



Physics

High School

5 hours

Unit Plan - Description

For this activity, students will learn about hydrogen fuel cells and what makes them a sustainable energy resource. They will explore the different components of a hydrogen fuel cell car, assemble it, and conduct experiments to see how it works. The primary content includes basic chemical reactions, transfer and conservation of energy, and designing and constructing engineering solutions.

Focus

Students will engage with multiple resources to understand how energy is transformed during chemical reactions and the relationship between chemical and electrical energy.

Behaviors

SWBAT construct a functioning electrolytic cell and explain its chemical reaction.

SWBAT explain how machines conserve energy.

SWBAT understand the difference between renewable and nonrenewable sources of energy.

NGSS Science and Engineering Practices

- Asking Questions and Defining Problems
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

NGSS Crosscutting Concepts

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Energy and Matter
- Structure and Function
- Stability and Change

↗ NGSS DCIs

HS-ETS1.B, HS-PS1.A, HS-PS1.B, HS-PS2.B, HS-PS3.B, HS-PS3.C

↗ Energy Literacy Framework

1.1, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 4.1, 4.2, 4.6, 4.7, 6.1, 6.4, 6.5, 6.8

↗ Common Core ELA and Math

RST.6-8.1, RST.6-8.3, WHST.6-8.7, MP.2, 6.RP.A.2, 6.RP.A.3, 6.SP.B.5

↗ Classroom and Homework Activities

1. Lab Activity sheet
2. [Intro. to Electrodes](#)
3. [Stating a Scientific Claim](#)
4. [Measuring Current in a Circuit](#)

↗ Electronic and Online Activities

1. [Electrolysis video](#)
2. [Hydrogen Fuel Cell video](#)
3. [Department of Energy website](#)
4. [Energy Conservation game](#)

↗ Procedure

Over the course of multiple lessons, students will engage with a variety of resources dealing with fuel cells and renewable energy resources. Electronic and online resources will be available to supplement in-class resources as well as instructor-led small- and whole-group discussions. Formative assessment will be conducted with oral questions during activities and students will complete a final written assessment at the close of the activity.

🔧 Lab Setup

- For this activity, you have the option of assembling the cars beforehand or allowing your students to assemble them by following the guiding questions in the "Assembly" section.
- If you choose to let your students assemble the cars themselves, it is recommended that you complete steps 1 through 3 of the "*Hydrocar Assembly Guide*" in advance so that your students don't need to use screwdrivers or cut lengths of tubing.
- If you choose to assemble the cars beforehand, be sure to allow time before class to assemble each car. You'll need AA batteries, scissors, a ruler, a small Philips-head screwdriver, and plenty of distilled

water to assemble them. See the "*Hydrocar Assembly Guide*" for complete assembly instructions.

- Please note that the PEM fuel cell's membrane should be kept from drying out. It's best to seal it in a plastic bag between uses. Before students use the cell, be sure it's filled with water and that the two small pieces of tubing are attached.
- Some of the parts of the car are quite small (such as tube caps) and can be lost easily. Setting up resource areas on lab tables with labeled containers for each group's pieces can prevent loss of these small parts and help keep the parts of each group's kit separate.

Safety

- Battery packs can short out and heat up if the red and black contacts touch each other while the unit is in the "on" position. Be sure to keep them "off" when not in use.
- Using regular tap water instead of distilled water will severely shorten the lifespan of the fuel cells. Distilled water can be found at most pharmacies or drug stores.
- Running electric current through dry fuel cells or attaching the battery packs backwards can destroy the fuel cells. Be sure to always connect red to red and black to black.
- Beware of water spills, and don't be surprised if someone tries to start a syringe water fight.

Notes on Using This Kit

- Though the car can detect and steer around objects that it bumps into, it won't detect the edge of a table. It may be best to put them on the floor when it's time to have them run.
- There is an on-off switch on the body of the car. Check that students have it set in the "on" position if they can't get their car to run.

Common Problems

- The solar cell works best with direct sunlight, and could take up to 20 minutes to fill the hydrogen container on the car. If pressed for time, use the battery pack instead.
- If the water level doesn't change after purging the cells, make sure the gaps on the base of the inner cylinders are open so that water can fill them.

Using the Comprehension Questions Formative Assessment Tool

- As your students are working on their activities and you circulate from group to group, use the grid system to keep track of how well individual students are understanding the material.
- You can use a code to quickly assess each individual's level of mastery after talking with them, for example: (B)elow Grade Level, (A)t Grade Level, (E)xceeds Grade Level.
- Feel free to adopt your own code, and be sure to write them in pencil so you can adjust them as your students improve over time. Use this tool to take stock of your students' progress at a glance and provide resources to those who need it.
- You can even add your own questions to gauge your students' knowledge of other areas of your curriculum.

Resource Availability

- The electronic and print resources included in this mini-unit are designed to be accessible by students at all levels of achievement. We suggest that you make as many resources as possible available to your students as they engage with the new content so they have multiple opportunities to familiarize themselves with the information.
- If you have additional resources or feel that some of our resources cover material outside the scope of your class, feel free to customize as needed.

Creating New Materials

- We include all our instructional files as modifiable files so that you can customize them to your own class. We've aligned our activities with the Next Generation Science Standards and the US Department of Energy's Energy Literacy Framework. If you need to add content to comply with a specific state standard or the scope and sequence of your course, feel free to do so.
- In fact, if you develop a great new experiment or additional student resource, let us know! We regularly select the best teacher-submitted lessons, labs, and activities and share them with other educators all over the world. Winners are all listed on our website and receive free Horizon Educational Kits for their classrooms.

Analysis

Conclusion
