

## Hands-On Hydrogen Race – Introduction & Overview

### Students Objective

The student

- will be able to explain the rules governing the construction and racing of H-O-H vehicles
- will be able to explain the basic design processes necessary to building a H-O-H vehicle

### Materials (this lesson)

- Hands-On Hydrogen race photos (available online-see Internet sites below)
- race rules
- large sheets of paper
- team journals

### Materials (future sessions)

- hydrogen fuel cell with motor
- wheels – found, recycled or purchased
- gears – found, recycled or purchased
- tanks - found, constructed or purchases
- various materials for car body and chassis such as balsa wood, styrofoam, foam core, aluminum, plastic, heavy paper, and recycled containers
- rods for axles
- plastic and metal tubing for bearings and bushings
- various glues such as hot glue, wood glue, and contact cement
- small vice or clamps
- wire
- alligator clips

<b>Key Words</b> parameter PEM photovoltaic
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### Time (this lesson):

1 class period

### Time (entire H-O-H project):

2 - 6 weeks

- various tools such as soldering iron and solder, needle nose pliers, screwdriver, razor knife, scissors, wire cutters, small adjustable wrench, electric drill & bits (inc. hole saw)
- velcro
- electrical tape
- safety glasses

## **Background Information**

The Hands-On-Hydrogen (H-O-H) event was added to the Energy Whiz Olympics in 2004 to give an opportunity to showcase the vehicles made by the finalists in the Southeast Regional Middle School Science Bowl competition. The H-O-H competition challenges students to design, build and race model cars powered entirely by hydrogen. The students are challenged to use scientific know-how, creative thinking, experimentation and teamwork to design and build a fuel cell powered electric vehicle.

## **Procedure**

1. Project or pass around photos of H-O-H and high school Hydrogen Sprint vehicles.
2. Lead a classroom discussion about the designs of the cars and the challenges of designing a lightweight, low power vehicle
3. Assign students to groups of 2 - 6 students per team
4. Distribute the *Race Rules* pages to each team
5. Students should brainstorm and sketch their ideas on the large sheets of paper.

## **Related Research**

1. How can fuel cells be utilized in full sized cars? Research full sized fuel cell vehicles in use today.
2. How could the hydrogen be stored on a full sized vehicle? Draw a diagram or find a photograph on the internet of an fuel cell car and explain how its hydrogen is stored and used.
3. Could the hydrogen for a vehicle be produced on board the vehicle? Research how this might be done and discuss the pros and cons on doing this on a working vehicle.

## **Internet Sites**

<http://media.fsec.ucf.edu/>

Photos of Hands-On-Hydrogen and Hydrogen Sprint vehicles

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**parameter** - characteristic

**PEM** - Proton Exchange Membrane. Refers to the most common type of fuel cell membrane.

**photovoltaic** - the effect of producing electric current using light

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### Vehicle Design and Construction

Each team of students is responsible for designing and building a hydrogen fuel cell powered model race car. The fuel cell your team receives will enable you to produce hydrogen from photovoltaics and then during the race, the hydrogen will be used to produce electricity to power the car.

### Car Parameters

The dimensions of the H-O-H car cannot exceed

- 30 cm. in width
- 60 cm. in length
- 30 cm in height

### Construction requirements

- a PEM type hydrogen fuel cell model 7110303, purchased from FuelCellStore.com or the Florida Solar Energy Center. No other fuel cell will be permitted in the Hands-On-Hydrogen competition. The fuel cell may not be modified in any way.
- the motor obtained with the fuel cell above. No other motor will be permitted in the Hands-On-Hydrogen competition. The motor may not be modified in any way.
- a photovoltaic (PV) panel and wiring. The team may use any panel and wiring system they choose; however, it is strongly recommended that these be paired up to the suggested input amperage of the fuel cell. If the input amps exceed 0.5 amps, the fuel cell may be destroyed.

All other construction parts are at the team's discretion.

### Energy Source

The electricity needed for the electrolysis procedure must be provided by photovoltaics. The PV cells are to be separate from the vehicle; the electrolysis is to be done in the charging area prior to the start of the race. The only energy source permitted on the vehicle is the fuel cell with the hydrogen that was produced from the electrolysis procedure.

### Vehicle components

Each team, on their own, will provide the additional parts needed for the construction of the car. Individualized components may be purchased, but the entire car must be designed, assembled and when possible, fabricated by the students. All component and fabrication choices must also be made by student team members.

Individual decals may be affixed, and the body may be decorated at the teams discretion, but a 3 cm. square space must be left free on each side and the bottom for the H-O-H decal number.

### **Steering**

An eyelet (see examples below) must be attached to the bottom of the car. A guide wire, approximately 1 cm. from the surface of the track, will go through the eyelet, serve as the steering mechanism, and keep the car in its lane. The vehicle must be easily removable from the guide wire, without disconnecting the guide wire. This is the only allowable method of steering the car. No radio control is permitted in Hands-On-Hydrogen race. Lane changing/crossing will result in disqualification from that heat.



**Failure to meet the above expectations will result in disqualification**

### **A component list and a design document are required to be submitted with the vehicle for technical judging.**

The component list must indicate all parts purchased for your vehicle, including the name of the supplier and the price of the part. This list of parts and prices should allow someone to make the same purchases at approximately the same price. Any outside (non-student) labor (i.e. machine shop) must also be listed.

The design document is not a daily journal, but instead should contain notes on the design process, salient points of the design and concrete decisions taken by the team to arrive at the final product. A good design document should give enough information, sketches and drawings for someone to recreate the vehicle without seeing the finished product. Furthermore, the design document should not be a finished, 'polished' document, but rather a log of the notes, sketches and test results of the design in progress. The purpose of this document is to share design techniques and practices to further the knowledge of all future student teams. These documents will not be returned to the teams, and parts of these documents may be published or disseminated to future participants.

The design document must include:

- specifications of final vehicle (size, weight, wheel size, gear ratio, etc.)
- detailed design drawings
- electrical schematics

- assembly process (steps of order)
- formulas and calculations used
- issues and problems encountered and modifications made
- photos taken periodically during construction process

The design documents and component lists for the winning cars (1<sup>st</sup> place design and 1<sup>st</sup> place race) will be published on the Energy Whiz Olympics website.

**Failure to meet the above expectations will negatively impact the team's design score.**

## **Vehicle Race**

### **Race Day Electrolysis Procedure**

Before the scheduled race start, all teams must report to the charging station with their fuel cell and photovoltaic panel. Distilled water will be provided at the charging station for the electrolysis process. Heats will be run every three minutes. When a team is ready to participate in a heat, a team member reports to the finish line and turns in their team race card to the line/finish judge. At the end of the heat, one team member will pick up their card from the scorekeeper while the rest of the team will return to the electrolysis area to get ready for their next heat. Performing electrolysis in a timely fashion and participating in three heats in the allotted race time is the responsibility of the team.

The photovoltaic panel is to be used as the energy source for the electrolysis only; it may not be used to charge up any auxiliary power systems, or stored on the vehicle in any way. The only energy source permitted on the vehicle is the fuel cell with the hydrogen that it produces from the electrolysis procedure.

### **Race Parameters**

The track:

The racetrack is 20 meters long and 1 meter wide (for two lanes)

The track is set up on a hard, flat, smooth surface such as a tennis court.

The Race Heat:

- When the team is ready to race, one team member reports to the finish line and turns in their team's race card to the line/finish judge.
- When the team is called up for the next heat, the car is attached to the guide wire and placed behind the starting line.
- After attaching the car to the guide wire, one team member stays with the car at the starting line and one team member prepares to catch the car at the finish line—all other team members must remain behind the stantions to view the race. The coach may not assist the team at any time, at either the starting line or the finish line.

- At the start signal, the team member at the starting line will start the car (flip the switch, make the connection, etc)
- Team members may not push a vehicle to start it, nor may they accompany the vehicle in its lane during the race.
- When the vehicle crosses the finish line, the finish line judge records the car's time on the team race card and turns it over to the scorekeeper.
- After the team member at the finish line 'catches' the car and disengages it from the guide wire, they will pick up the race card from the scorekeeper and then prepare the vehicle for their next heat.
- The race heats are over when each team has raced in three heats or one hour has elapsed. It is the responsibility of each team to make sure that they have raced in three heats. Be advised that a fixed number of heats are available during the racing time. The students are free to choose which heats to race; however, if they are unable to complete three heats in the allotted time, all remaining heats will be considered a DNF (did not finish).

**Failure to meet the above expectations will result in disqualification.**

### **Hands-On-Hydrogen Awards**

The awards will be as follows:

- 1st Place (Race)
- 2nd Place (Race)
- 3rd Place (Race)
- 1<sup>st</sup> Place Vehicle Design

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### Race Organization

This information is included for teachers and organizers who wish to have an intramural race at their school and would like to duplicate the conditions as much as possible of the Florida Hands-On-Hydrogen event.

### Track Specifications

Lane Length:	20 meters
Lane Width:	50 centimeters

### Track Surface

- As smooth as possible, flat and level or slightly downhill in the direction of the race.
- Oriented if possible, so that prevailing winds are behind the vehicles as crosswinds can be a problem.

### Layout

- Security roping should be placed around the perimeter of the track, as the guide wires are difficult to see.
- A second level of security roping should be used for team movement and to keep spectators off the track.
- A staging area near the start line and a run-off area beyond the finish line is necessary.
- A pit area is needed for ‘charging’ (hydrogen production) between races. At your discretion, you can supply photovoltaic panels here for electrolysis or require teams to bring their own. An adequate supply (several gallons) of distilled or de-ionized water is also necessary.

### Guide Lines

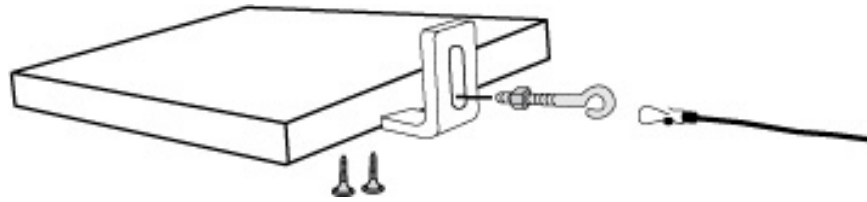
- Monofilament fishing line, 60-lb test is adequate.
- The line should be suspended about 1 cm (+/- .5 cm) off the ground.
- Lines must be kept taut.

One way that the guide lines may be attached (see diagram following instructions):

- A 12" x 12" piece of 3/4" plywood may be used to anchor both ends of the guide wire.
- A threaded eye-bolt can be attached to a corner-reinforcing bracket to allow for height adjustment of the guide wire.
- Pre-measured guide wires can be attached to the eye bolts with fishing tackle clips.
- Once assembled, plywood should be anchored with 40lbs. of ballast (concrete blocks are



acceptable) and moved apart to give the desired line tension.



#### Timer

- Two timers should be stationed at the finish line. The average between their times should be used as the official time.

#### Communication

- Efficient communication is needed between the starting line, the finish line, and the scoreboard.
- A loudspeaker or bullhorn is helpful for public announcements and crowd control.