Hydrogen Sprint – The Body

Student Objective

The student:

- given a design will be able to predict whether the aerodynamic drag will increase or decrease as variables in the frontal area and body shape are manipulated
- can explain the use of a wind tunnel to assist in aerodynamic design

Key Words:
aerodynamics
chassis
drag
turbulence

Time:
1 - 1.5 hours for investigation

Materials:

- miniature or toy car (1 per group). Note: teams may use their H_2Sprint chassis/wheel assembly if they can disconnect the motor and any gearing so that it is free rolling
- 6 x 8" piece of foamcore or thin plywood (1 per group)
- masking tape
- ramp
- empty soda can (1 per group)
- heavy paper
- (2) dowels, 10" long, ½" in diameter or greater (2 per group)
- Various materials such as heavy paper, aluminum foil, shirt cardboard, thin foam, mylar, plastic sheeting, and recycled materials such as plastic soda bottles, disposable containers, and food packaging items
- 6" strips of lightweight string or yarn
- box fan
- cardboard box with a face dimension close to that of the fan
- cardboard tubes (paper towel size)

Internet Sites:

http://www.uh.edu/engines/engines.htm

University of Houston's College of Engineering's *Engines of Our Ingenuity* series, #255 "Car Design" (**http://www.uh.edu/engines/epi255.htm**), and #1520 "Automobile Drag Coefficients" (**http://www.uh.edu/engines/epi1520.htm**). These are transcripts from John Lienhard's popular radio show. Audio versions are also available on the website.

Procedure (prior to class time):

1. Remove two opposite sides from the cardboard box and fill it with cardboard tubes so that air blown in one side must pass through the tubes to flow out the other side. This is to help funnel the air from the fan in one straight direction to simulate an air tunnel.

Procedure:

1. Students should work in their Sprint teams (2 - 6 students).
2. Lead a classroom review of aerodynamics. Remember that aerodynamics also applies to boats and other objects in water, as well as birds, fish, penguins, etc. Some of the students may wish to discuss current commercial and race car body designs.
3. Have a box of various body materials available so that students can pick their own investigation materials.
4. Pass out the materials that all the groups will be using.
5. Students should complete the exercises in the Laboratory Manual.
6. Give the teams time to discuss how they plan to use these findings in their vehicle design.
7. Students should continue working on their Sprint vehicles.

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			.1	.2	.3	.4	.5	.6	.7	.8
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.H.1.4.1 - The students knows that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.

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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aerodynamics - the study of air flow and its effect on moving objects

chassis - the component that must provide structural support for the motor, wheels, axles, etc.

drag - the retarding force (friction) acting on a body moving through a fluid (such as water or air)

turbulence - the flow of a fluid (such as water or air) that varies in direction or magnitude

Hydrogen Sprint – The Body

The body of your family automobile has several purposes. It protects the passengers from the weather, provides safety in the event of a crash, and it adds to the way the car looks. But it also improves the way the car performs because a well designed body can reduce the force of the air as the car moves through it. This force, the force that the air exerts on the vehicle as it moves through it, is called aerodynamic drag or 'wind resistance'.

Part 1 - Vehicle Size and Shape
There are two primary physical characteristics responsible for aerodynamic drag on a vehicle moving forward–the frontal area of the vehicle, and how streamlined the vehicle is.

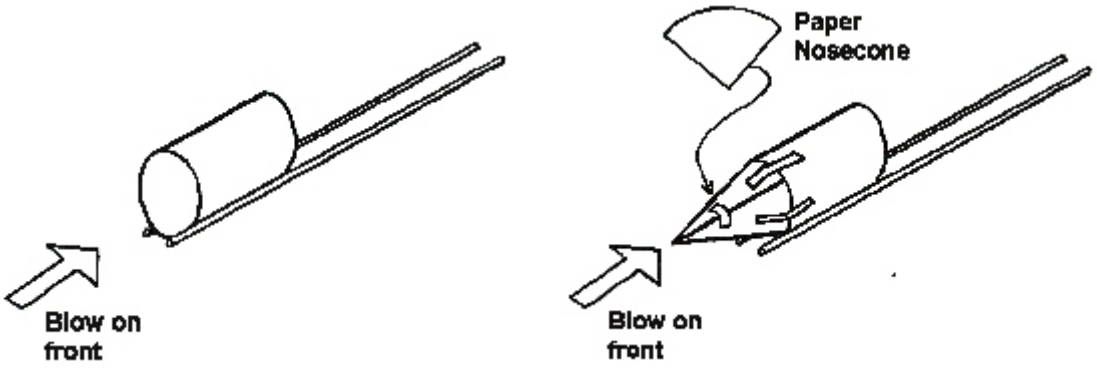
1. Using a ramp and a toy car (or your H_2S vehicle with the fuel cell removed and the motor and gears disconnected so that it is free rolling), release the car from the top of the ramp several times until you can observe where the car repeatedly stops. Mark this distance with a piece of masking tape. Measure the distance and enter it in the chart below.

   Attach a 6 x 8" piece of foamcore or plywood with masking tape to the chassis of the car in the orientations listed below. In tests #2 and #3 the panel should be extending straight up from the top of the car. Run each test several times to observe where the car repeatedly stops. Mark this distance and add it to the chart below.

Test #	Orientation of board	Distance Traveled
1	No dummy fuel cell assembly attached	
2	Dummy assembly perpendicular to the direction traveled	
3	Dummy assembly parallel to the direction traveled	

2. In which test did the results come closest to test #1? Why?

Place an empty soda can on two dowels, as in the diagram on the left below, so that it rests on the dowels instead of the table. Blow on the can to see how easy or hard it is to make it move.



3. Make a nosecone for the can and attach it with tape. Place the can back on the dowels and blow on it. Is it easier or harder to move the can? Why do you think this is so?

Part 2 - Wind Tunnel Testing

Wind tunnels are used frequently in the design process for automobiles, airplanes, rockets, and even bicycles. Wind tunnel experiments show which areas of the vehicle body have a streamlined efficient design, and which areas have turbulence–an increase in the amount of aerodynamic drag.

A simulated wind tunnel can be made with a box fan and a cardboard box filled with tubes to help funnel the wind in one streamlined direction. Position a platform that is large enough to hold your vehicle near the center of the box where the air will be coming out.

4. Using heavy paper, aluminum foil, shirt cardboard, thin foam, mylar, plastic sheeting, or any recycled material that you wish, construct a prototype body for your chassis. (Note: this body is for this investigation only–it does not have to be your finished design!)

   Attach strings in several places on the front of your vehicle, and also one on each side just back of the front wheels and three along the back edge of your vehicle. Place your vehicle on the platform and turn the fan on high. Observe the string. In an efficient design, the strings will float straight along the surface of the car. In a less effective design, they will flap. Describe below what you observed.

5. How would you modify your prototype to make it more aerodynamic?

Discussion and Design

With your group, discuss how you might use the findings from your investigation to help you design your Sprint vehicle. As before, remember there are a lot of variables to consider. The challenge from this investigation is to decide what type of body material and shape you want for your vehicle. As you plan, here are some things to consider:

- Aerodynamic drag occurs on the underside of your vehicle also!
- Most things that move through the air use smooth, 'slick' body surfaces. This is because smooth surfaces will slip through the air, causing less turbulence, than rough surfaces
- The position of your fuel cell and tanking system can increase the vehicle's aerodynamic drag.
- Think lightweight! If attached smoothly, thin materials such as paper or cellophane can be an effective body.