

Name: _____

Class: _____

Date: _____



Physical Sciences

Middle School

5 hours

Objective

Build and modify a hydrogen fuel cell car to improve its efficiency and increase the time it can run on a single tank of fuel.

Materials

- Horizon's Hydrocar Science Kit
- Distilled water
- Stopwatch
- Horizon Renewable Energy Monitor (optional)

Background



Toyota's Fuel Cell Vehicle (FCV)

The car on your desk might not look like the car in this picture (Figure 1) but they have a lot in common. They're both powered by a high-tech device called a hydrogen fuel cell.

Hydrogen fuel cells use electrical energy from a battery or solar cell to split water into hydrogen and oxygen, then it combines the hydrogen with the oxygen to produce water and an electric current to power the motor. You can read [Introduction to Electrodes and Fuel Cells](#) to find out more about how the hydrogen fuel cell works.

All sources of fuel have different levels of efficiency in the engines they run. For instance, a gasoline engine in a full-sized car has an efficiency of around 20-40%. Fuel cells like the one in our little car can produce energy at up to 60% efficiency. An engine's efficiency can be thought of as the difference between how much energy was put into the engine and how much was converted to kinetic energy to make the engine move. A more efficient engine means you get more movement out of the same amount of fuel, so we can get an idea of how efficient our engine is by measuring how long our car moves before it runs out of fuel.

If the energy we put into the car isn't being converted into motion to make the car run, where is it going? What kinds of things do you think will affect how long your car will run? Real-life engineers have had to think about these questions and more when designing fuel cell cars and now we'll use our car to do the same.

Method

We will test different ways to make the car more energy efficient and try to make it drive for a longer period of time when fully charged with hydrogen fuel. Each trial will only change one variable so we can be certain of the cause of any difference in driving time.

Assembly

If car is already assembled, go to the Procedure section

These discussion questions will help you assemble your car. Read each of them carefully and discuss your responses with your group, then use your answers to put your car together. As you assemble your car, write down any interesting observations you have in the **Observations** section below.

1. The body of your car has places where other pieces can attach to it. Discuss with your group where you think individual pieces should go.
2. How would you attach the H₂ and O₂ cylinders to the body of the car? Does it matter where they go?
3. Look at the fuel cell. It has two short tubes attached to it. Are there any other places on the fuel cell where you could attach the longer pieces of tubing?
4. When turned on with electric current, the fuel cell will produce hydrogen and oxygen gas from the water inside it. How will you trap the gas so that it doesn't float away?
5. What source of electricity will be better at separating the hydrogen and oxygen in the water: the solar cell or the battery pack? How should the electricity source be connected?
6. How do you know when the fuel cell is generating hydrogen? How can the hydrogen be used to power the car?

Procedure

As you try out different experiments to increase the efficiency of your car, write down any interesting observations you have in the **Observations** section below.

1. To generate hydrogen, you must attach an electric current to your fuel cell. Use the solar cell or the battery pack to power the fuel cell by connecting the red and black wires to the appropriate sockets on the fuel cell.
2. Observe the car as it's creating hydrogen. How do you know that it's working? What do you *observe* as the fuel cell splits the water inside it?
3. When the cylinders can't hold any more gas, you'll see bubbles start to come up from the bottom. Once this happens, you can disconnect the power source. Your car is now ready to run.
4. Have one group member ready with the stopwatch before you plug in the car's motor. The car will

run as soon as you plug it in.

5. Measure how much time the car runs and record it in the data table below.
6. Talk within your group about how you want to change the car to make it run for longer. Do you want to change the weight of the car? How about the surface it runs on? What else could you change?
7. Change one characteristic and repeat the steps to produce more hydrogen and run the car again. Record your data in the table below.
8. Repeat this process for as many different characteristics as you can think of. If you can think of more things to change, record your data on a separate sheet of paper.

Observations:

Write down anything interesting you observe while building or running the car.

Trial	Time (sec)	How Car Was Changed
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Analysis

Make a *scientific claim* about your car: what affected how far or how fast it could go? To help you write a claim statement, see [Stating a Scientific Claim](#).

Claim

What evidence can you use from your observations of the car to back up your claim? State the reasoning you used to make your claim.

Evidence

State the reasoning you used to make your claim.

Reasoning

Use the data you collected to *design an experiment* that you could run to test whether the temperature of the water would affect the speed of the car. Explain the steps of your experiment here:

Use your knowledge of the properties of hydrogen and oxygen to *design an experiment* that you could run to prove that hydrogen and oxygen are the gases produced by the reaction in the fuel cell. Explain the steps of your experiment here:

Conclusion

1. What is the most important change that affected how long the car will run? *Develop an argument* to support your position using evidence you observed during this activity and defend your argument if there are different points of view in your group.

2. Do you think hydrogen fuel cells would make a good fuel source for a full-sized car? *Develop an argument* to support your position using evidence you observed during this activity and defend your argument if there are different points of view in your group.

3. How many ways was energy transformed during this activity? *Construct an explanation* of the different types of energy you observed during this activity and what caused them to transform.

4. Was energy created or used up during this experiment? *Construct an explanation* of where energy was moving during this activity and how you know if it was created or used up.

Measurement

Is the amount of time the car runs related to the amount of electric current it produces? To find out, we'll need to use an ammeter to measure the amount of current being produced by the fuel cell. Read [Measuring Current in a Circuit](#) for more information on how to set this up.

With an ammeter connected to the car, connect the circuit to the fuel cell and start the car. What is the amperage produced?

Car running produces _____ amps.

Using some of the ways you modified the car in the previous section of this activity, try to make the car run for as long and as short as possible. What happens to the amount of electricity produced?

Longer run time produces _____ amps. Shorter run time produces _____ amps.

Make a *scientific claim* about the cause of the differences you observe. What evidence can back up your claim? What is your reasoning?

What if your car didn't carry water to produce hydrogen and instead just carried hydrogen gas. How would that car be different? In the space below, sketch what that car might look like and write an explanation of how it would work.

A large, empty rectangular box with a thin black border, intended for a student to draw a sketch of a car and write an explanation of its operation.