HORIZON

DIY Fuel Cell Car: Activity Guide

horizonhq.org

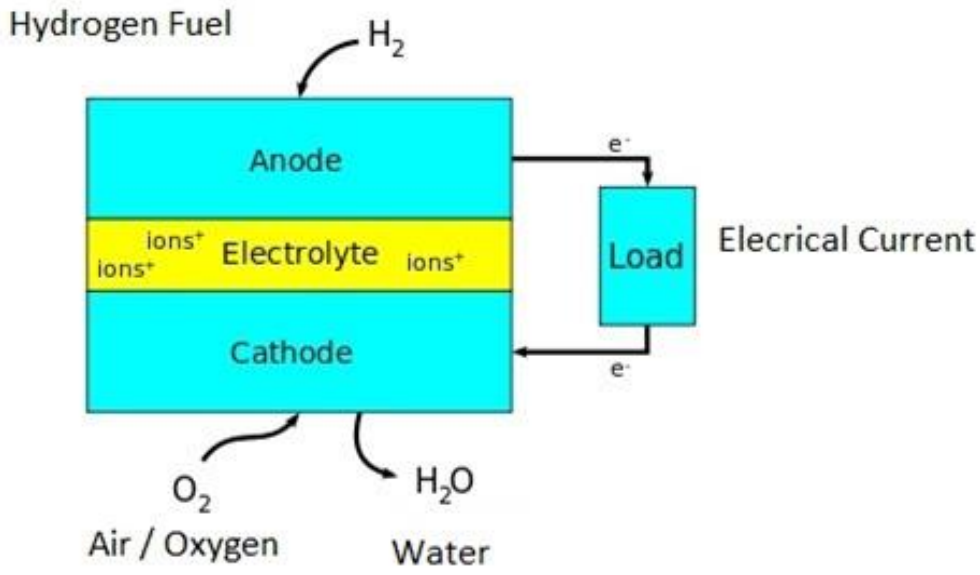
UNDERSTANDING THE FUEL CELL

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 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.



Activity 1: Electrolysis

Objective:

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 related to the chemical name for water - H2O.

Theory

- **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.
1. Take timed measurements for hydrogen & oxygen production @ 1, 2, 3, 4 and 5 minutes. Record results on the chart to the right.
1. What is the rate of Hydrogen to oxygen production during the electrolysis process?
   ___:___
1. 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			

Activity 2: Fuel Cell Power

Objective

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)
- **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**

Conversion Table

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

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.

1) 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 Fabrication

Objective:

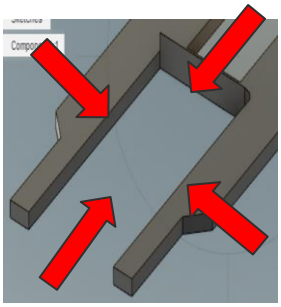
In this lesson we will sketch out a design for our own chassis using the provided chassis as a reference. We will label key chassis components from the provided chassis and integrate them into our own custom designs. We will then bring our designs to life by fabricating them out of recycled materials such as cardcoard, wood, styrofoam, etc.

Special note: You may need to break this activity into a 2-day activity depending on class size! An easy way to accomplish this is to separate Design and Fabrication into individual activities.

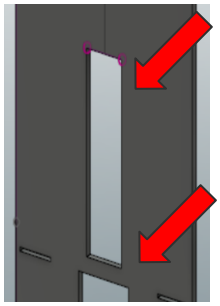
Theory:

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

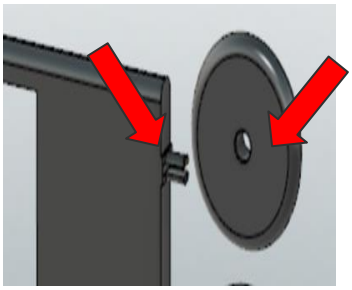
1) A place to attach the motor to the chassis



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 rover 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.

Activity 4: Data Collection

Objective:

Today we will be racing and collecting data to see which car will travel the farthest on 1 full tank of Hydrogen. You will be completing 2-4 runs in total. First 1-2 runs will be with the stock vehicle. The 2nd test runs will be with your Custom vehicle. We will collect data to see how far the rover 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)	Score (points)
1		
2		
3		
4		

Which traveled further, your car or the stock carr?

_____

Why do you think this is?

_____

_____

_____

_____

COMPETITION GUIDE

GOAL: How far can your Fuel Cell car travel?

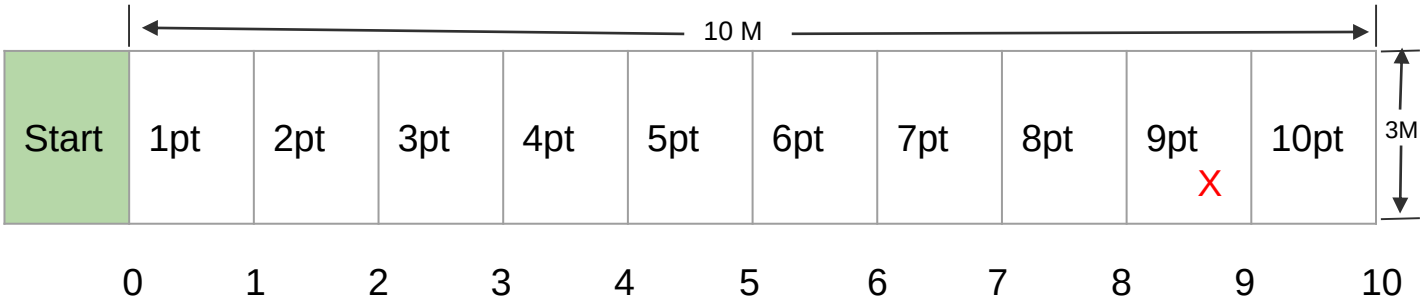
- Design teams will test to see how far their Fuel Cell car will travel
- Teams will test the provided “stock” car vs their own car design to see which travels further.

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:
  - 1-2 with the stock car
  - 1-2 with the custom car.

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 marker distance plus 1.
- In order to get an exact score, use a centimeter ruler to get an exact measurement past the marker line.
- Example:
  - The red x is your car
  - It has stopped in the 9 point box 75 cm past the 8 meter marker line.
  - The score for this car is 9.75
- Car must stay between the 3 meter side walls in order to score. If car goes outside the lines, record score at the place it left the coarse.