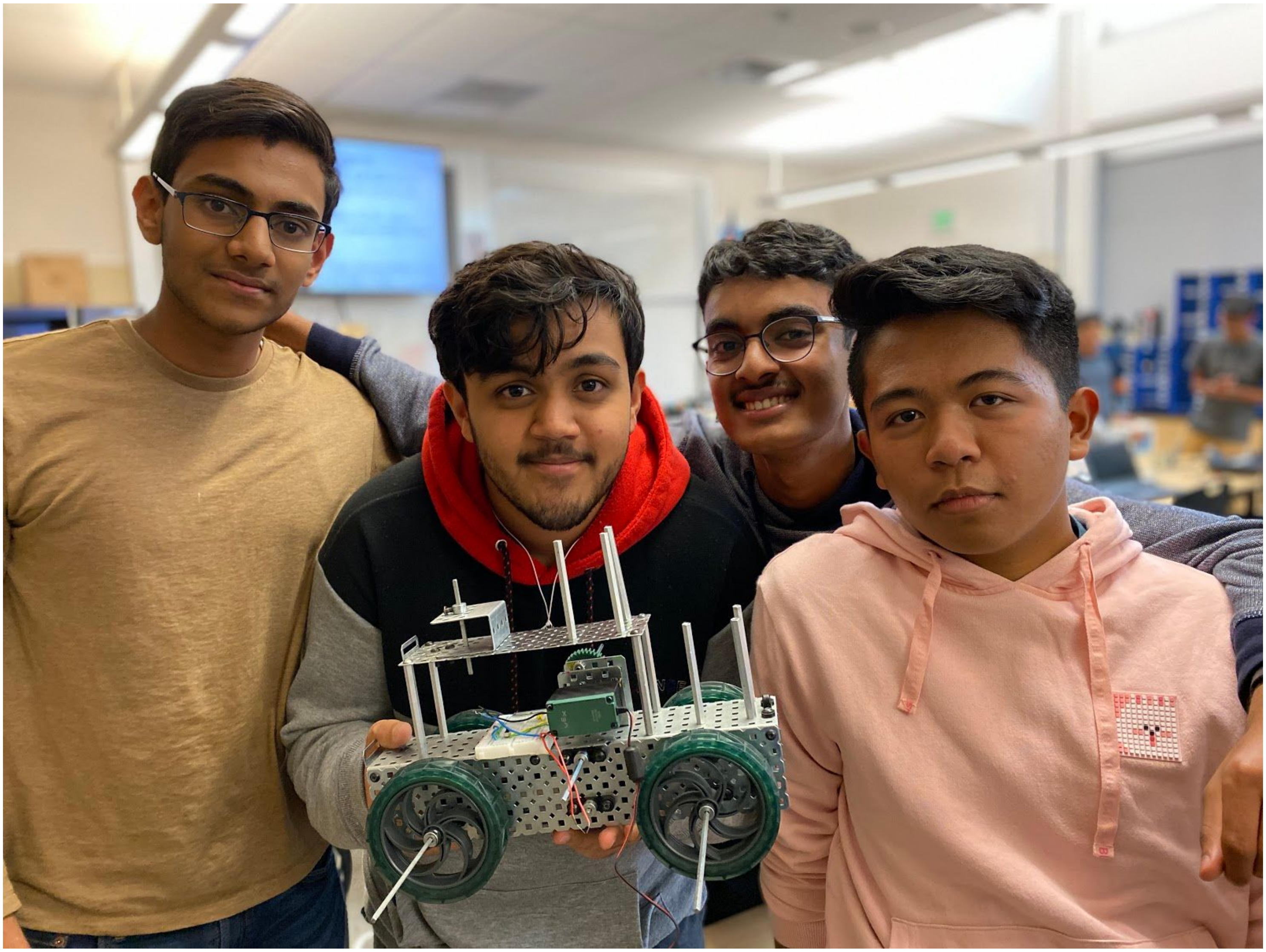
P1.3.2 Solar and Hydrogen Vehicle

Honors Principles of Engineering Period 6th 2019-2020

Tanish Baranwal, Romyr Concepcion, Rohil Khare, Krishna Rao



Team Name: El Bando

Development cycle: 10/30/2019- 11/18/2019

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Design Brief

Designers: Tanish Baranwal, Romyr Concepcion, Rohil Khare, Krishna Rao

Client: Tesla Motors

Problem Statement: Using electric power to fuel cars requires fossil fuels to be used which doesn't immediately cut down the usage of CO2. The increasing popularity of electric cars are also increasing the emissions from the creation of that electricity. It takes too long to charge an electric car, when a gas powered car can be filled up in mere minutes. Additionally, current electric car designs aren't delivering the amount of power and speed Tesla wishes to achieve.

Design Statement: Design, build, and test a scale prototype vehicle that is powered by various configurations of solar panels and hydrogen fuel cells. Determine the best configuration and make a recommendation of how to create the next clean energy vehicle.

Constraints:

- Vehicle must be made exclusively from provided VEX or FisherTek parts.
- Vehicle must securely hold solar panels and hydrogen fuel cells
- Vehicle may be no larger than 5" by 12" from above
- Vehicle must use a breadboard to easily change between power source configurations
- Documentation must be turned in by November 18, 2019 at 11:59 PM
    - Individual deliverables are due by November 20, 2019

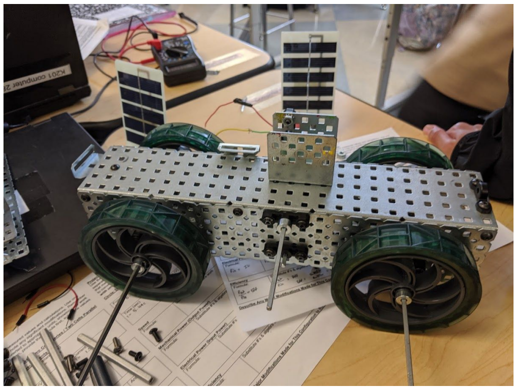
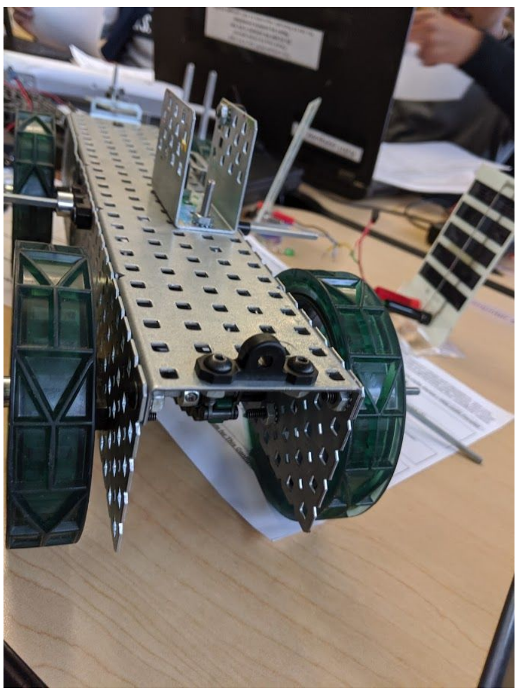
Deliverables:

At the end of P1.3.2, groups are to provide:

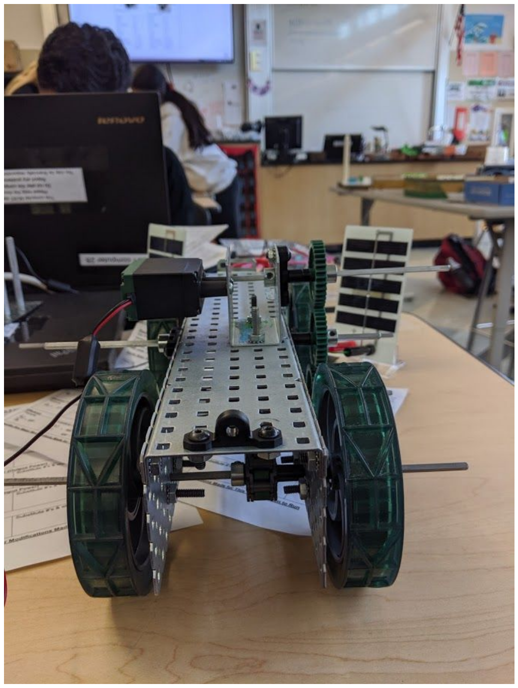
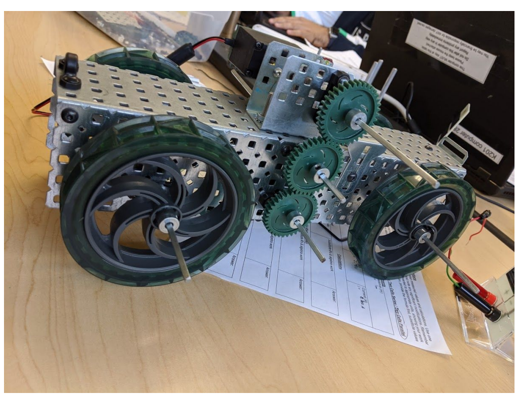
- Online documentation in Google Drive folder
- A physical prototype of the vehicle
- Individual Documentation
- Proposed brainstorms
- Daily Project Logs for each individual
- A set of completed conclusion questions

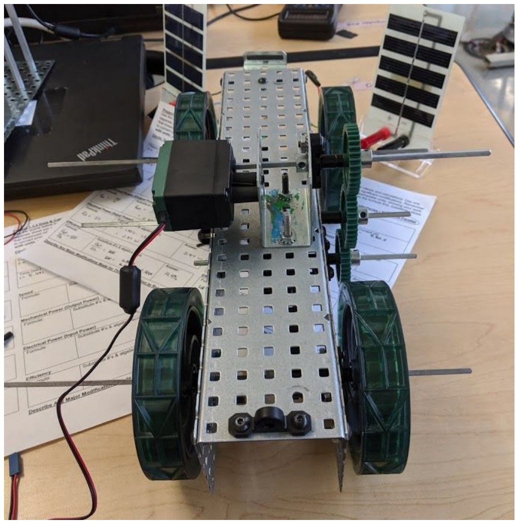
Photos of Design

Prototype 1

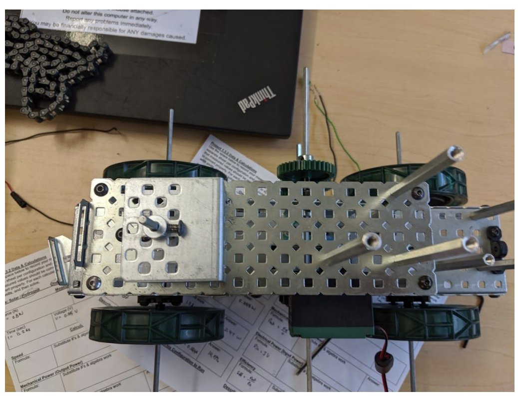
Date & Electronic Signatures	Image	Explanation of change in design/image details
Date: 11/01/19 Electronic Signatures: Tanish Baranwal Romyr Concepcion Rohil Khare Krisha Rao	Side view 	In the initial stages of our project, our group had decided to place a sprocket train on the exterior portion of our prototype. This unfortunately didn’t meet the constraint of the 5’x12” and exceeded the limit (in terms of width) by almost 1.2 inches. In this image, the following changes have been made: The sprocket change had been moved to the inside of the chassis to match the size constraint.
Date: 11/01/19 Electronic Signatures: Tanish Baranwal Romyr Concepcion Rohil Khare Krisna Rao	Length Wise View 	The following image contains the length wise view. This view had originally had the gear train on the left hand side and was aided by the running motor on top of the base that our group had created. The image showcases the change we made to accommodate the gear train as seen within the base of our prototype. This allowed our group to meet the 5 inch constraint.

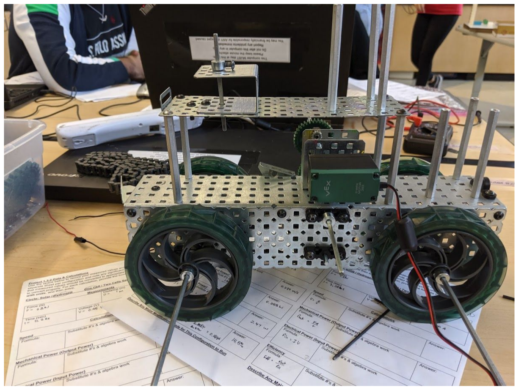
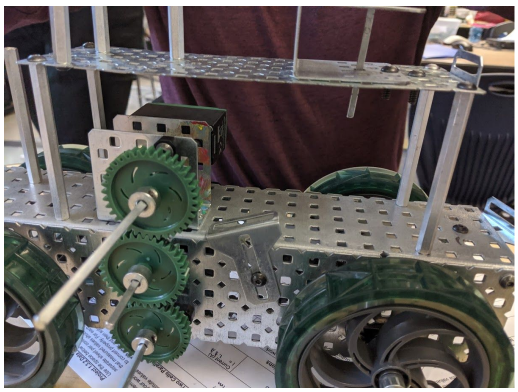
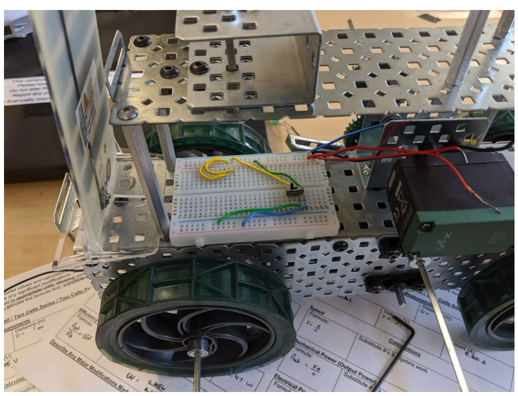
Prototype 2

Date & Electronic Signatures	Image	Explanation of change in design/Image Details
Date: 11/06/19 Electronic Signatures: Tanish Baranwal Romyr Concepcion Rohil Khare Krishna Rao	Length Wise View 	The following image illustrates the modification that we had made in order to accommodate the same size constraint our group had faced. Our motor was too far placed which exceeded the 5 inch wide constraint. This prompted our group to immediately switch the placement of the motor as seen in the image above, such that our motor was above the chassis instead of sticking out of one side.
Date: 11/06/19 Electronic Signatures: Tanish Baranwal Romyr Concepcion Rohil Khare Krishna Rao	Side View 	This view currently shows the updated placement of our 1 to 1 gear train, which is connected to a motor via the axle and is secured by a U bracket. This ensures that the motor isn't placed too far out and ruins the 5 inch constraint and affirms that our internal sprocket chain can run properly and efficiently.
Date: 11/06/19 Electronic Signatures: Tanish Baranwal Romyr Concepcion Rohil Khare	Side/Top View	This view depicts the orientation of both the 1 to 1 gear train and the motor via the axle and the U bracket. This clearly shows that the gear train is connected to the axle of the sprocket train and also shows the motor being perfectly placed, fitting the 5 inch constraint for the

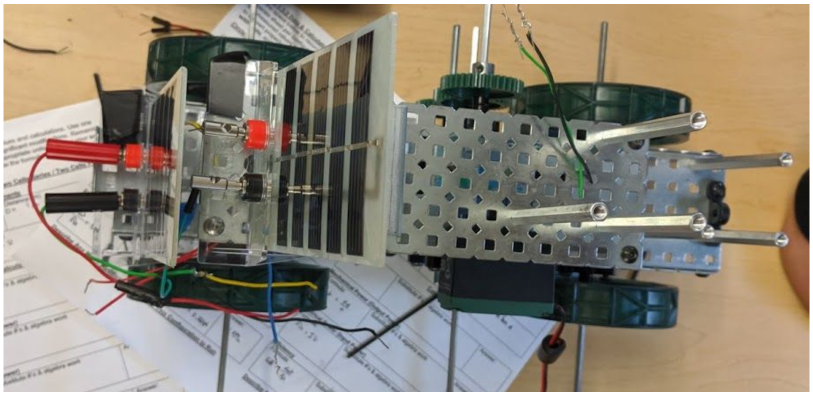
Krishna Rao		prototype. This image also shows that the motor, the gear train, and the U bracket are all secured properly with the help of nuts and bolts as well as collars which secure the gear train onto the axle and makes sure the axle cannot slide out of the motor.

Final Prototype

Date & Electronic Signatures	Image	Explanation of change in design/Image Details
Date: 11/08/19 Electronic Signatures: Tanish Baranwal Romyr Concepción Rohil Khare Krishna Rao	Top-down view 	This image depicts our prototype at the end of our countless modifications. In this top view, we can see the standoffs which protrude from the main chassis.. These standoffs were used to hold the hydrogen cell in place and we have two sets of three standoffs to hold both of the hydrogen cells in place simultaneously.

Date: 11/08/19 Electronic Signatures: Tanish Baranwal Romyr Concepción Rohil Khare Krishna Rao	Side views  	Top Photo: In this side view, we can see the wheels we used for the vehicle which were the larger VEX wheels. We have a second layer to our vehicle to help house our second hydrogen and solar cell. The single T bracket at the left side of our vehicle(in terms of the photo) can be tightened to push the solar panel into the U bracket so the solar panel stays in place. Bottom Photo: In this view, we can see the 1 to 1 to 1 gear ratio we used to reach our main sprocket driving axle. The motor resides on top of the main chassis, attached to a U bracket.
Date: 11/08/19 Electronic Signatures: Tanish Baranwal Romyr Concepción Rohil Khare Krishna Rao	Bread Board Image 	In this view, we can see that the breadboard is being held onto the vehicle using another T bracket. This T bracket is first loosened, then pushed against the breadboard, and then the screw is tightened to tightly secure the breadboard. In this view, we can also see the solar panel which has been attached on by the T bracket.

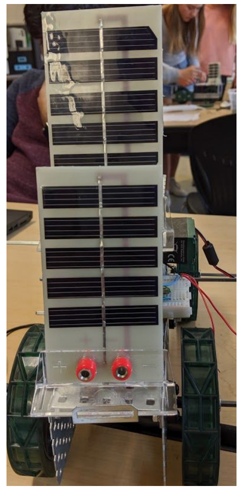
1 Solar Cell Efficiency Calculations



Vehicle in configuration to be powered by a single solar cell
*No modifications were made to accommodate source except for wiring

Variable	Value	Calculations
V	2.48 V	N/A
I	0.110 A	N/A
F	0.5 N	N/A
d	1.00 m	N/A
t	5.49 s	N/A
v	0.1821 m/s	$V = dt^{-1}$ $V = (1.00\text{ m})\,(5.49\text{ s})^{-1}$ $V = 0.1821\text{ m/s}$
P_{out}	0.091 W	$P_{out} = Fdt^{-1}$ $P_{out} = 0.5\text{ N} \times 1.00\text{ m} \times 5.49^{-1}\text{ s}$ $P_{out} = 0.091\text{ W}$
P_{in}	0.273 W	$P_{in} = IV$ $P_{in} = 0.110\text{ A} \times 2.48\text{ V}$ $P_{in} = 0.273\text{ W}$
Efficiency	33.4%	$Eff = P_{out} \times P_{in}^{-1} \times 100\%$ $Eff = 0.091\text{ W} \times (0.273\text{ W})^{-1} \times 100\%$ $Eff = 33.4\%$

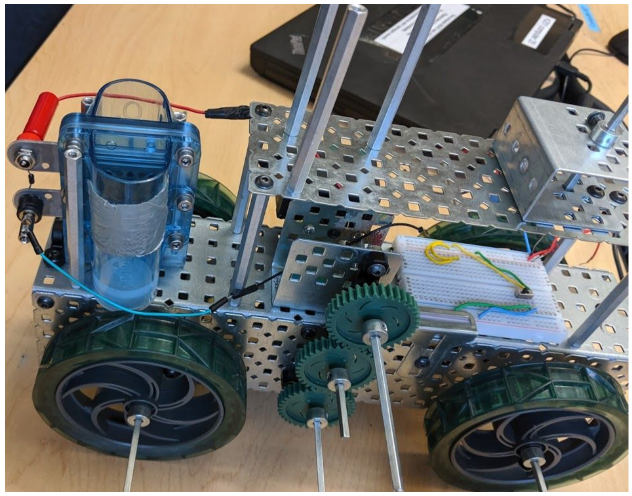
2 Solar Cell Parallel Efficiency Calculations



Vehicle in configuration to be powered by two solar cells
*No modifications were made to accommodate source except for wiring

Variable	Value	Calculations
V	2.78 V	N/A
I	0.300 A	N/A
F	1.3 N	N/A
d	1.00 m	N/A
t	3.28 s	N/A
v	0.305 m/s	$V = dt^{-1}$ $V = (1.00\text{ m})\ (3.28\text{ s})^{-1}$ $V = 0.305\text{ m/s}$
P_{out}	0.396 W	$P_{out} = Fdt^{-1}$ $P_{out} = 1.3\text{ N} \times 1.00\text{ m} \times 3.28^{-1}\text{ s}$ $P_{out} = 0.396\text{ W}$
P_{in}	0.273 W	$P_{in} = IV$ $P_{in} = 0.110\text{ A} \times 2.48\text{ V}$ $P_{in} = 0.273\text{ W}$
Efficiency	33.4%	$Eff = P_{out} \times P_{in}^{-1} \times 100\%$ $Eff = 0.091\text{ W} \times (0.273\text{ W})^{-1} \times 100\%$ $Eff = 33.4\%$

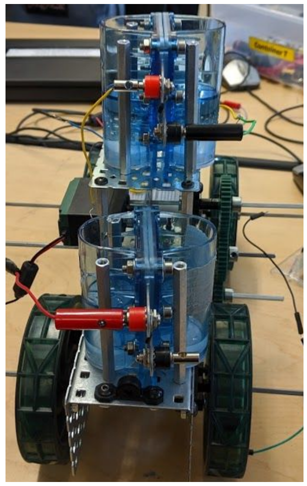
1 Hydrogen Fuel Cell Efficiency Calculations



Vehicle in configuration to be powered by one hydrogen fuel cell
*No modifications were made to accommodate source except for wiring

Variable	Value	Calculations
V	0.95 V	N/A
I	1.3 A	N/A
F	0.5 N	N/A
d	1.00 m	N/A
t	5.49 s	N/A
v	0.0889 m/s	$V = dt^{-1}$ $V = (1.00\ m)\ (11.26\ s)^{-1}$ $V = 0.0889\ m/s$
P_{out}	0.071 W	$P_{out} = Fdt^{-1}$ $P_{out} = 0.8\ N \times 1.00\ m \times 11.26^{-1}\ s$ $P_{out} = 0.071\ W$
P_{in}	1.235 W	$P_{in} = IV$ $P_{in} = 1.3\ A \times 0.95\ V$ $P_{in} = 1.235\ W$
Efficiency	5.8%	$Eff = P_{out} \times P_{in}^{-1} \times 100\%$ $Eff = 0.071\ W \times (1.235\ W)^{-1} \times 100\%$ $Eff = 5.8\%$

2 Hydrogen Fuel Cell Series Efficiency Calculations



Vehicle in configuration to be powered by two hydrogen fuel cells wired in series
*No modifications were made to accommodate source except for wiring

Variable	Value	Calculations
V	1.90 V	N/A
I	2.6 A	N/A
F	1.5 N	N/A
d	1.00 m	N/A
t	4.19 s	N/A
v	0.239 m/s	$V = dt^{-1}$ $V = (1.00\text{ m})\,(4.19\text{ s})^{-1}$ $V = 0.239\text{ m/s}$
P_{out}	0.358 W	$P_{out} = Fdt^{-1}$ $P_{out} = 1.5\text{ N} \times 1.00\text{ m} \times 4.19^{-1}\text{ s}$ $P_{out} = 0.358\text{ W}$
P_{in}	2.47 W	$P_{in} = IV$ $P_{in} = 2.6\text{ A} \times 1.90\text{ V}$ $P_{in} = 2.47\text{ W}$
Efficiency	14.5%	$Eff = P_{out} \times P_{in}^{-1} \times 100\%$ $Eff = 0.358\text{ W} \times (2.47\text{ W})^{-1} \times 100\%$ $Eff = 14.5\%$

Power Source Evaluation / Testing Summary

In our evaluation of the different power sources, in general we found out that the hydrogen fuel cells have a high amperage output with a low voltage output, while the solar cells have a high voltage output and a low amperage output. Overall, the hydrogen fuel cells have a higher power output that diminishes over time while the solar cells have a lower, constant power output. According to our efficiency calculations, the solar cell powered car had higher efficiency across the board, while the hydrogen fuel cell efficiency was much lower. If we were to simply base our decision on the efficiency of the power sources, we would recommend using two solar cells wired in parallel to power the car. However, considering the practicality of scaling this up to an actual car, the hydrogen fuel cell in series is a more viable option for powering the car because it allows instant energy once fueled up and can store energy. The solar cells are at the mercy of the availability of the sun, and if the solar cells are used to charge a battery, the lack of current output will make that process very slow and the act of storing the electricity in a battery then using it will have a serious impact on the efficiency of the system. A battery would degrade over time and add additional weight to the vehicle. An added benefit of using hydrogen to power the car is that it appeals to consumer habit of refilling their cars with fuel or charging their cars. Hydrogen refueling stations could replace or stay alongside gas stations. Some items that would need to be addressed when scaling up either the solar cell or hydrogen cell include the fact that as a car increases in size, the weight and power requirement increases cubically. A car powered by solar cells would need a very large solar cell to provide enough power to move the car, something that would be unwieldy and not comfortable to drive. In addition, putting the cell in a place exposed to the sun also exposes it to wear and tear from the surrounding environment. A hydrogen cell would be able to take the place of a standard gasoline fuel tank, albeit bigger. In summary, our prototype model shows that two solar cells in parallel are best for powering a car for a short time, but are unreliable, require upkeep to keep them functioning, and need a battery to store electricity. We recommend the use of two hydrogen cells in series to get the best balance of environmental impact, efficiency, reliability, and power output.

As we tested, we found that solar panels, although powerful when they work, are too unreliable for sustained use in a full size car. They require intense sunlight and absolutely no obstructions in order to power the car, and even then minor damage from simply moving the solar cells around and colliding with the environment can prevent current from flowing. Even when they are able to generate electricity, a battery of some kind is required to store that energy in a usable state. Another flaw is that there are few flat, empty spaces on a car that are exposed to sunlight that are not also exposed to danger. This team finds that solar cells are too sensitive to be recommended. When testing hydrogen cells, we found them to work perfectly every time, even on partial charge and after sustained use. The car did not move as fast or exert as much force, but it did move more reliably. On a full size car, the hydrogen cells would probably take the place of a standard gas tank or otherwise sit near the engine, as on current designs. They would be able to be recharged via electrolysis, a process that can take the form of a familiar gas station. Instead of fuel, water is pumped into the cells and electricity is sent through the cell. This simple process, the ability of a hydrogen cell to store energy, and the overall greater reliability of hydrogen power are why we recommend that the client use two hydrogen fuel cells in series to power their next vehicle.