



DIY Fuel Cell Derby: Competition Guide

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DIY Competition Guide Overview

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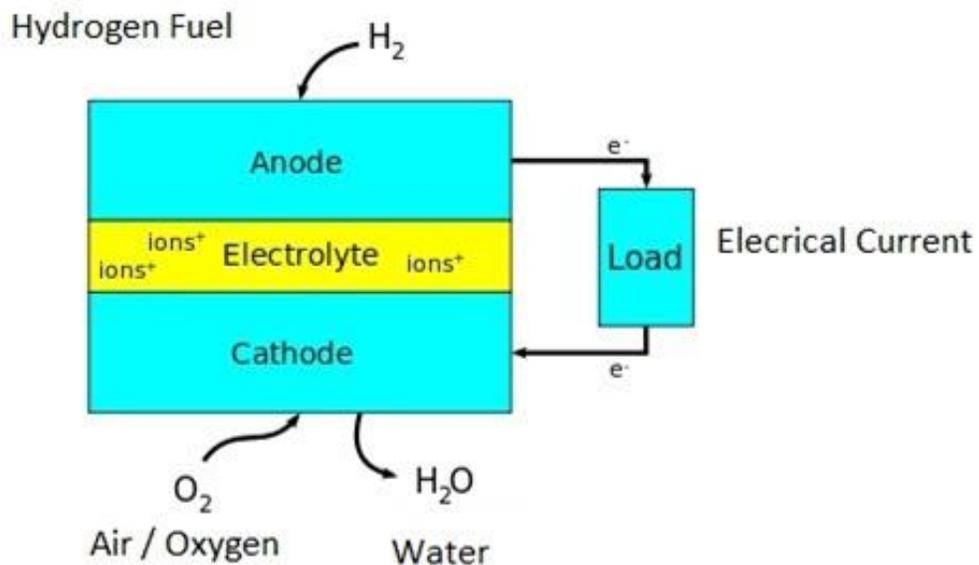
HYDROGEN BASICS UNDERSTANDING THE FUEL CELL

INTRODUCTION:

Fuel Cells have been in existence for over 150 years but they have only recently become popularized in the mainstream as an effective energy generator to be used in powering everything from electric vehicles to homes and buildings.

The first fuel cell was invented by Sir William Grove in 1839 and was originally called as "Gas Battery". A Fuel Cell is a lot like a battery, except it doesn't discharge or need to be recharged. It simply recharges itself continuously by generating its own power from the internal chemical reactions between Hydrogen gas and Oxygen that are taking place. These reactions produces a tremendous amount of electricity relative to the size of the fuel cell and its only emissions are heat and water. There is no **combustion** within a fuel cell and it will continue to produce electricity as long as it has a continuous supply of fuel. Just like a battery, a fuel cell can have multiple cells that are combined together in a **Stack** to reach higher power output.

A Hydrogen Fuel Cell does this by specifically pumping Hydrogen (H_2) to the anode (-) side of the fuel cell and Oxygen (O_2) (from the air) to the cathode (+) side of the fuel cell. The Hydrogen ions are stripped of their electrons and pass through a membrane that is only big enough for the Hydrogen Proton to pass through. The electrons are forced to take the long way around where they pass through the electronic load and travel to the cathode side where Oxygen from the air is pumped in. It is in this side where the Hydrogen, Oxygen, and electrons recombine together creating water. The energy released from this process creates heat which is why our 3 major outputs from a PEMFC are Electricity, Water and Heat as seen in the diagram from the previous paragraph



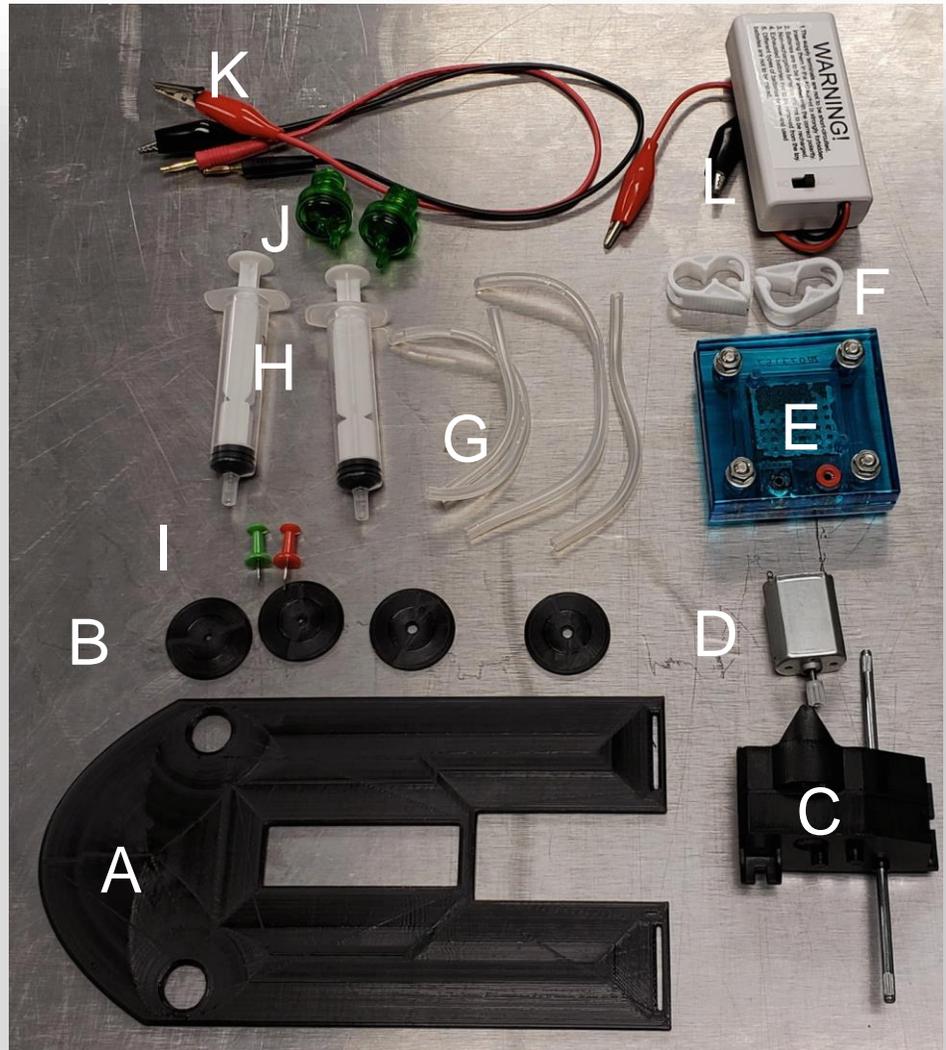


DIY FUEL CELL DERBY CAR PARTS LIST

INCLUDED

YOU NEED TO MAKE

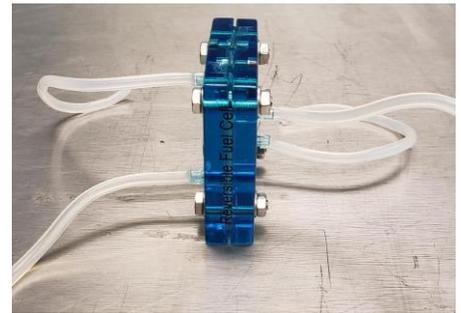
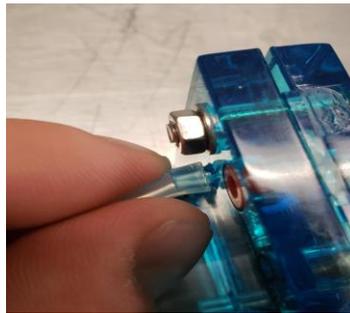
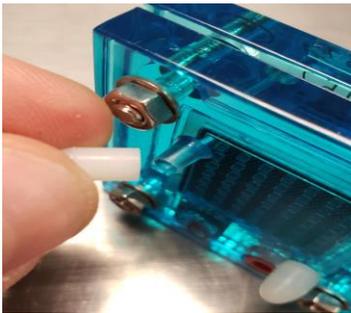
- A) CHASSIS**
- B) WHEELS**
- C) TRANSAXLE**
- D) DC MOTOR**
- E) FUEL CELL**
- F) GAS CLIPS**
- G) SILICON TUBING**
- H) GAS STORAGE SYRINGE**
- I) FRONT AXLE PINS**
- J) PRESSURE RELIEF VALVE**
- K) POWER WIRES**
- L) BATTERY BOX**





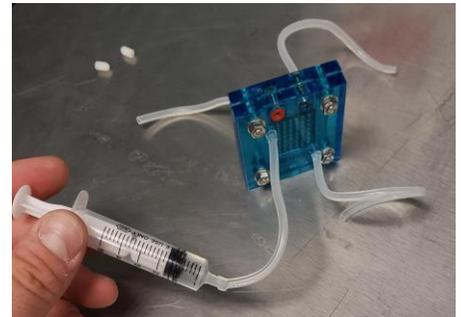
DIY FUEL CELL/ELECTROLYZER SYSTEM ASSEMBLY

- **STEP 1:** Remove the Blue fuel cell from the package along with 2 green check valves, 2 white clips, and 4 pieces of silicon tubing.
- **STEP 2:** Cut the tubing to 4 inch lengths.
- **STEP 3:** Attach the tubing to all 4 ports on the fuel cell.

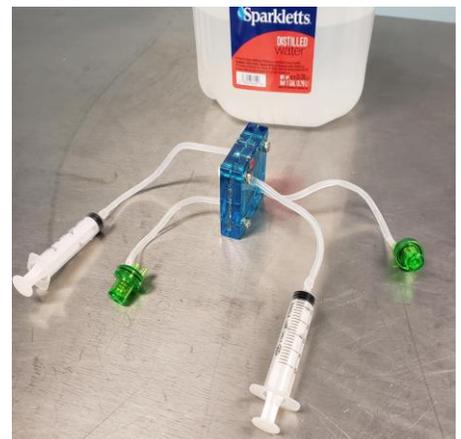


- **STEP 4:** Use the syringe to add 1 mL of distilled or deionized (DI) water through the top tube next to the positive (**Red**) side. Leave the tube connected for next step.

****Hint**** water should spill out of the bottom tube if done correctly



- **STEP 5:** Repeat for negative (**Black**) side.
- **STEP 6:** Connect the green pressure release valves to both bottom tubes. When your cell matches the picture move on to step .

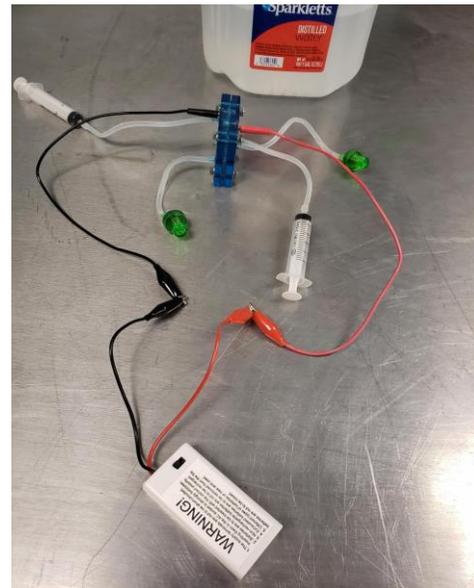
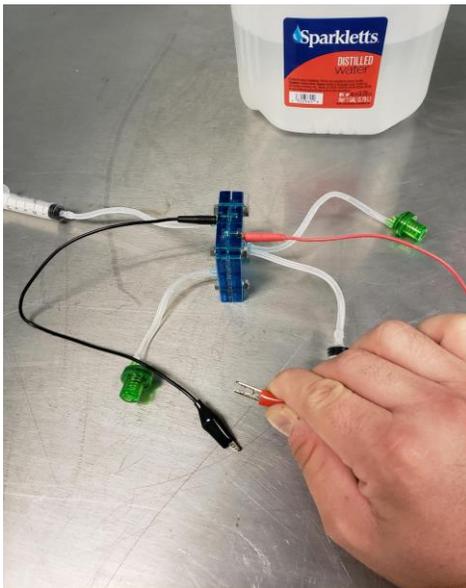




Generating Hydrogen

DIY FUEL CELL/ELECTROLYZER HYDROGEN GENERATION

- **STEP 1: Connect the positive and negative leads to the fuel cell. Be sure to match colors.**
- **STEP 2: Attach the alligator clips to the white battery box. Match the colors and turn the battery on.**



- **STEP 3: You should immediately notice small bubbles forming inside the fuel cell. After a few moments you will notice the syringes begin to fill up with what appears to be air. This is where our hydrogen and oxygen gasses are being stored for later use. Leave the battery on until both syringes are full. You may notice the Hydrogen is filling up roughly twice as fast as the Oxygen. The overflow valve on the hydrogen (negative) side will compensate for this offset. Remove leads from battery pack and attach leads from fuel cell to LED light to test.**





Vehicle Fabrication

The Chassis in this section was Designed and 3D printed by Horizon Educational. For videos on how to 3D print your own chassis, look in Troubleshooting section for links to our YouTube DIY Video Series.

VEHICLE FABRICATION

Chassis Assembly

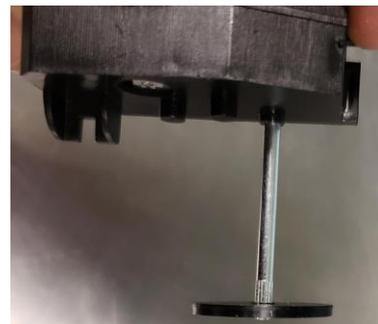
- **STEP 1: Connect the front wheels to the chassis with the included push pins. Front wheels can be identified by smaller center holes.**



- **STEP 2: Attach the small DC motor to the transaxle with the red dot facing down. Make sure the flat side of the motor aligns with the flat side of the transaxle.**



- **STEP 3: Attach rear wheels to the ends of the transaxle. Push gently until they are on securely.**

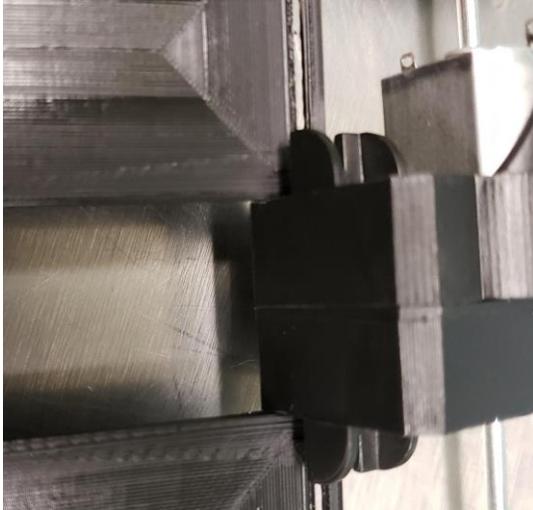




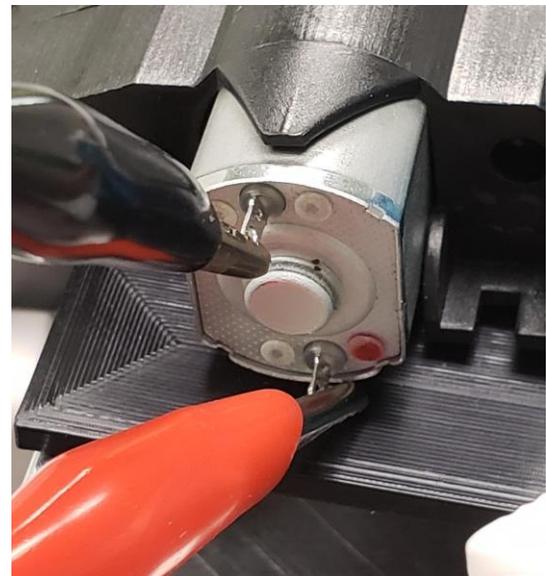
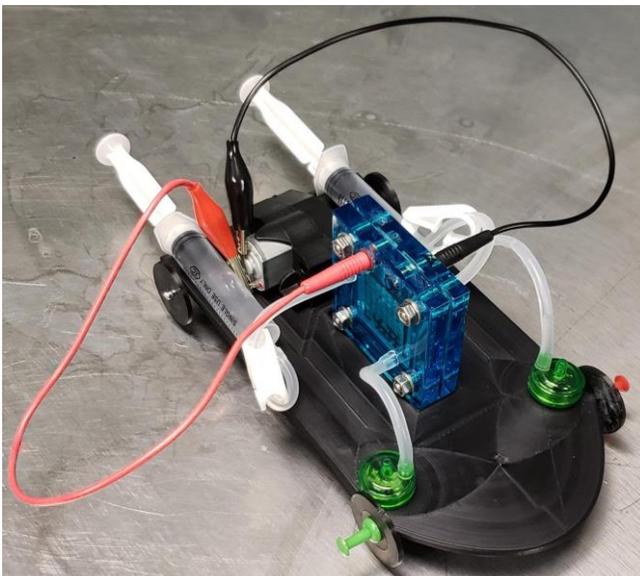
VEHICLE FABRICATION

Fuel Cell System Assembly

- **STEP 1: Attach the motor assembly to the chassis.**



- **STEP 2: Attach the fuel cell assembly to the chassis in the designated space. Be sure to support the chassis with the other hand as you may need to press firmly to make the fuel cell fit in the slot. Attach the purge valves and the syringes in the appropriate locations. Do Not attach the wires to the motor until you are ready to test. Once ready attach the alligator clips to the corresponding colors and place the car on the floor and watch it go.**





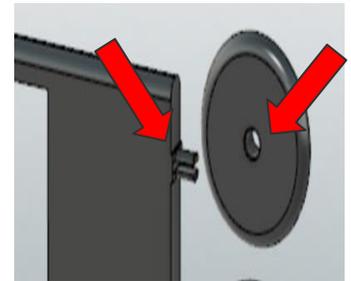
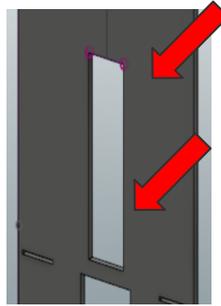
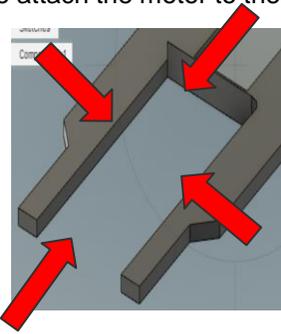
Vehicle Fabrication Guide

Objective:

In this lesson we will sketch out a design for our own chassis using the provided chassis as a reference. We will label key chassis components to integrate into your own custom designs. We will then bring our designs to life by fabricating them out of recycled materials such as cardboard, wood, styrofoam, etc, or by designing a chassis with CAD software and 3D printing them. To see how, check out the Youtube link in the Troubleshooting section.

Theory: You must find a way to integrate these 3 components into your chassis in order for it to work with the kit components.

- 1) A place to attach the motor to the chassis 2) A place to attach the fuel cell to the chassis 3) A way to attach wheels to the chassis



Design Procedure:

- 1) On a separate sheet of paper, trace all the components from the rover chassis to use as a template.
- 2) Sketch your own chassis of about the same size and dimensions using your creativity to make modifications where you wish.
- 3) Place your custom rover drawing over the top of the traced drawing. The traced drawing will be used as your template to locate and place the motor mount, fuel cell mount and green check valve mount.
- 4) Cut out your newly designed rover chassis template and prepare for fabrication process.

Fabrication Procedure:

- 1) Find a piece of suitable material from a recycled source to construct your Chassis out of. (Cardboard is a great material to use as it is easy to find)
- 2) Use your custom template to trace your design onto your chassis material.
- 3) Use scissors or exacto knife to cut your design out of the material you have selected.
- 4) Find a way to secure the wheels to your custom rover. (thumbtacks are an easy solution)
- 5) Place all components on your chassis and test to make sure they fit and work.
- 6) Practice run.



Competition Guide

COMPETITION RULES

GOAL: How far can your Fuel Cell car travel?

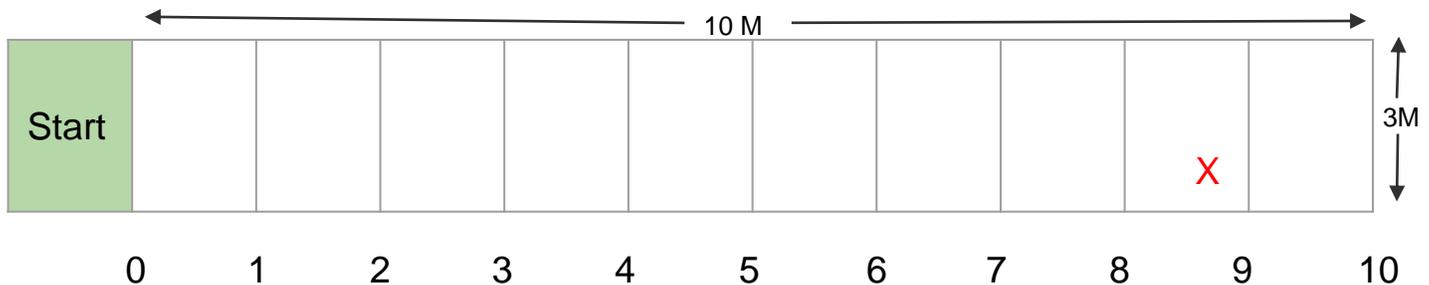
- Design teams will test to see how far their Fuel Cell car will travel
- Teams will test their designs to see which design can travel the furthest.

Race Format:

- Teams will release their cars in the start box and measure the distance it travels.
- Each team will make a total of 2-4 runs:

Track Setup

- Measure out a rectangle in the dimensions of 10 Meters long and 3 meters wide.
- Measure and mark every meter from 1 to 10. Be sure to mark 0 as your starting point



Scoring

- Teams will score more points the further their Fuel Cell Vehicle (FCV) travels
- Once a vehicle passes a main marker, you will score the exact distance traveled..
- In order to get an exact score, use a centimeter/inch ruler to get an exact measurement past the marker line.
- If the car keeps going after the end, turn the car around and send it back the opposite direction.
- Example:
 - The red x is your car
 - It has stopped 75 cm past the 8 meter line. The score for this car is 8.75
- Car must stay between the 3 meter side walls in order to score. If car goes outside the lines, either manually straighten it out or record score at the place it left the course.



Data Collection Guide

Objective:

Today we will be racing and collecting data to see how far your car will travel on 1 full tank of Hydrogen. You will be completing 2-4 runs in total. We will collect data to see how far your car will travel. You can pump hydrogen and oxygen in the fuel cell when it stops until both syringes are completely empty. After this your run is over so take your car back to your pit, fix, and get ready for your next run.

Collected Race Day Data: Circle the run that traveled the furthest distance.

Run Number	Distance Traveled (meters or feet)
1	
2	
3	
4	

Add all distances together and scores together.

How far did your car travel in total? How many points did you score in total?

Why do you think this is?



TROUBLESHOOTING GUIDE

General:

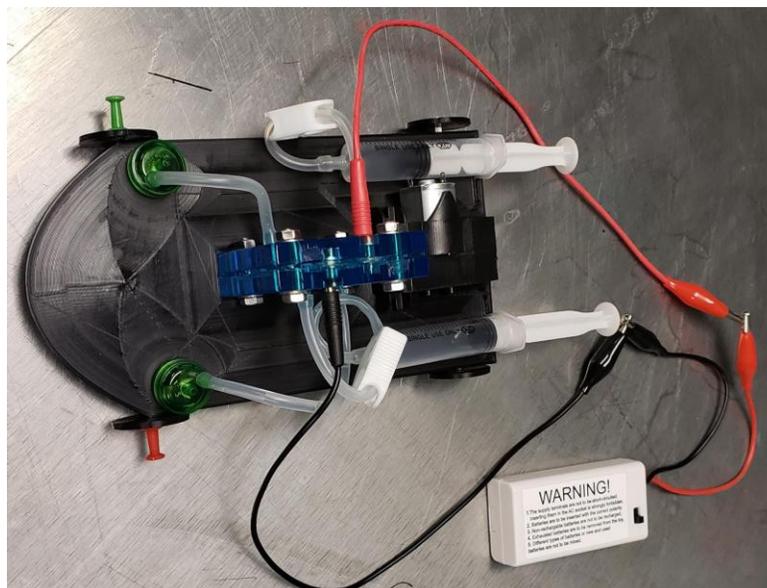
- **Adding drinking water into the Fuel Cell will severely impact its performance.**
- **Do not add anything but distilled or deionized water into the cell.**
- The Battery Box may or may not come with batteries included so please double check before testing.
- The fuel cell will perform better after a few cycles. This is because you allow the cell to humidify internally resulting in better and more reliable performance.
- DIY Fuel Cell Derby Video Series links
 - **DIY Video Playlist link:** https://www.youtube.com/playlist?list=PLRWS8k-KYaPgDCF5wSZhuDyTg_Dbb-Sxl
 - **CAD Design Video Link:** <https://youtu.be/OaDjQImX6N8>

Wheel alignment

- If the rover wheels are not aligned properly this could create excess drag resulting in lost efficiency. Precious energy will be wasted overcoming the forces of drag on the wheels which will cause the car to not travel as far

Refueling:

- **Disconnect the red and black clips from the motor and attach them to the battery box. Once syringes are filled with gas disconnect from battery and reattach to the motor.**





TROUBLESHOOTING GUIDE

Motor will not run:

- Check all wires to make sure they are connected properly
- Purge the Cell - the cell needs to be purged of excess water build up in order to run properly. Refill syringes with H₂ and O₂ gas and manually press the gasses into the cell. Water should begin to squirt out of the green purge valves. And the motor should begin to run again. Continue to push gently until syringes are empty. Reconnect to the battery and refill once more to resume experiment. Be very gentle during this process as too much pressure from the syringe can cause the seal inside the fuel cell to burst. If this happens you may notice bubbles on the outside of the cell. If this happens the cell needs to be replaced.

No gas in 1 or both storage tanks:

- Check to see if either side looks dry inside. You should see a bit of condensation inside the cell. If not add some more Distilled water inside. Also, check the silicon lines to make sure there are no rips or tears. If so cut at the tear, reattach and try again.

Broken Seal

- A broken internal seal will cause the fuel cell to not work properly and you will not be able to power the car. A blown seal can be easily identified by bubbles will form on top of the cell where the 2 parts of the cell are joined. A blown seal can result from pushing water through the cell with too much pressure.

Humidifying the Cell

- The fuel cell will perform better after a few cycles. This is because you allow the cell to humidify internally resulting in better and more reliable performance.

Wheel alignment

- If the rover wheels are not aligned properly this could create excess drag resulting in lost efficiency. Precious energy will be wasted overcoming the forces of drag on the wheels which will cause the car to not travel as far

Fuel Cell Storage

- When the fuel cell is not in use, store in a sealable container or ziplock bag. Another option is to attach a piece of tube between the input and output on both H₂ and O₂ sides.