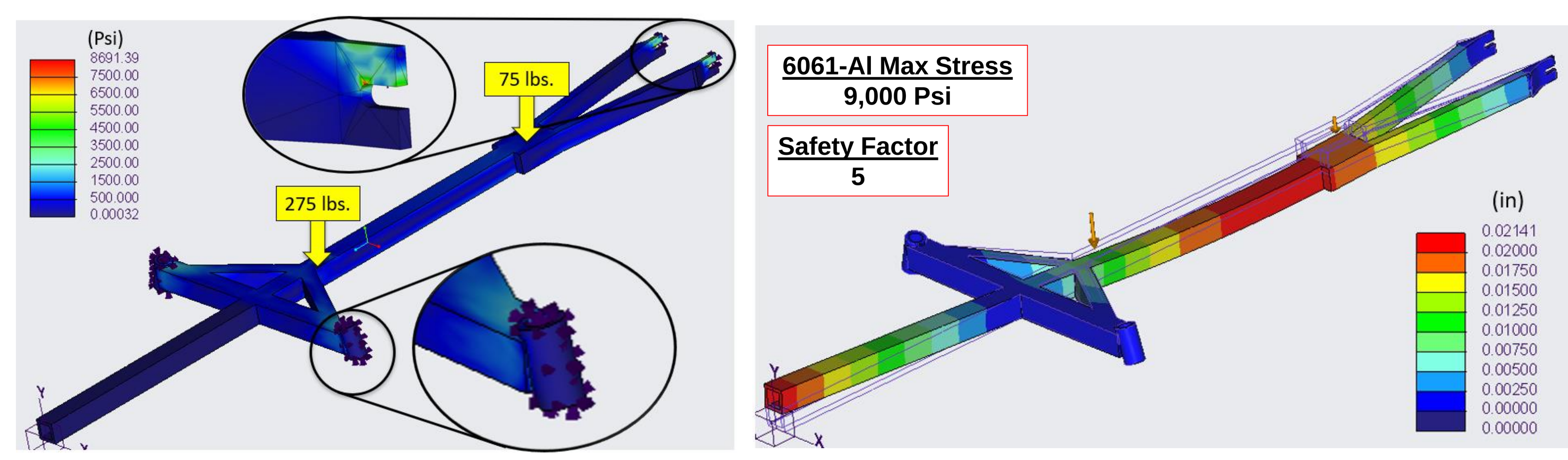


Optimization Process

Pathway to Design

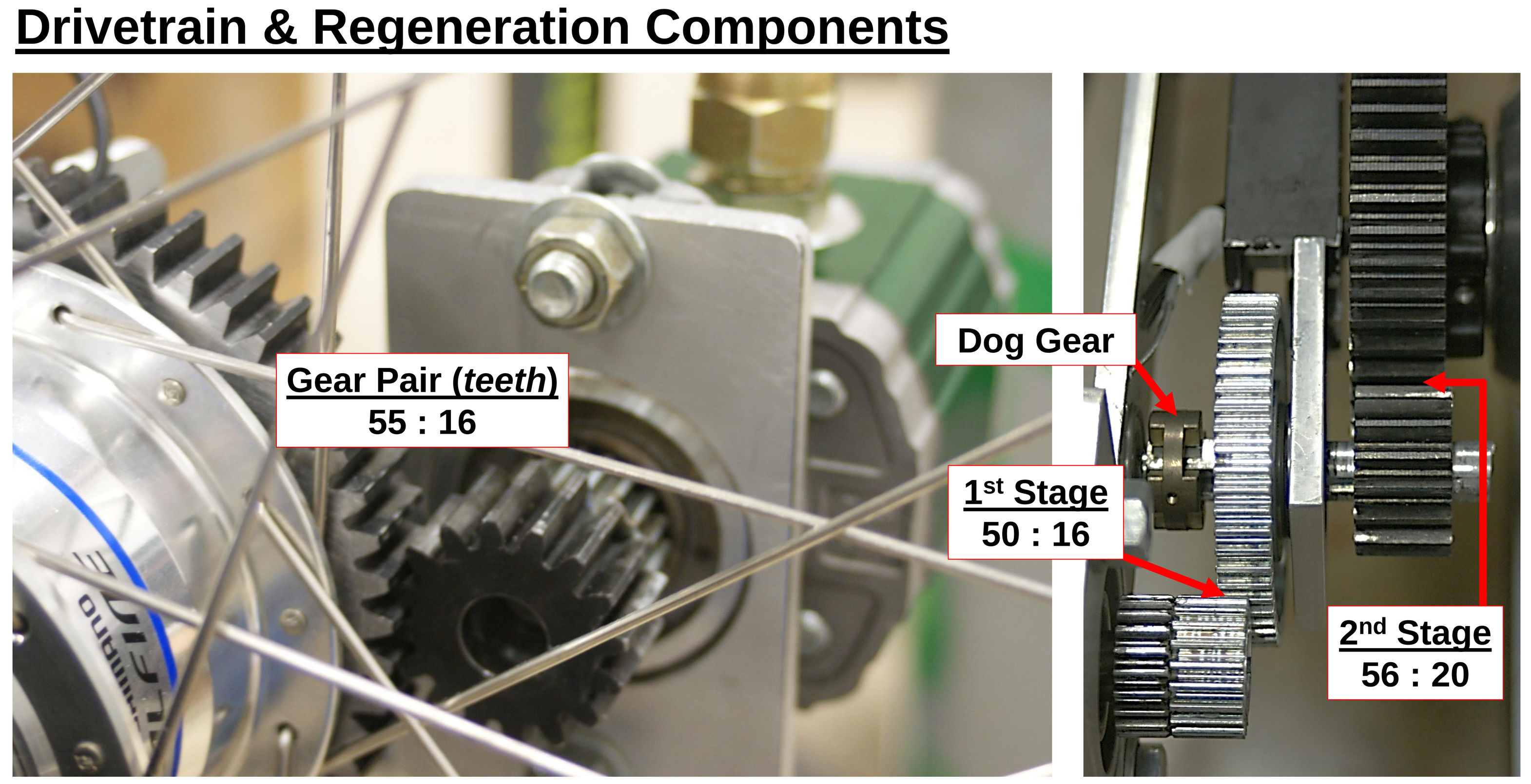
Race Considerations	Criteria	Constraints
• Sprint Race	• Fastest time in 600 ft.	• Standing start w/o pushing
• Efficiency Challenge	• Propel vehicle forward	• One stop & restart
• Endurance Race	• MAX power out / MIN weight	• No pedaling for Efficiency Race
	• Store & transfer hydraulic fluid	• MAX weight of 210 lbs.

Frame & Mechanical System Design



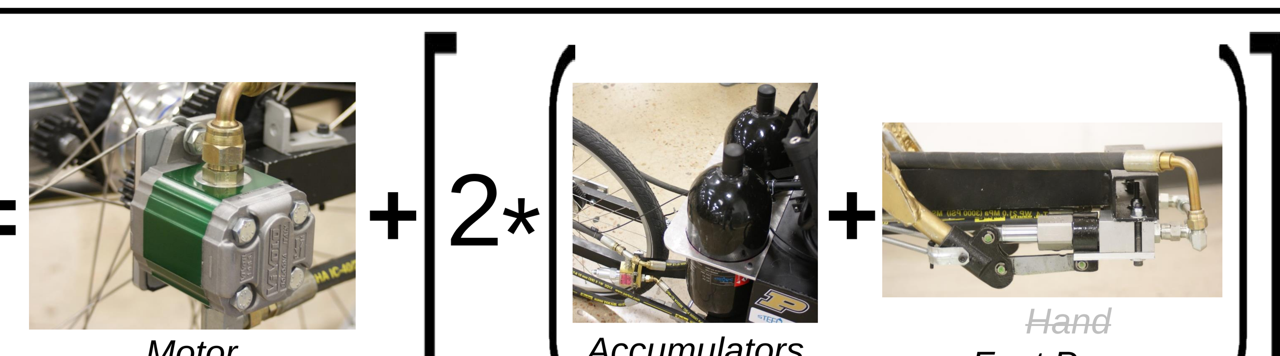
Finite Element Analysis (FEA) — *Von Mises Deformation*

Drivetrain & Regeneration Components



Motor Gearbox — *Regenerative Braking*

Vehicle Power = Motor + [2*(Accumulators + Hand Foot Pumps)]



Motor — *Accumulators* — *Foot Pumps*

Alternative Solutions

Hydraulics
- Pneumatic Pump
- Rotary Pump

Frame & Mechanical
- Internal Tank
- Two Wheels

Electronics
- Arduino Uno
- Heartrate Sensor
- Mobile App

NFPA Fluid Power Vehicle Challenge — April 10th – 12th

IMI Precision Engineering

Final Specifications

Performance
- Tested Speed – 19 mph
- Boosting Distance – 1 mile
- Charge Time – 2 min.

Key Features
- Lightweight – 157 lbs.
- (2) Modified Foot Pumps
- (2) 1.3 gal Accumulators
- Regenerative Braking
- Electronic Control System

Factors Considered

Factor	Importance
Public Health	Contribute to **scoring** of final design at **competition**
Public Safety	
Public Welfare	
Cultural	Availability of **parts** to build the bike
Environmental	Climate (**altitude & temperature**) in CO
Economic	Scarcity of **funds**
Global Factors	People all over the world ride bikes to get from place-to-place
Social Factors	

Cost Analysis

The overall cost of the vehicle has been dissected into four main systems with accompanying subsystems.

System	Cost ($)
Bike	2174.15
Steering	711.78
Wheels (Front & Rear)	1462.37
Hydraulics	2990.78
Valves & Connections	900.08
Components	2090.70
Mechanics	569.79
Gears	264.02
Frame	305.77
Electronics	329.72
Sensors & Supply	63.13
Central Unit	266.59
Total	6064.44

Cost Analysis w/o Donation from Sponsors

The total cost including donations from our sponsors was $3073.66.

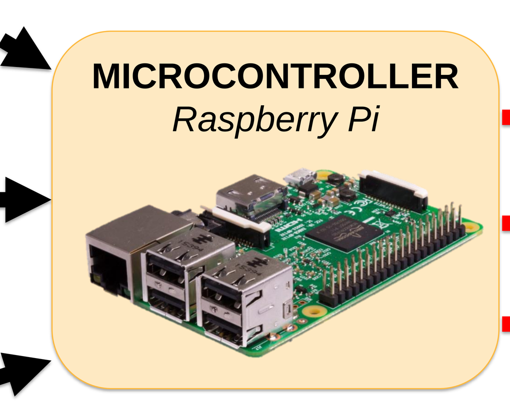
Generous donations from Vivolo, Steelhead, and the NFPA, greatly reduced the cost of the vehicle.

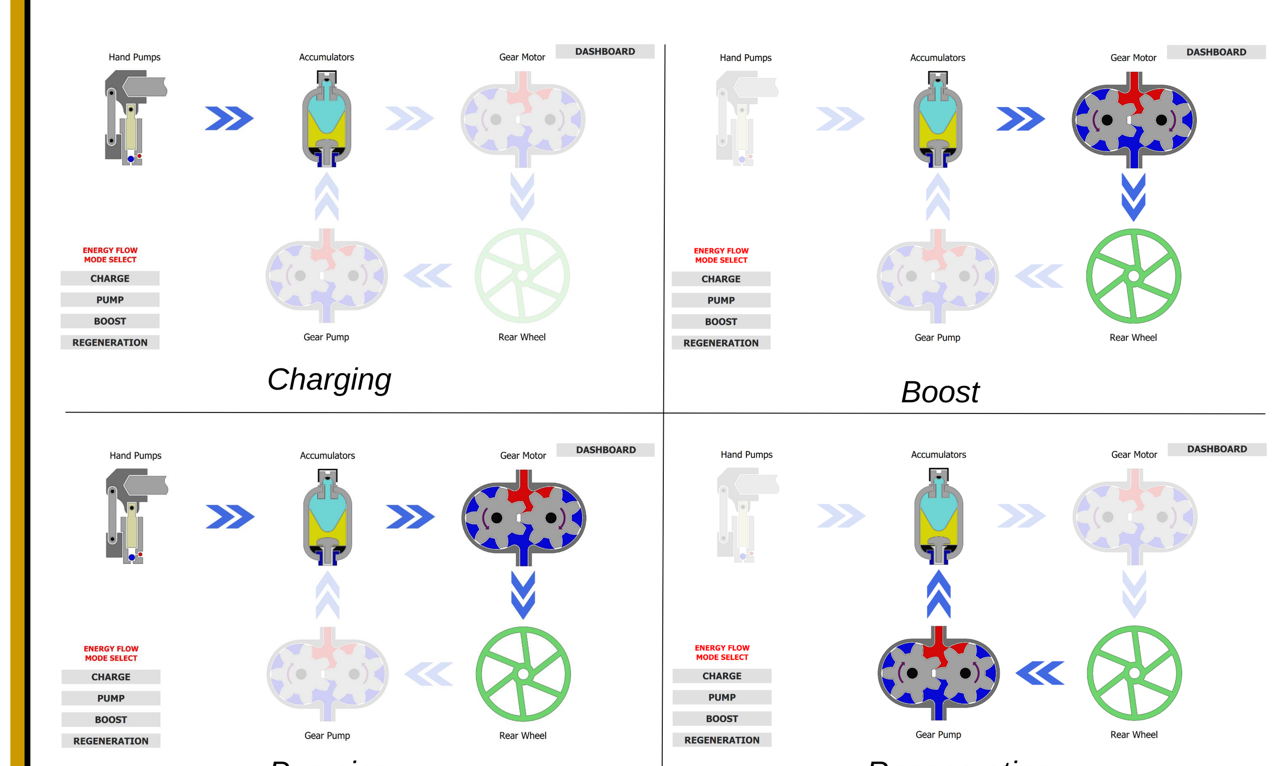
Electronic Control Features

Hydraulic System
- Accumulators Pressure
- Mainline Pressure

Bicycle System
- Distance
- Speed
- Wheel RPM

Human User
- Heart-Rate





Conclusion

- Developed a deeper understanding of fluid power
- Applied new knowledge to create industrial design
- Used novel approaches through innovative tech.

Sponsors:
National Fluid Power Association
Steelhead Composites
Parker
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Bimba
IMI Engineering
Lube Tech
Source Fluid Power

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