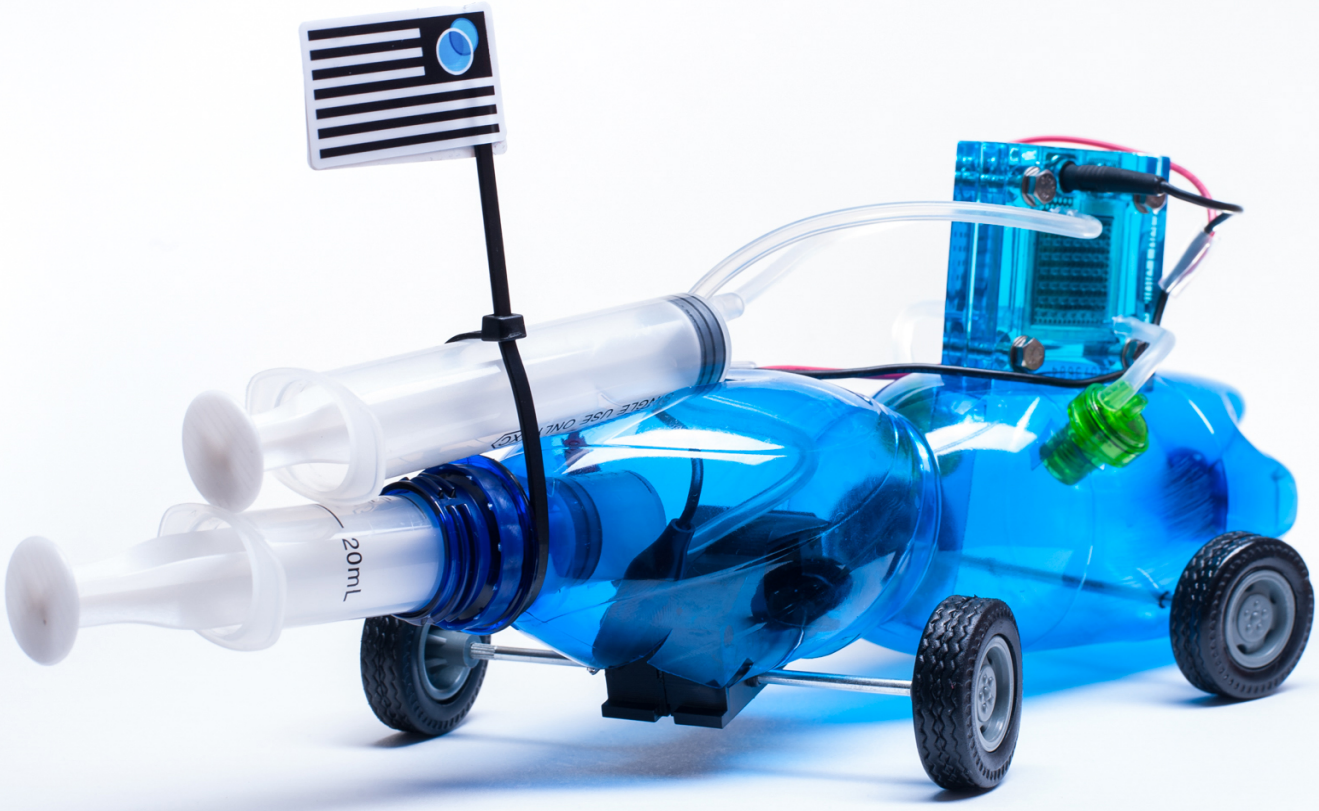
Horizon Hydrogen DIY RACE

ACTIVITY GUIDE

BUILD IT ! TEST IT ! RACE IT !

Brief overview p.1
1. Activity 1 - Electrolysis p.2
2. Activity 2 - Fuel Cell Power p.3
3. Activity 3 - Vehicle Design & Fabrication p.4
4. HINT - Assemble the Fuel Cell / Electrolyzer p.5
5. HINT - Generating Hydrogen p.6
6. Activity 4 - Data Collection p.7

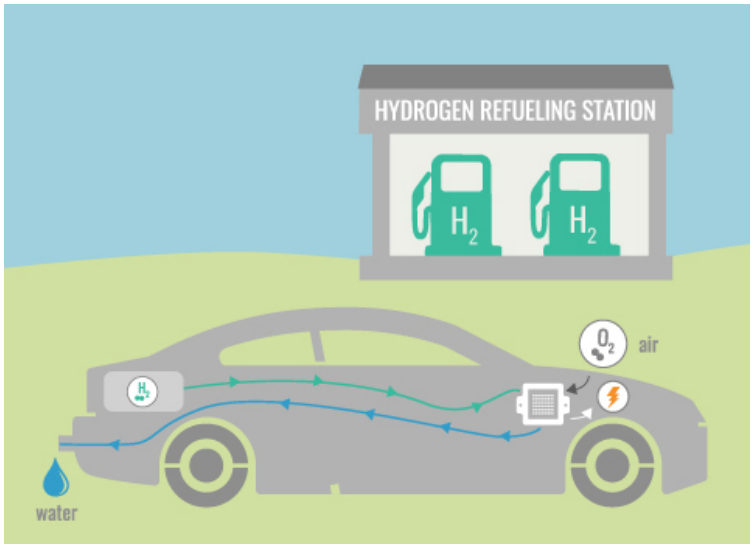


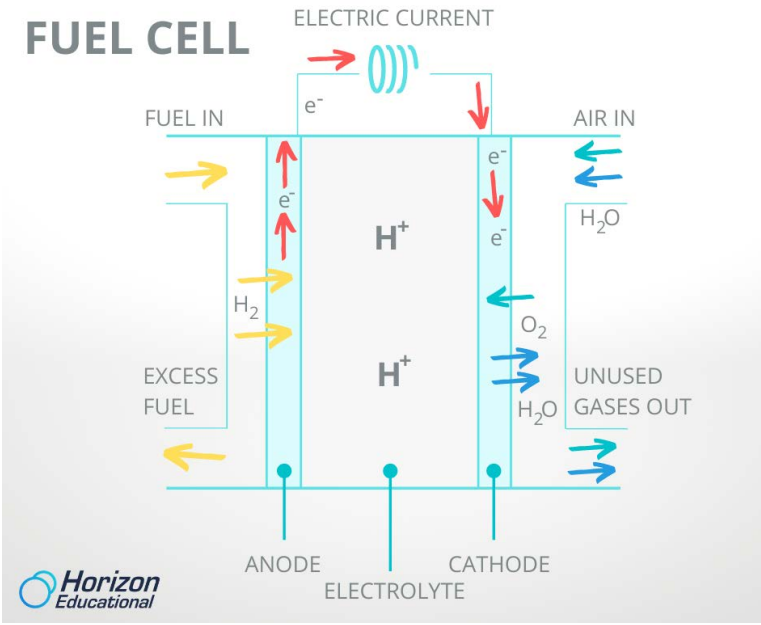
BRIEF OVERVIEW

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 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 a “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 or PEM (Proton Exchange Membrane) Fuel Cell does this by specifically pumping Hydrogen (H2) to the anode (-) side of the fuel cell and Oxygen (O2) (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.





Anode: $H_2\ (g) \rightarrow 2H^+\ (aq) + 2e^-$

Cathode: $\frac{1}{2}\ O_2\ (g) + 2H^+\ (aq) + 2e^- \rightarrow\ H_2O$

Overall: $H_2\ (g) + \frac{1}{2}\ O_2\ (g) \rightarrow\ H_2O\ (l)$ + electric energy + waste heat

LEARNING BY DOING

ACTIVITY 1 - ELECTROLYSIS

In this experiment we will be converting electrical energy to chemical energy in the form of hydrogen through a process called water electrolysis. We will also find the ratio of hydrogen to oxygen production and see how this is related to the chemical name for water - H2O.

- ✓ 1st law of Conservation of Energy: Energy can be transformed from one form to another, but can never be created nor destroyed!
- ✓ Electrolysis Balanced Equation: 2H2O + Energy = O2 + 2H2

Your Turn! Draw the balanced equation for Electrolysis below.

Experiment Procedure:

1. Assemble the reversible fuel cell following steps 1 & 2 in the assembly manual.
2. Take timed measurements for hydrogen & oxygen production @ 1, 2, 3, 4 and 5 minutes. Record results on the chart to the right.
3. What is the rate of Hydrogen to oxygen production during the electrolysis process?
   ___:___
4. How does the chemical name for water (H2O) related to your collected data for water electrolysis? Explain in your own words in the space below.

Collected Data

Electrolysis data recording chart:

Time (Min)	Volume of Hydrogen (ml)	Volume of Oxygen (ml)	Ratio (H_2 to O_2 volume)
1			
2			
3			
4			
5			

LEARNING BY DOING

ACTIVITY 2 - FUEL CELL POWER

In this experiment we will be converting chemical energy in the form of hydrogen and oxygen to electricity through a device called a PEM Fuel Cell. The created electricity will be used to power a simple DC motor from the car kit and we will calculate the power output of the fuel cell to the motor by learning how Voltage and Amperage are used to determine Watts. Finally we will determine how much hydrogen is needed to power the DC motor for 1 minute.

Theory

- **Power** (P) = **Watts** (W)
- **Watts (W)** = **Volts** (V) x **Amps** (A)

Conversion Table

W=VxA V=W/A A=W/V

- **Example:** You are using a fuel cell to power your house. If the fuel cell is producing 120 Volts(V) at 20 Amps(A), how much power is your fuel cell making?

  P=W: W=VxA : W= 120x20 : **W= 2400** : The fuel cell makes **2,400 Watts**

Experiment Procedure:

Note: Set up the fuel cell system following steps 1 and 2 in the assembly manual.

1) If the DC motor needs 0.45V and 0.45A to turn on, how many watts does the Fuel Cell need to make to power the motor? Calculate to the right and circle your answer in watts.

2) Fill out the chart to the right to determine how much fuel is needed to power the motor for 10, 20 and 30 seconds. Use your critical thinking skills to calculate the amount of fuel consumed by the fuel cell in 1 minute based on your collected data.

Hint

If the motor stops but there is still gas in the syringes, push 1mL gently through each side until the motor starts again.

Calculated Data

1) DC Motor Power Calculation:

2) Gas Consumption Rate:

Time (sec)	Hydrogen (mL)	Oxygen (mL)
10		
20		
30		

How much Hydrogen will be consumed by the fuel cell in 1 minute?

_____mL H_2 _____mL O_2

ACTIVITY 3 - VEHICLE DESIGN & FABRICATION

In this lesson you will sketch out a design your own chassis You will then bring your designs to life by fabricating them out of recycled materials such as cardoard, wood, styrofoam, etc.

Design Procedure:

First, you will sketch out your ideas on paper in order to help you come up with a plan of how you want to design our vehicle.

Next, you will need to source materials that are strong enough to hold the components of the fuel cell system, but light enough to allow the car to travel as far as possible.

Finally, you will build your own prototype!

Fabrication Procedure:

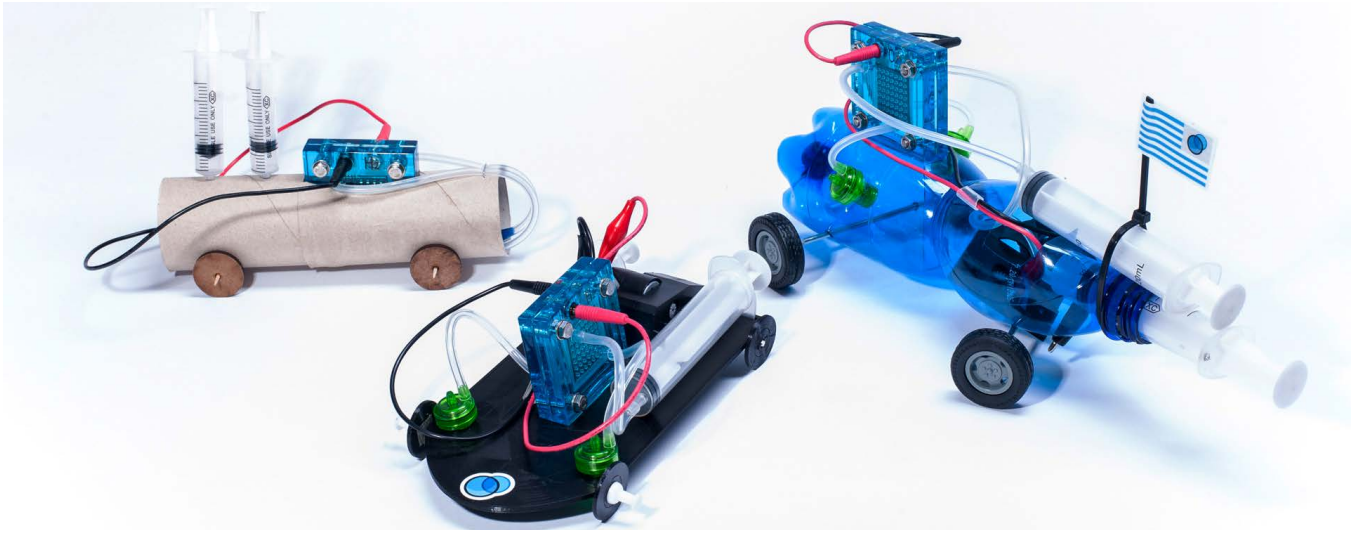
1) Find a piece of suitable material from a recycled source to construct your chassis out of (cardboard is a great material to use as it is easy to find).

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.

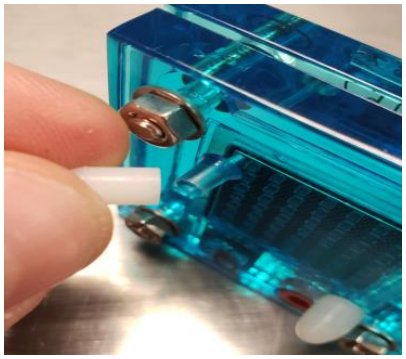
4) Find a way to secure the wheels to your custom vehicle (thumbtacks are an easy solution).

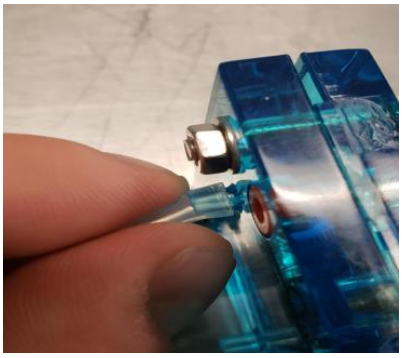
5) Place all components on your chassis and test to make sure they fit and work.

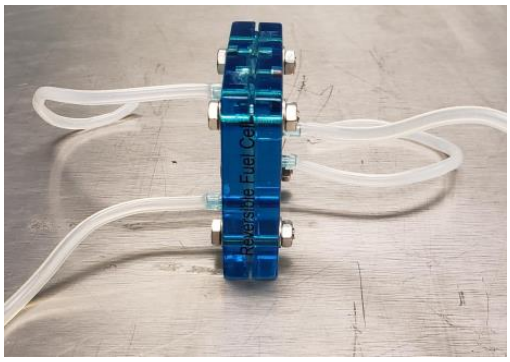


HINT: ASSEMBLE THE FUEL CELL/ELECTROLYZER

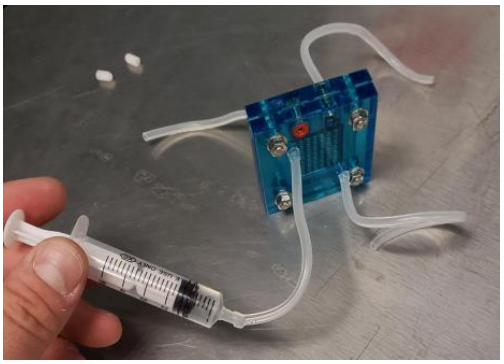
- Remove the Blue fuel cell from the package along with 2 green check valves, 2 white clips, and the silicon tubing.
- Cut the silicon tubing into 4 pieces of each 4 inch.
- Attach the tubing to all 4 ports on the fuel cell.



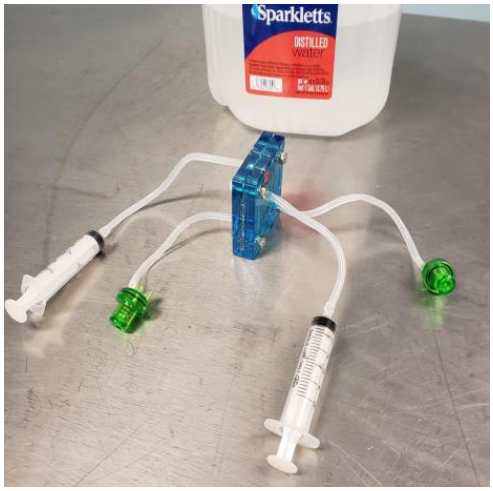




- Use the syringe to add 1 mL of distilled or deionized (DI) water through the top tube next to the positive (Red) side.



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

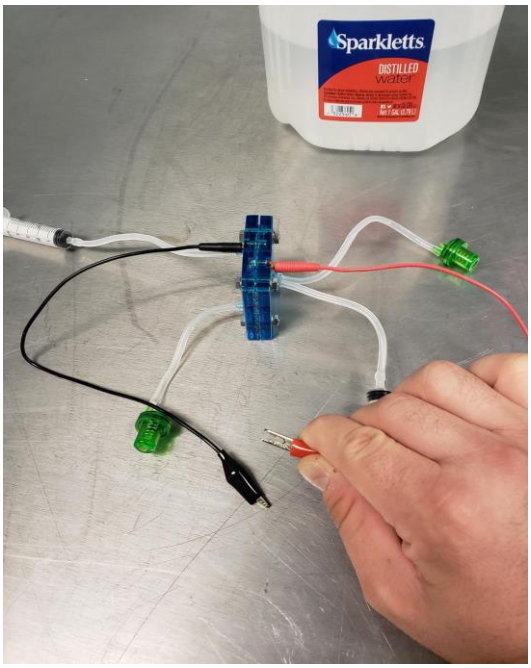


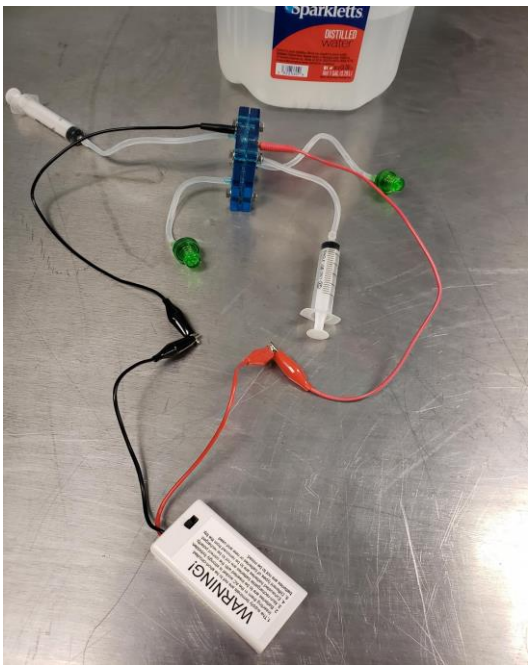
- Repeat for negative (Black) side.

- Connect the green pressure release valves to both bottom tubes. When your cell matches the picture move on to step .

HINT: GENERATING HYDROGEN

- Connect the RED and BLACK leads to the fuel cell. Be sure to match the colors.
- Attach the alligator clips to the white battery box. Match the colors and turn the battery on.





- 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 syringe is filling up roughly twice as fast as the oxygen syringe.The overflow valve on the hydrogen (negative) side will compensate for this offset.

ACTIVITY 4 - DATA COLLECTION

Now we will be racing and collecting data to see in which run your car will travel the farthest on 1 full tank of Hydrogen.

You will be completing 4 runs in total. We will collect data to see how far the car traveled and the time it took to reach its final distance. You can pump hydrogen and oxygen in the fuel cell when it stops until both syringes are completely empty.

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

Run number	Distance traveled (meters)	Time (seconds)
1		
2		
3		
4		

Which traveled further, your car or your classmate car?

_____

Why do you think this is?

_____

_____

_____

_____