Hydrogen Sprint – Introduction & Overview

Students Objective
The student
- will be able to explain the rules governing the construction and racing of Hydrogen Sprint vehicles
- will be able to explain the basic design processes necessary to building a Hydrogen Sprint vehicle

Key Words
parameter
PEM
photovoltaic

Time (this lesson):
1 class period
Time (entire Hydrogen Sprint project):
2 - 6 weeks

Materials (this lesson)
- Hydrogen Sprint photos (available online-see Internet sites below)
- race rules
- large sheets of paper
- team journals

Materials (future sessions)
- hydrogen fuel cell
- wheels – found, recycled or purchased
- motor
- 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
- 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)
- small vice or clamps
- wire
- alligator clips
- electrical tape
- velcro
- safety glasses

Background Information

The Hydrogen Sprint competition was started by the Florida Solar Energy Center in 2003 to expose students to hydrogen fuel cells and their future potential. The 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 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://www.fsec.ucf.edu/en/education/k-12/events/h2sprint.htm

Florida Solar Energy Center's Hydrogen Sprint web page.

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

Photos of Hydrogen Sprint vehicles

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Benchmarks and Grade Level Expectations are listed for each sub activity of this unit in that specific unit. Listed below are the benchmarks for the Hydrogen Sprint activity in general, if none of the sub activities are used in the process.

			.1	.2	.3	.4	.5	.6	.7	.8
Nature of Matter	Standard 1	SC.A.1.4-	X				X			
	Standard 2	SC.A.2.4-	X							
Energy	Standard 1	SC.B.1.4-		X			X	X	X	
	Standard 2	SC.B.2.4-								
The Nature of Science	Standard 1	SC.H.1.4-	X							
	Standard 2	SC.H.2.4-								
	Standard 3	SC.H.3.4	X					X		

Benchmark SC.A.1.4.1 - The student knows that the electron configuration in atoms determines how a substance reacts and how much energy is involved in its reaction.

Benchmark SC.A.1.4.5 - The student knows that connections form between substances when outer shell electrons are either transferred or shared between their atoms, changing the properties of substances.

Benchmark SC.A.2.4.1 - The student knows that the number and configuration of electrons will equal the number of protons in an electrically neutral atom and when an atom gains or loses electrons, the charge is unbalanced.

Benchmark SC.B.1.4.2 - The student understands that there is conservation of mass and energy when matter is transformed.

Benchmark SC.B.1.4.5 - The student knows that each source of energy presents advantages and disadvantages to its use in society.

Benchmark SC.B.1.4.6 - The student knows that the first law of thermodynamics relates to the transfer of energy to the work done and the heat transferred.

Benchmark SC.B.1.4.7 - The student knows that the total amount of usable energy always decreases, even though the total amount of energy is conserved in any transfer.

Benchmark SC.H.1.4.1 - The students knows that technological problems often create a demand for new scientific knowledge and that new technologies make it possible for scientists to extend their research in a way that advances science.

Benchmark SC.H.3.4.1 - The students knows that performance testing is often conducted using small-scale models, computer simulations, or analogous systems to reduce the chance of system failure.

Benchmark SC.H.3.4.6 - The student knows that scientific knowledge is used by those who engage in design and technology to solve practical problems, taking human values and limitations into account.

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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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The Hydrogen Sprint is a three part competition encompassing vehicle design, a hydrogen presentation and the vehicle race. It was developed to provide a hands-on opportunity for high school students to explore the emerging scientific technology of hydrogen power.

1. Vehicle Design and Construction

Each team of 2 - 6 students is responsible for designing and building a hydrogen fuel cell powered model race car. The fuel cell your team purchases 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 Hydrogen Sprint 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 Hydrogen Sprint competition. The fuel cell 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.

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.

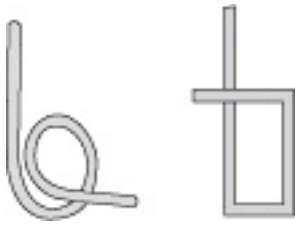
Vehicle components

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 Sprint 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 Hydrogen Sprint 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 (1st place design and 1st 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.

2. 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.

3. H2 Presentation

Each team is required to compete in the presentation part of the Hydrogen Sprint. This is the chance for the teams to showcase their expertise, knowledge and talents that may not be obvious in the race. The team presentation is to be 5 - 10 minutes in length and can be in any format that the team chooses. Examples might include:

- Skit
- Slide Show
- Video
- Song

These examples are not meant to be exclusive; students are encouraged to be creative. The performance may be on any hydrogen related topic the team chooses and should be geared toward a middle school audience. Below are some examples.

- the design of our hydrogen vehicle
- how hydrogen fits into the future economy of Florida
- creating hydrogen from biomass
- hydrogen as a transportation fuel
- fuel cells in our present and future
- densification of hydrogen
- history of hydrogen fuel in space
- comparison of commercial sources of hydrogen

The teams will be judged on content knowledge, creativity, and presentation. Points will be

deducted from a team's presentation score for exceeding 10 minutes or reading projected slides verbatim to the audience.

Teams are to send in one copy of any A/V components of their presentation, to arrive at least 24 hours before race day. The team should also bring a back-up copy of the presentation with them. Teams are to check in with A/V personnel immediately upon arrival the day of the event. FSEC is not responsible for any presentations that are lost in transit or that are unable to play on standard presentation software used on IBM and Apple PCs. DVDs and VHS are also acceptable. All A/V compatibility issues should be discussed with event personnel prior to the day of the event. One copy of each presentation will become the property of FSEC for possible posting on the event site.

Hydrogen Sprint Awards

The awards will be as follows:

- 1st Place Overall
- 2nd Place Overall
- 3rd Place Overall
- 1st Place Vehicle Design
- 1st Place Vehicle Performance (race)
- 1st Place Hydrogen Presentation

The scoring for the overall prizes will be composed of 1/3 vehicle construction (design and innovation), 1/3 race results, and 1/3 presentation.

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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 Hydrogen Sprint event.

Track Specifications

Lane Length:	20 meters
Lane Width:	50 centimeters

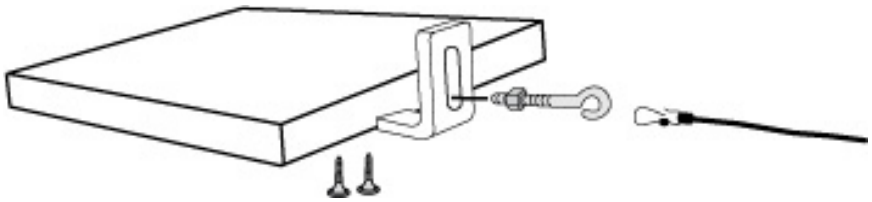
Track Surface
- As smooth as possible, flat and level or slightly downhill in the direction of the race.
- Shade is preferable for the starting line.
- Oriented if possible, so that prevailing winds are behind the vehicles as crosswinds can be a problem.

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 comer-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.