NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

Final Presentation
Cleveland State University
2018 Fluid Power Vehicle Challenge Team
Advisor: Joseph Kovach
April 12, 2018

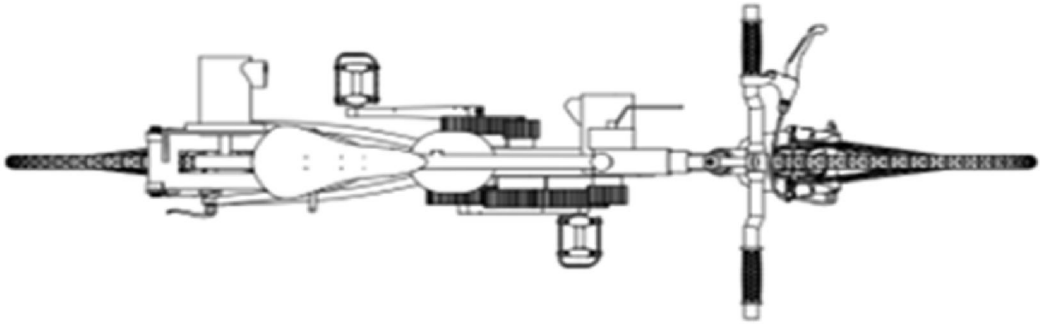
CSU 2018 Team

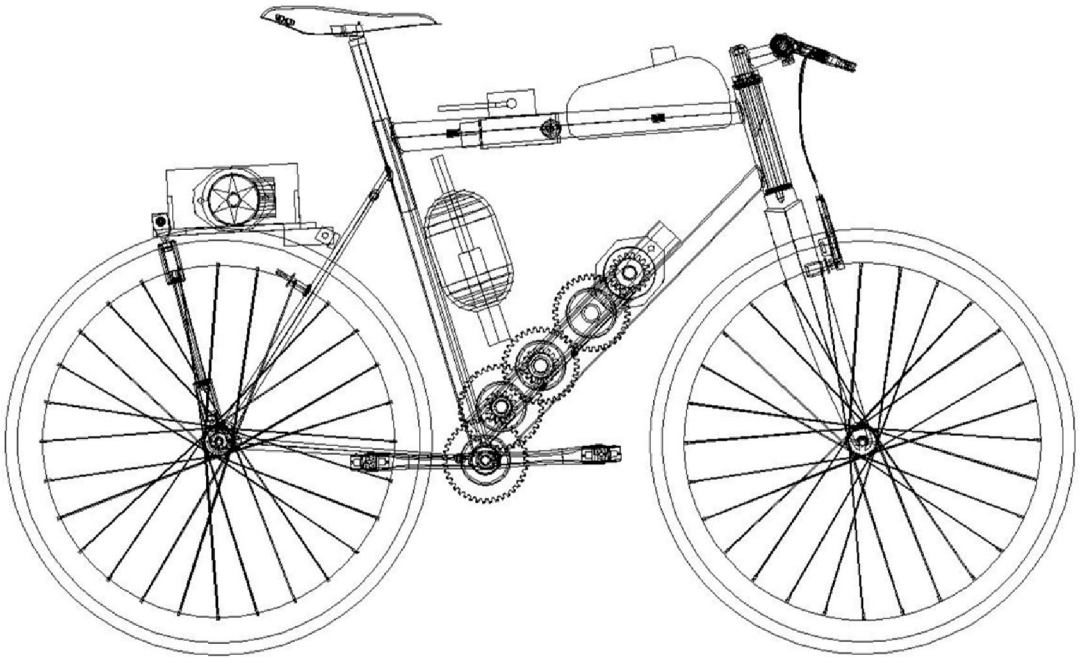
- From Left to Right
  - Mac Magruder
  - Matt Kubulins
  - Lydia Fawzy
  - Loi Doan
  - Joseph Muneratto

Project Objectives

- Design a working bicycle that is driven by hydraulics
- Include regenerative braking
- Maximize efficiency
- Win competition
- Understand how hydraulics work

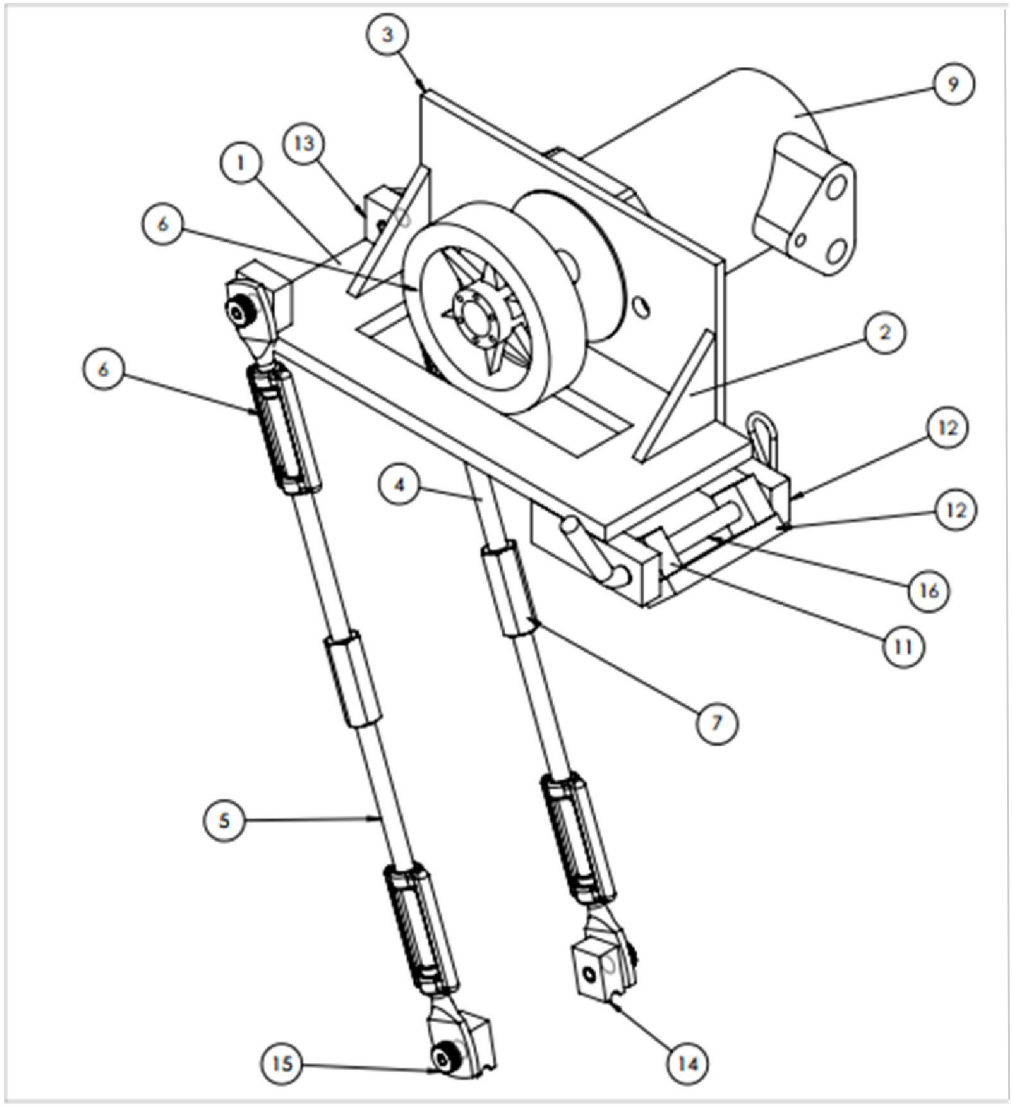
Midway Review Design





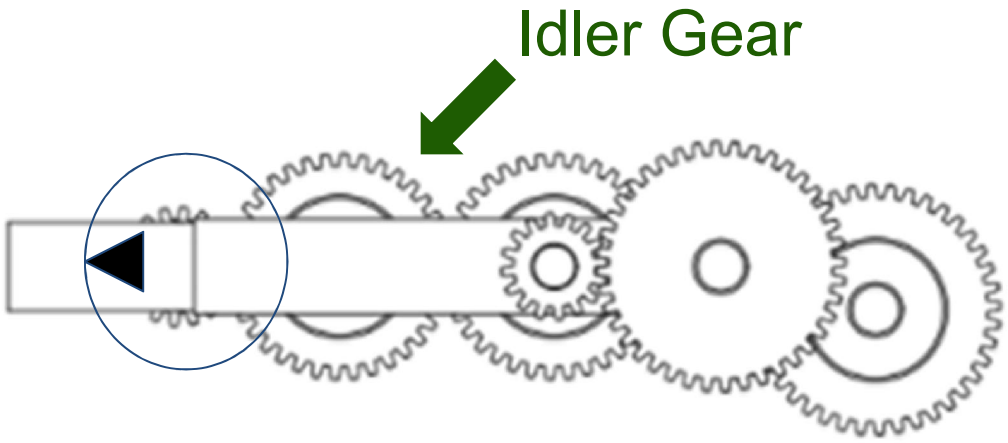
Overall Design

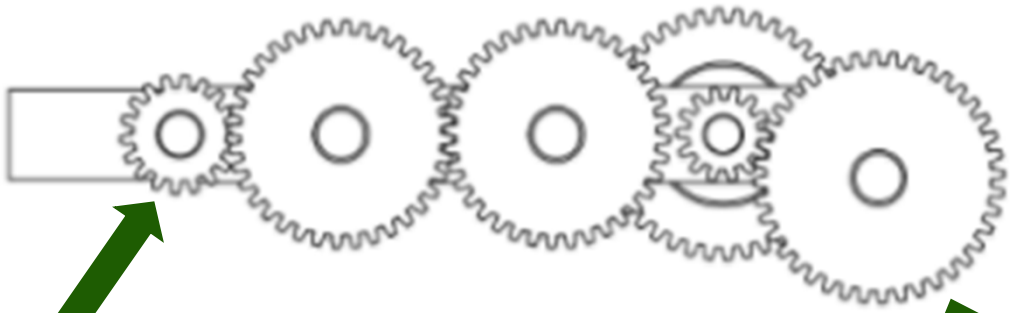
Midway Review Design



Friction Wheel Assembly

Midway Review Design

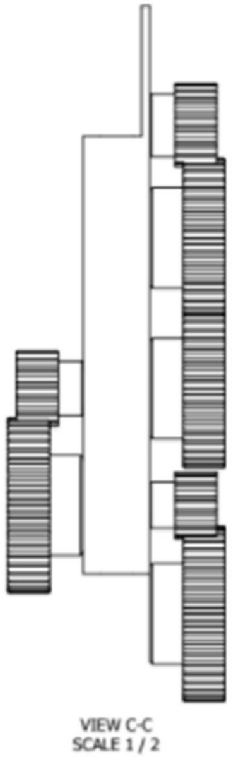


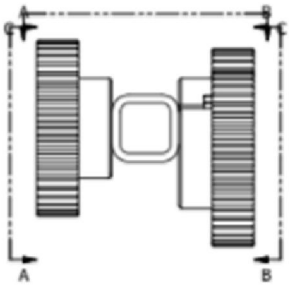


Pump Output

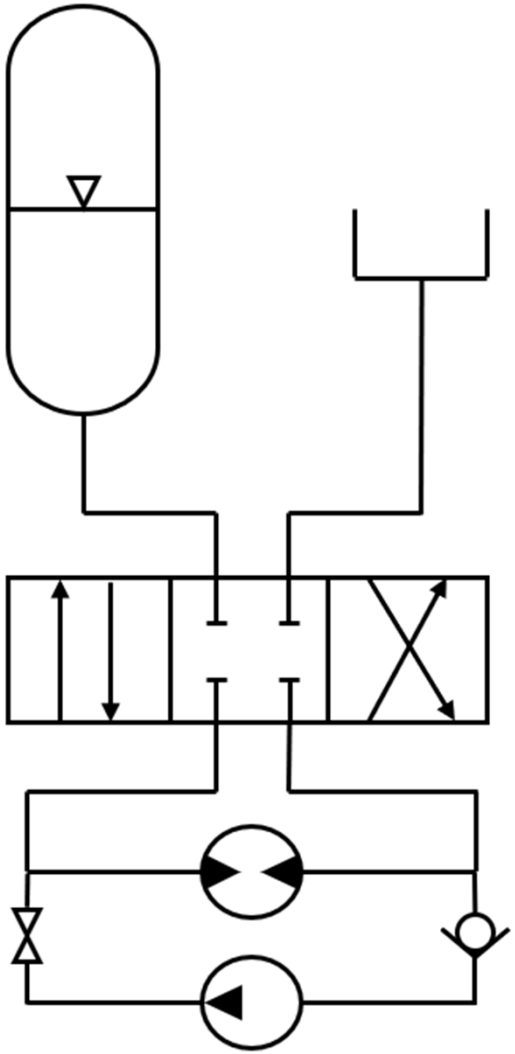
Note: Pedaling input gear is not attached to the gear train

Pedaling Input





Midway Review Design



Hydraulic Circuit Design

Calculations

- Output power to maintain speed :
  - HP= (T*RPM)/5252
  - (8.85 ftlb * 127.5 RPM)/5252
  - Power (P) = **0.215 HP**
- Required Pump Output
  - P* eff_{pump}
  - 0.215 HP * (0.7) = **0.307 HP**
- Required Pump Input
  - P* eff_{motor}
  - 0.307 HP * (0.7) = **0.439 HP**

Calculations Continued

Accumulator

- $E_{accumulator} = (P_{initial} - P_{final}) * V$
  - (2700 – 1240) * (57.75) = 84315 inlb = **9526 Joule**
- Total boost Distance = **365.5 ft**
- Velocity of bicycle = **11 mph**

Vehicle Construction

- Manufacturing of the gear train
  - welded gear train to bike frame
  - machine gears-saved weight
  - bottom shaft
- Friction wheel build
  - back bracket and connection
- Gear hub integration
  - EDM wire rear sprocket
  - motor-sprocket

Manufacturing done by us

Vehicle Testing

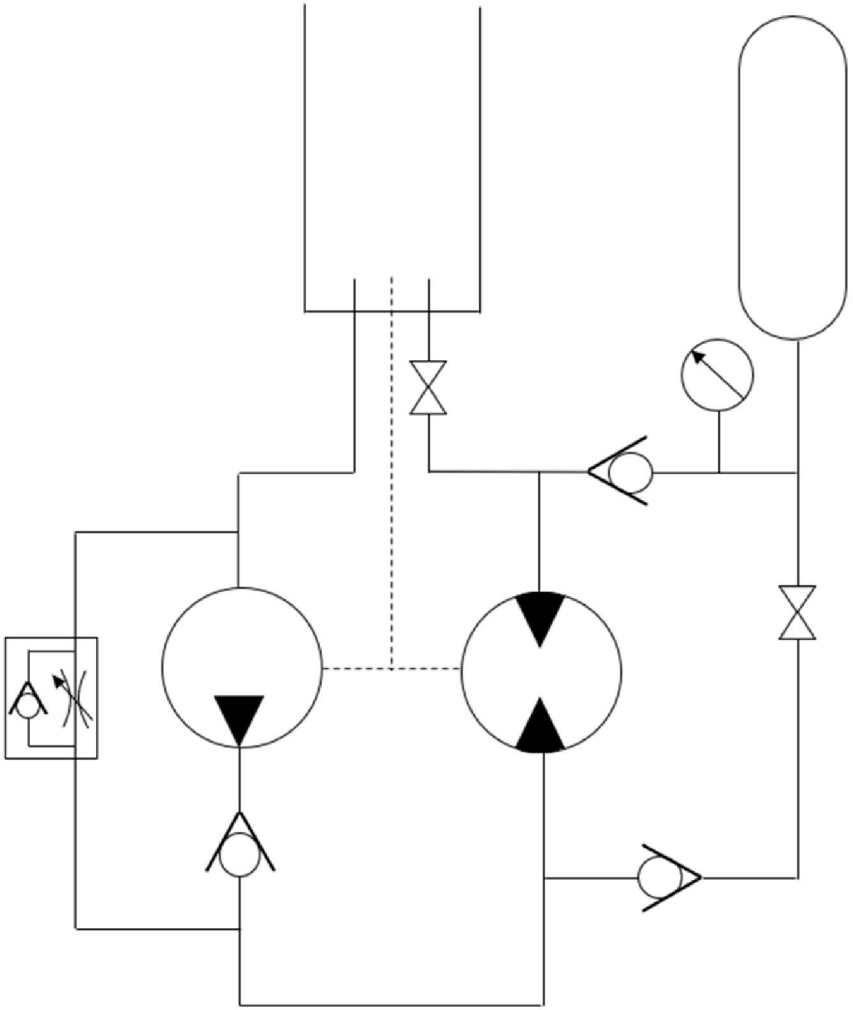
- Testing of the accumulator
  - precharge of 700 psi vs 1000 psi
- Testing of friction wheel
  - 4 inch friction wheel vs 6 inch friction wheel
    - 4 inch was better for pedaling
      - sprint race
    - 6 inch was better for accumulator boost
      - efficiency challenge
      - boosting distance was off by only half a foot from predictions

Vehicle Testing

- Testing in different weather conditions
  - friction wheel slipped too much when raining
  - 33% chance of rain on race day
    - creation of the gear hub design
- Testing hydraulic circuit
  - optimization of hydraulic circuit

Final Design

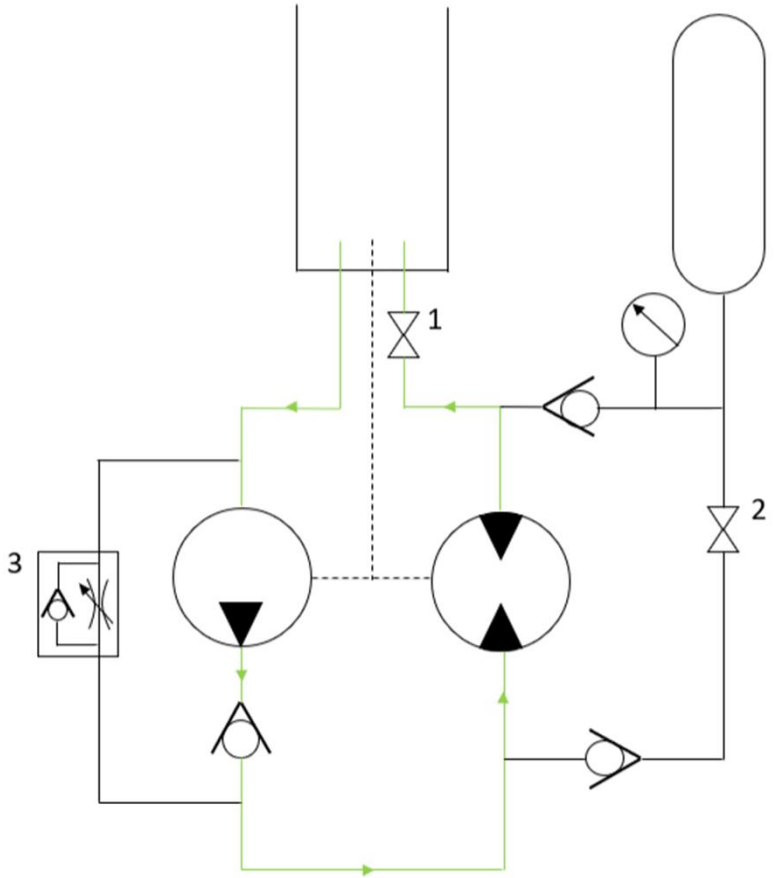
Final Hydraulic Circuit



Final Circuit Derivatives

Pedaling Mode

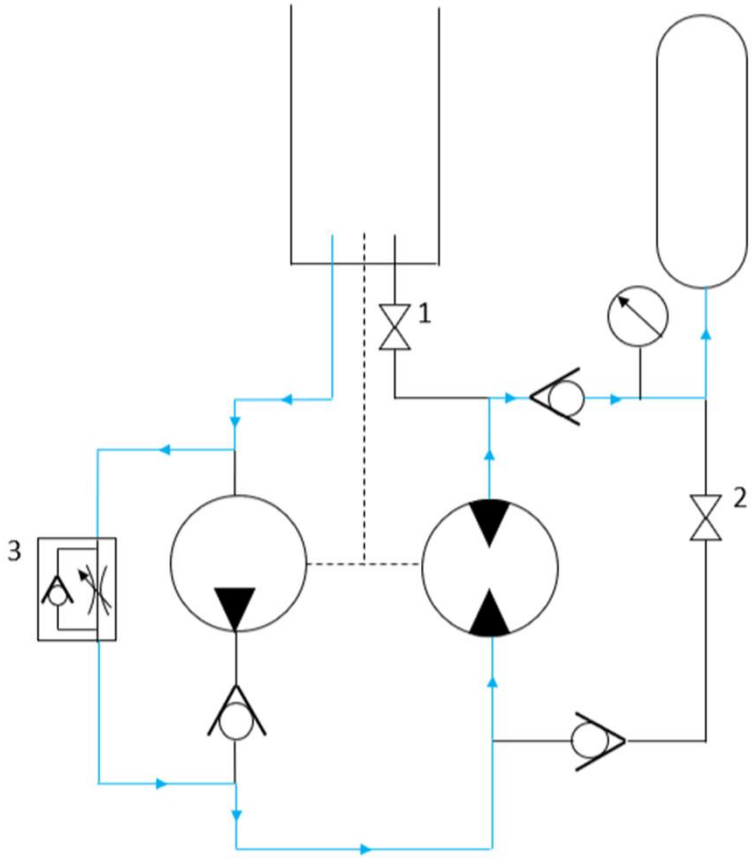
- As a rider pedals, the pump rotates
- Fluid flows from the tank to the pump to the motor and back to the tank



Final Circuit Derivatives

Regenerative Braking Mode

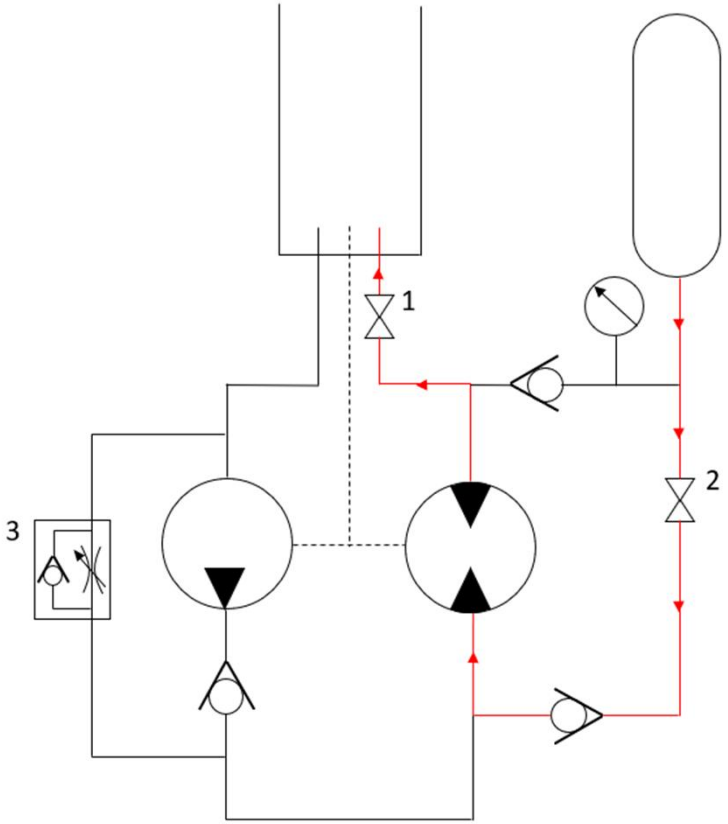
- As the pedaling stops, the pump halts
  - fluid flows to the motor and into the accumulator
- The accumulator stores energy for the boosting mode



Final Circuit Derivatives

Boosting Mode

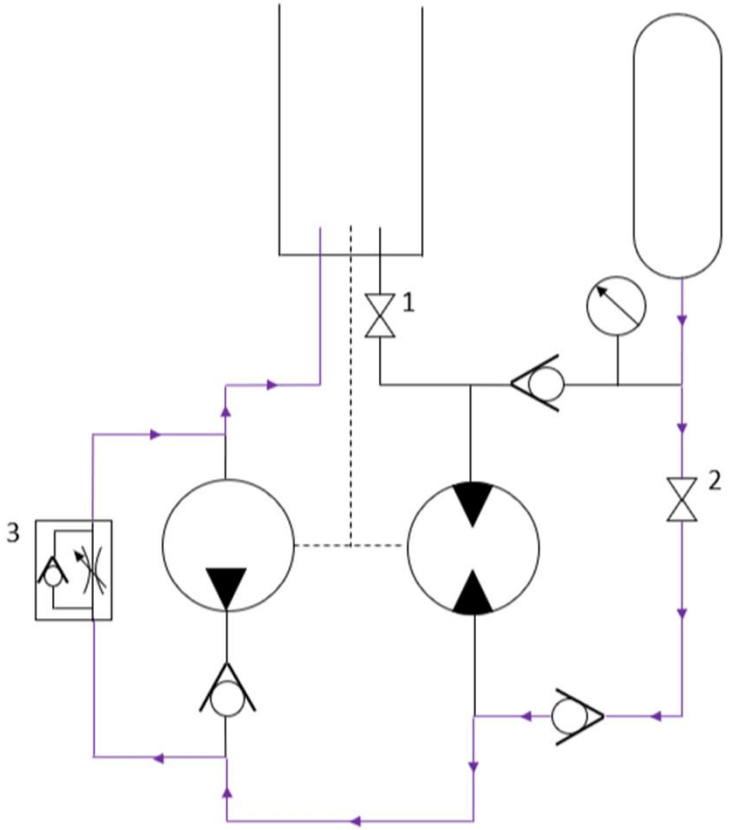
- The accumulator discharges fluid into the motor which moves the bike forward without pedaling



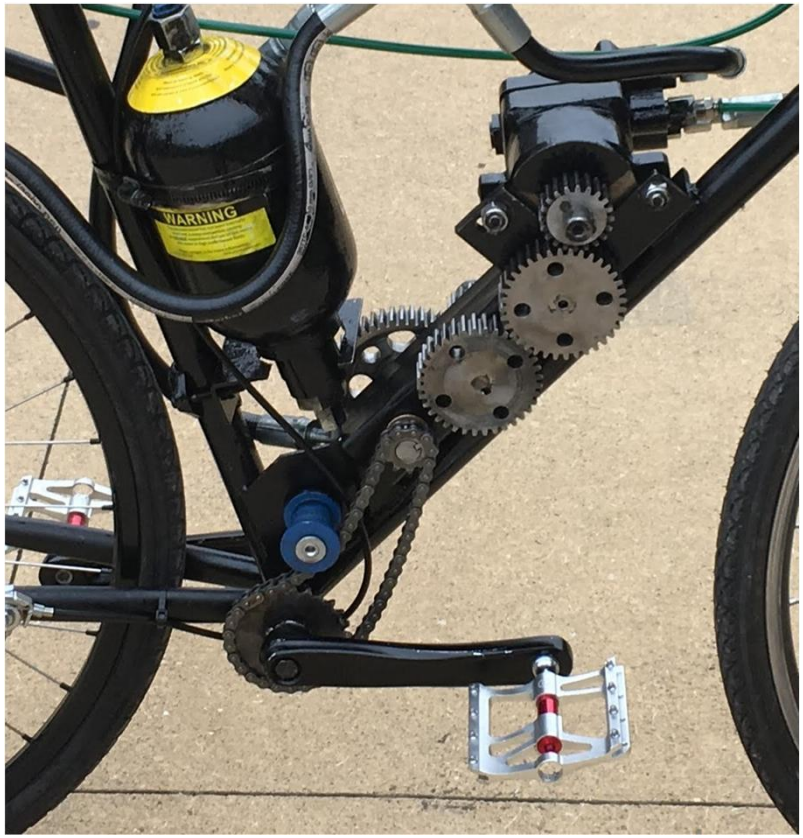
Final Circuit Derivatives

Emergency Pressure Release Mode

- fluid is discharged from the accumulator and directly into the tank
- no fluid runs through the motor, so the bike does not move



Final Gear Train



- Overall ratio → 14:1
- Improves pump's efficiency

Final Gear Hub

Overall Gearing Ratios

Motor Sprocket Size	Hub Sprocket Size	1st Gear	2nd Gear	3rd Gear
13	60	1.90	2.28	3.04
14	60	2.05	2.46	3.28
15	60	2.19	2.63	3.51

Design Advantages

- Only one motor for drive system and regenerative braking
- Lightweight
  - 105 lbs
- Variable Speed
  - 3 speeds
- Adaptability
  - Easily adjusted gearing ratios
  - Easy replacement of broken parts

Lessons Learned

- How hydraulic systems work
- The importance of researching beforehand
- Value of good craftsmanship
- Ordering of parts
- Project organization and delegation
- The reality of unknown variables
- Always have a Plan B

Questions?