Human-Powered Vehicle Team

Final Presentation

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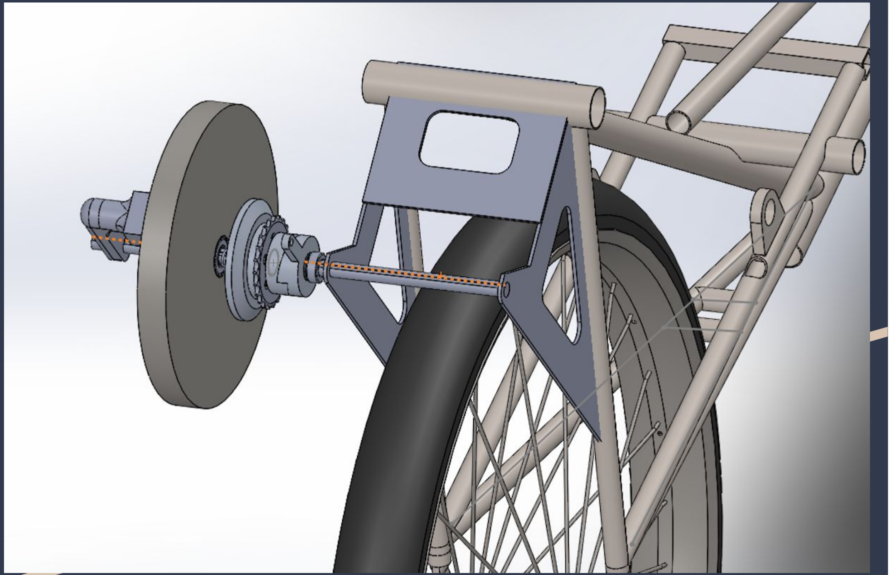
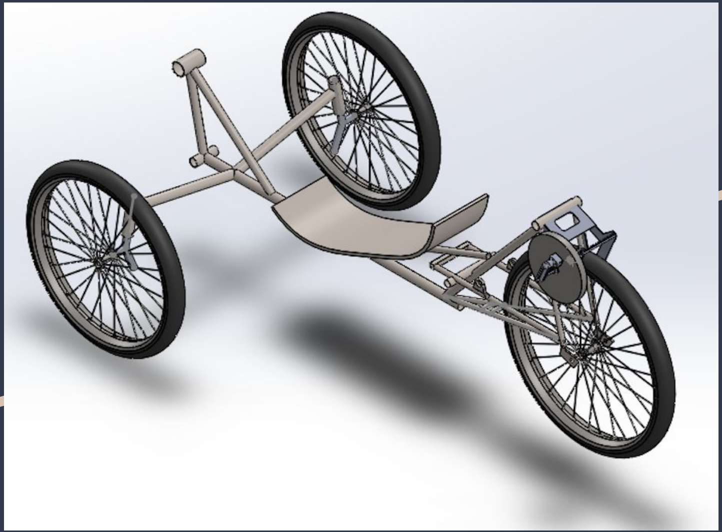
Project Description



- Originally, the project was to create an innovative propulsion system for an HPV utilizing multiple muscle groups
- This semester, the team transitioned to retrofitting a propulsion system that recaptures spent energy to an existing HPV
- The operative part of the system is the flywheel, allowing for mechanical energy storage with minimal loss
- The system is user actuated, but metrics will be displayed to the user based on the system's immediate state

Design Description
-Requirements and specifications



- The propulsion system now recaptures energy through regenerative braking, with no input from the user
- 15% efficiency goal from intake to output after systematic losses
- 600J sustained energy storage in flywheel
- Energy gathered at 20mph or lower

No.	Engineerig Req.	Value
1	Energy Stored	600 J
2	Regen. Braking Efficiency	0.15
3	Max. Speed	20 mph
4	Display Metrics	Yes/No
5	Usable Energy Threshold	200 J

Design Calculations

- After the Change of scope, the most important parts of the design were the clutch and flywheel.
- These design tools were created to help ensure ERs were met. Values found by using these governed our design

Clutch Design

Material			cork on steel or cast iron
Surface Finish			
Outer diameter	D	in	4
Inner Diameter	d	in	3
Thickness	th	in	0.25
Actuating Force	F	lb	*200*
Contact Pressure	P	psi	36.37827271
Wear Coefficient (Clutch)	K	in^3*min/(lbf*ft*h)	0.00013
Wear Coefficient (Flywheel)	K	in^3*min/(lbf*ft*h)	0.000017
Coeff. of Friction	u		0.5
Angular Velocity	v_ang	rad/s	0.3912559018
Peripheral Velocity	V	ft/min	2.934419263
time used	t	hour	100
Revolutions		rpm	147.5
Desired Safety Factor			1.5
Max Pressure	P_a	psi	36.37827271
Clutch Wear	w	in	1.387738355
Flywheel Wear	w_	in	0.1814734771
Contact (Normal) Force	F	lbf	171.4285714
Frictional Force	fric	lbf	85.71428571
Torque Capacity	T	lb-ft	12.5
Max Torque	SFT	lb-ft	8.333333333

Flywheel Design

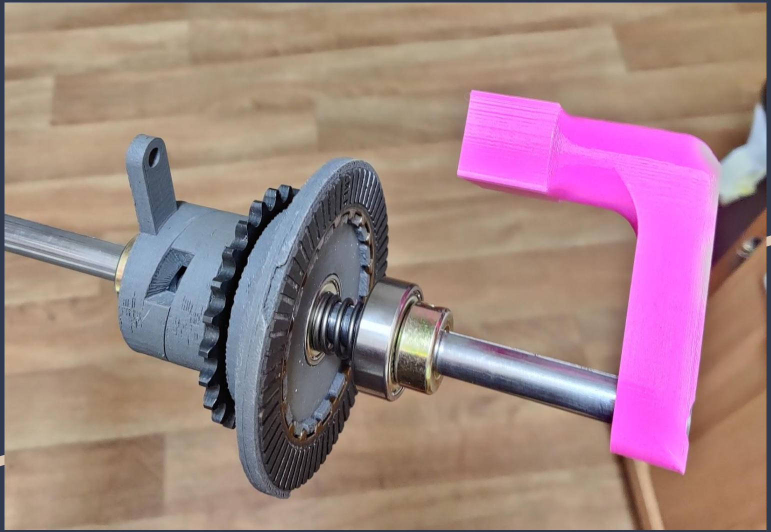
Material			Steel
Angular Velocity	w	rad/s	102.21
Density	p	kg/m^3	8000
Inner Diameter	d	m	0.0127
Outer Diameter	D	m	0.279
Thickness	th	m	0.0508
Flywheel Mass	m_f	kg	24.87
Inertial constant	k	-	0.3
Moment of inertia	I	kg*m^2	0.146
Flywheel KE	E_f	Nm (J)	760.5

Bike Mass	m_b	kg	35
Bike Speed	v	m/s	9.00
Wheel Diameter	D_b	m	0.6604
Angular Velocity	w_b	rad/s	27.26
Bike KE	E_b	Nm (J)	2835.0

Input Values
Stagnant Values
Calculated Values

Final Speed ?% Efficient
2.95 m/s
6.59 mph

Manufacturing and Design Solution



- Original design required inputs from the operator and the kinetic energy recovery system, but a mounting system was never designed
- The current system is built to be modular, and is built onto a single shaft, with a channel to index the components
- Clutch fixture machined from aluminum, which carries the sprocket and translates along the shaft
- Jaw actuator 3D printed from steel reinforced filament
- All parts are carried by bearings, and the system is returned to neutral by a spring, and is captured by collars at each end

Testing Plan

No.	Engineerig Req.	Value
1	Energy Stored	600 J
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5	Usable Energy Threshold	200 J

Software/Sensor Test Procedures

1. **Unit Tests**
   a. Display
      i. Assert Display On = True
      ii. Test character limits
      iii. Test scrolling
   b. Sensor
      i. Assert Low Input = True
      ii. Assert Low Input = Led True
   c. Calculations
      i. Assert with base case input
      ii. Compare against calculator
      iii. Test with inconsistent RPM
2. **System Testing**
   a. Test cases involving expected input and output
   b. Use of Tachometer & Odometer
   c. Test lowest and highest threshold
   d. Test safety measures
3. **End User Acceptance Testing**
   a. Non biassed user tests
   b. Refine based on result of tests

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Energy Storage/Efficiency Test Procedures

1. Measure vehicle speed
   a. Sensors will measure speed
   b. Double check with Odometer App
   c. Record Data
2. Engage clutch to power flywheel
   a. This will take some practice
   b. Measure the amount of time of engagement
3. Measure flywheel angular velocity
   a. Using sensors
   b. Double Check with tachometer
4. Re-measure vehicle speed
5. Engage clutch to remove power from flywheel
6. Measure vehicle speed
7. Repeat steps at different speeds
   a. Increments of roughly 5 mph

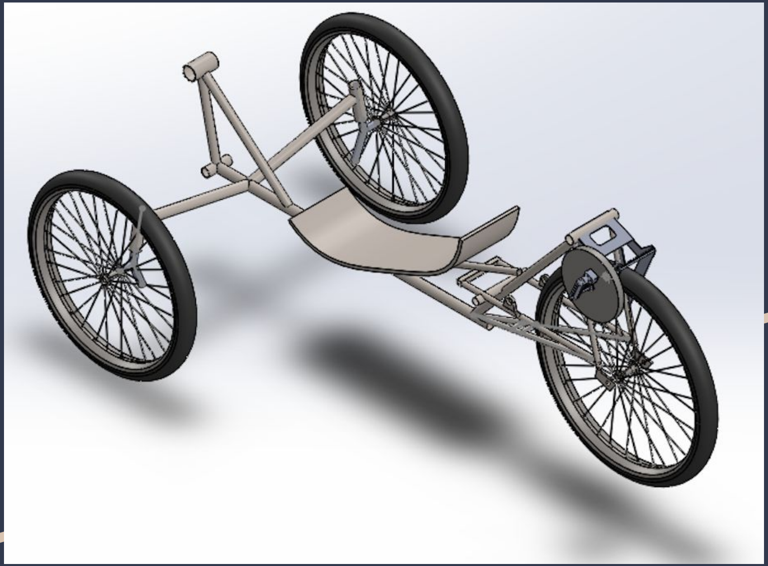
Budget

Bill of Materials

Team				HPVCP			
Part #	**Part Name**	**Qty**	**Description**	**Material**	**Dimensions**	**Cost**	**Link to Cost estimate**
1	Elegoo Kit	1	Electronics kit	Various		$59.00	https://www.amazon.com/gp/product/
2	Hall Effect Sensor US1881	3	Latching	Steel	TBD	$10.78	https://www.sparkfun.com/products/9
3	Backlight Graphic LCD	1	Display	Various	75x52.7mm	$23.95	https://www.sparkfun.com/products/7
4	N24 Neodymium Disk Magnet	3		Nickel-plated neodymi	0.250"* 0.200"	$9.75	https://www.magnetshop.com/neodym
5	Manual Clutch Set	1	Clutch	Carbon Steel		$40.39	https://www.amazon.com/GOOFIT-Hea
6	Radial Ball Bearing	1	Bearing	Steel	Outside Dia.1.37	$9.92	https://www.grainger.com/product/TRI
7	Radial Ball Bearing	4	Bearing	Steel	Outside Dia.1.12	$25.80	https://www.grainger.com/product/TRI
8	Thrust Bearing	1	Bearing	Steel	Outside Dia.1.56	$7.28	https://www.grainger.com/product/INA
9	Roller Chain Plate sprocket	2	sprocket	Carbon Steel	24 Teeth 1/2" Bo	$32.48	https://www.amazon.com/KOVPT-Rolle
10	Keyed Shaft	1	Shaft	Steel	1/2" X 36"	$23.00	https://thebigbearingstore.com/1-2-x-
11	11 Tooth Sprocket	2	sprocket	Carbon Steel	11 Teeth	$20.74	https://thebigbearingstore.com/11-too
12	Low-Carbon Steel Disc	1	Flywheel	Carbon Steel	10'' 1''Lg	$76.87	https://www.mcmaster.com/7786T292
13	Thrust Bearing	1	Bearing	Steel	0.5 in Bore	$5.08	https://www.grainger.com/product/INA
14	Rear Disc Hub	1	hub		7.5 x 4 x 3 inche	$59.95	https://www.amazon.com/SHIMANO-F
15	Screen mount	1	3D Print	PLA		$21.42	
16	friction plate fixture	1	3D Print	PLA		$6.21	
17	spiral jaw	1	3D Print	PLA		$19.20	
18	fixture	1	3D Print	PLA		$36.00	
19							
20							
Total Cost Estimate:						$487.82	

Budget remain: $1500 - $487.82 = $1012.18

Future Work



- To complete the system, the clutch and flywheel assembly needs to be mounted to the vehicle.
- To have continuity in the system, the sprockets need to be bored in order to be mounted to the wheel and clutch. Flywheel needs to be bored as well.
- The new hub needs to be laced to the rear wheel