# Hydraulic System for Human Powered Vehicle Team # 27

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## Background

The Human Powered vehicle is for the Purdue Fluid Power Club, where the vehicle will enter the National Fluid Power Association vehicle challenge in the spring semester.

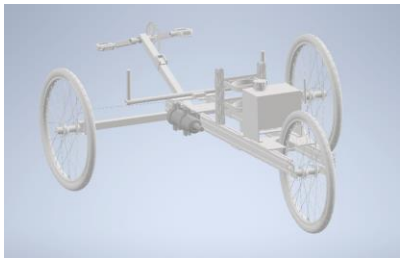
## Problem Statement

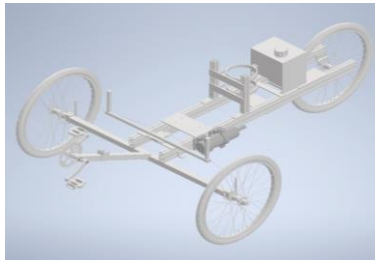
The goal of this study revolves around designing, building, and testing a mechanical frame that can support different systems and the pilot itself. Another aim is to improve the hydraulic system mounted on the vehicle by testing and refining various components within the system.

## Requirements

| | | | |
|---|---|---|---|
| 1 | Hydraulic Power with Human movement as the prime mover | Hydraulic system must be able to run off average human pedaling capability (~250 Watts) | measure/research the average power output of a person cycling and research specifications on Hydraulic pumps |
| | Vehicle is required by the NFPA to have a hydraulic system that uses human power as the primary mover for the system | | |
| 2 | Vehicle must include an accumulator | Fluid & Air combined must not exceed 1 gallon & presure must not exceed Accumulator rating or 3000 psi (whichever is lower) | Design for Accumulator that has a max of 1 gallon and min of 3000 psi |
| | Vehicle is required to have a hydraulic energy storage system | | |
| 3 | 2 Pressure indicators (1 @ outlet of acumulator & 1 @ supply side of Hydraulic Motor | The indicators help to make sure we know the pressure of the systems at all time | Visual inspections and making sure indicators are well attached |
| | This is to make sure the pressure is kept at safe, stable level | | |
| 4 | Vehicle must use fluids provided by the competition | Hydraulic components should be design to work with specified Oil | review specifications to ensure all components are compatible with fluid |
| | Required by NFPA to have a standardized fluid for performance. | | |
| 5 | The rider must be able to enter and exit the vehicle unassisted | There should be no obstructions of the seat of the vehicle | Visual inspections |
| | Required by the NFPA for safety | | |
| 6 | Vehicle is only for a single rider | There should be one seat capable of holding 1 person | Visual inspections |
| | Having more than 1 can risk injury to them and risk damage to the car | | |
| 7 | The maximum weight of vehicle. | 210lbs | Scale |
| | Weight limit set by NFPA | | |
| 8 | The components on the vehicle must stay on during race | Vehicle should stay intact | Visual inspections of fasteners and mounting |
| | This is for safety reasons in order to keep the rider and others safe. | | |

## Experimentation and Concepts





**Pump Calculations**

$$V_{dp} = \frac{V_{dm} * N_{out}}{N_{in}} = \frac{V_{dp} * N_{in} = V_{dm} * N_{out}}{\frac{3.65\ cc * 2000\ rpm}{600\ rpm}} = 3.2\ cc$$

**Enviolo gear box 380% range**

$$\frac{2000\ rpm}{3.8} = 526.32\ rpm$$

$$\frac{3.65cc * 2000\ rpm}{600\ rpm} = 12.17\ cc$$

Pump Range @ 600 rpm:
**3.2cc - 12.17cc**

**Motor Calculations**

m = 145 kg
a = 0.45 m/s^2 (goal)
mg = 1422.45 N
$F_f$ = 5.69 N

$ma = TF - F_f$
$TF = ma + F_f$
TF = 65.25 N + 5.69 N = 70.94 N
**TF = 70.94 N**
T = TF * r = 70.94 N * 0.3302 m = 23.42 Nm = 207.32 lb-in
**T = 207.32 lb-in**

25 mph = 2200 ft/min
2000 rpm @ Motor

$$\frac{2200\ ft/min}{\left(\pi * \left(\frac{26\ in}{12\ in/ft}\right)\right)} = 323.21\ rpm@wheel$$

$$\frac{2000\ rpm}{323.21\ rpm} = \mathbf{6.19\ gear\ ratio}$$

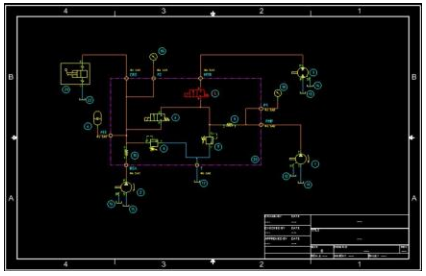
$$\frac{207.32\ lb-in}{6.19} = 33.50\ lb-in$$

$$\frac{33.50\ lb-in}{(0.7 * 0.9)} = 53.18\ lb-in$$

$$\frac{53.18\ lb-in * 2\pi}{1500\ psi} = 0.223\ in^3/rev$$

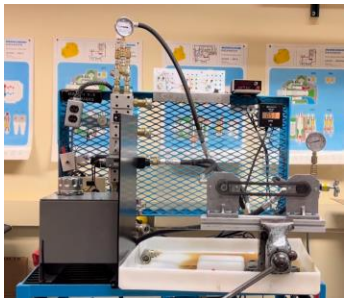
**0.223 $in^3$/rev = 3.65 cc/rev**

## Final Design



## Testing

| Efficiency of Boost | |
|---|---|
| Starting Pressure | Efficiency |
| 1450 | 8.92% |
| 1230 | 6.91% |
| 1740 | 8.82% |



| Torque Rating of 5/16 Bolts | | |
|---|---|---|
| Torque (ft.lbs) | Grade 5 Bolts | Grade 8 Bolts |
| 5 | Pass | Pass |
| 10 | Pass | Pass |
| 15 | Pass | Pass |
| 20 | Fail | Pass |
| 25 | N/A | Pass |
| 30 | N/A | Fail |