Junior Solar Sprint – The Chassis

Student Objectives
The student:
- given a problem scenario regarding the materials being used in a design, will be able to predict how the structure will function as variables in the materials are changed
- will explain how the properties of materials (i.e. weight, shape, stiffness, strength) affect the structure being built
- will explain how the application of materials such as weight distribution, orientation of bracing, and the use of composite materials affects the structure being built
- will explain the difference between a material's strength and its stiffness.

Key Words:
chassis
composite structure
material stiffness
material strength

Time:
1 - 1.5 hours for investigation

Materials:
- Various materials such as:
balsa wood sheet 1/16" and 1/8", foam core, stiff insulating foam, cardboard 1/16" thick, rigid plastic, polyflute, and heavy paper; all materials in various sizes
- scale
- small weights up to 1 lb. (uniformly weighted objects such as pennies may be used)
- 3 pieces (per group) of cover stock or posterboard 4 1/4" x 11"
- 2 dowels (per group) 5" – 10" long (½" in diameter or greater)
- ruler
- Junior Solar Sprint Design Notebooks

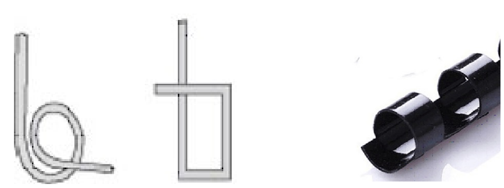
Procedure
1. Have a box of various materials available so that students can pick their own investigation materials.
2. Students should work in their Sprint teams (2 – 4 students).
3. Ask the class what is meant by the term chassis. Make sure that they can differentiate between chassis materials and body materials. For example, a plastic soda bottle may make an excellent body, but a lousy chassis, since it would be difficult to attach the axles, wheels, motors and gears to it.

4. Discuss with students the difference between stiffness and strength.
5. Lead the class in a discussion of how normally weak materials can be made stronger and how normally flexible materials can be made stiff (examples can include corrugation, bracing, rolling in a tube, folding in a fan shape, etc.).
6. Pass out dowels and weights to the groups.
7. Students should complete the exercises in their Science Journal.
8. Give teams time to discuss how they plan to incorporate these findings in their vehicle designs.
9. Teams should sketch their ideas in their Design Notebooks.
10. If time permits, and they feel ready, teams may begin to construct their vehicles.

Note: Next investigation will be on wheels, axles, and bearings. Announce to the class that they might want to bring some wheels from home to use with their investigations.

Tips For Success

1. Students should think about making their chassis as lightweight as possible.
2. Students may design a chassis that allows the angle of the panel to be adjusted to match the angle of the sunlight for a specific location and time of day.
3. Besides the motor and panel, the chassis will need to hold the battery clip(s), ping-pong ball holder, axles and eyelet. Most battery clips and ping-pong ball holders are located on the top and most eyelets and axles are on the bottom of the chassis. However, this is not a requirement; a car could instead have the eyelet on the front or on one side.
4. All parts need to be glued securely to the chassis. Hot glue, 2 part epoxy and Gorilla glue can all be used successfully. Hot glue works well on the motor, but can be challenging to get the motor in the perfect spot before it hardens. Also the students should be careful not to glue shut the motor's ventilation holes
5. The chassis and the glue holding the component parts should be strong enough to withstand some bumps and crashes. Students should design for worse case scenarios.
6. An eyelet (see examples below) must be attached to the bottom of the car. This is the way the car will be steered on a line down the track. The eyelet must be designed so the car can be easily removable from the guide line, without disconnecting the guide line.



The rules state that the guide line is "1 cm (+/- .5cm) from the surface of the track". The variance of +/- .5cm is the difference between the ends which are higher, and the middle of the track which will sag slightly. A rectangular (or oval) shaped eyelet has an advantage of having less friction when the guide wire is in the upper or lower position. The example on the right is a piece of a spine used for bound notebooks. It is extremely easy (and quick) to attach and disconnect from the wire.

7. A switch needs to be put in the electrical circuit so that the power supply can be switched from the photovoltaic panel to the battery clip if the race needs to be switched to batteries due to weather. Only one source of power may be powering the motor at any given time. All connections should be secure–soldered if possible.

Key Words & Definitions

- **chassis** – the component that must provide structural support for the motor, wheels, axles, etc.
- **composite structure** – a structure made of two or more materials glued or bonded together
- **material stiffness** – the quality of being unbending or lacking in suppleness. Stiffness does not necessarily mean strength.
- **material strength** – the quality of holding up against weight, tension or pressure. Strength does not necessarily include stiffness.
- **strength to weight ratio** – a way to describe a material's properties that compares its strength and weight. This is an easy way to compare the relative merits of several different materials. For example, in Junior Solar Sprint cars you may be looking for a material that has a high strength value and a low weight value.

Related Research

1. What materials are currently being used in the chassis of our cars? Are there other materials that could be used in the future? Research materials being used in other applications such as bicycles and rockets.
2. What is "monocoque" construction? How has this been used in vehicles?

Related Reading

- ***Car Science***, by Richard Hammond (DK Children, 2008)
  This book is a "how it works" guide to modern cars with exploded diagrams, cutaways, key physics concepts and a look into the future of cars.
- ***DK Eyewitness Books: Car***, by Richard Sutton (DK Eyewitness Books, 2005)
  A photographic history of the car.

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Florida NGSS Standards & Related Subject Common Core

			.1	.2	.3	.4	.5	.6	.7	.8	.9	.10	.11	.12
Grade 6														
Practice of Science	# 1	SC.6.N.1	X			X	X							
Theories, Laws, Hypothesis, Models	# 3	SC.6.N.3				X								
Forces & Changes in Motion	# 13	SC.6.P.13	X											
Grade 7														
Practice of Science	# 1	SC.7.N.1	X											
Grade 8														
Practice of Science	# 1	SC.8.N.1	X	X				X						
Role of Theories, Laws, Hypotheses, and Models	# 3	SC.8.N.3	X											

Sixth Grade Benchmarks
Science--Big Idea 1: The Practice of Science

- SC.6.N.1.1 - Define a problem from the sixth grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
- SC.6.N.1.4 - Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation.
- SC.6.N.1.5 - Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.

Science–Big Idea 3: The Role of Theories, Laws, Hypothesis and Models

- SC.6.N.3.4 - Identify the role of models in the context of the sixth grade science benchmarks.

Science–Big Idea 13: Forces and Changes in Motion

- SC.6.P.13.1 - Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic and gravitational.

Seventh Grade Benchmarks
Science--Big Idea 1: The Practice of Science

- SC.7.N.1.1 - Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

Eighth Grade Benchmarks
Science--Big Idea 1: The Practice of Science

- SC.8.N.1.1 - Define a problem from the eighth grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
- SC.8.N.1.2 - Design and conduct a study using repeated trails and replication.
- SC.8.N.1.6 - Understand that scientific investigations involve the collection of relevant empirical evidence, the use of logical reasoning, and the application of imagination in devising hypotheses, predictions, explanations and models to make sense of the collected evidence.

Science–Big Idea 3: The Role of Theories, Laws, Hypotheses, and Models

- SC.8.N.3.1 - Select models useful in relating the results of their own investigations.

National Next Generation Science Standards - Sixth to Eighth Grade Standards
Science–Engineering Design

- MS-ETS1-1 - Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2 - Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3 - Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4 - Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Junior Solar Sprint – The Chassis

The chassis for your car is the underlying structure that will provide support for the motor, wheels, axles, gearing, and body.

1. Make a list of the different materials that you could use for your vehicle's chassis.

Test 1 – Weight of Materials

2. Choose six materials and write them in the top row of boxes in the table below. Weigh each piece of material and put the weight in the second row of the table. Measure the piece of material and calculate the number of square centimeters of material that was in the sample that you weighed (length in centimeters multiplied by width in centimeters). Put this value for each material in the table. Then, find the weight per square centimeter of material (divide the total weight of the material by its size in square centimeters).

Material						
Weight						
Square centimeters						
Weight per square centimeter						

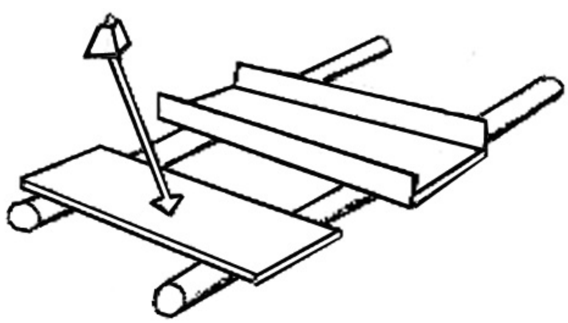
3. Which material was the heaviest per square centimeter?

4. Which material was the lightest per square centimeter?

5. Why would the weight of the material you use for your chassis make a difference?

Test 2 – Strength of Materials

6. Pick three of the materials from your weight investigation that you would like to test further. Place two dowels at least 6 inches apart. (Measure this distance and make sure all your tests use this same distance) Lay a material across the dowels. (See illustration) Place weights one at a time on the material in the middle of the space between the dowels. Record how much weight (or number of weights, if using something standard like coins) can be placed on each material before the material sags or breaks.
To be able to determine when a material is starting to sag, use a ruler to measure the distance the material is from the table and note if this distance changes as you add weight.



Material			
Amount of weight before sagging/breaking			

7. Which material was able to hold the most weight before it broke or began sagging?

Test 3 – Distribution of Weight
On your Sprint car, the motor will probably be the heaviest thing attached to your chassis. To find out if it matters where the motor is placed, pick one of the materials from the previous investigation and place it again on the dowels. Investigate putting the weight on different areas of the material between the dowels. See if you can increase the amount of weight the material can handle before it sags.

8. If you were able to increase the amount of weight your material could hold without sagging/breaking, what area(s) did you place the weight? Draw or describe below.

9. How could you use this information to help you decide where to place your motor?

Test 4 – Stiffness and Shape of Materials
It is also possible to use flexible materials if they are constructed or shaped in ways that increase their stiffness. Engineers frequently use this technique in bridge and building design.

10. Using pieces of card stock or poster board, investigate some methods of increasing their stiffness by folding, bending, or bracing the card stock material. Try three different methods, sketching your stiffening method and recording your findings in the chart below.

Method of stiffening (sketch)			
Amount of weight before sagging			

11. Which method of stiffening worked best on your card stock?

Orientation

Orientation of the stiffening or bracing material is also very important.

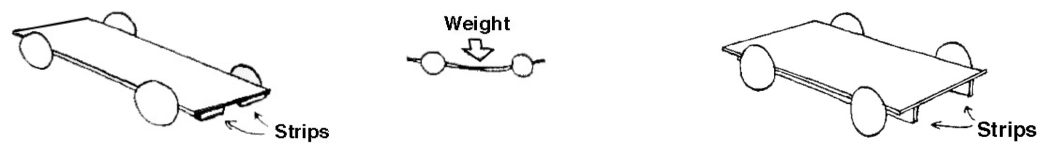


Diagram A *Diagram B*

12. In the diagrams above, which method of bracing will result in the stiffer chassis – diagram A with the bracing flat in relation to the chassis, or diagram B with the bracing on edge in relation to the chassis? To find out, use a ruler to simulate the bracing and try and bend it downwards while holding it (at the ends) first flat like in diagram A, and then on edge like in diagram B. Which way was it the hardest to bend the ruler?

Composite Materials

13. Composites use two or more materials to make use of the best qualities of each. Imagine that the local cardboard manufacturer decided to sponsor the Junior Solar Sprint, and changed the rules so that each team was required to use corrugated cardboard for a main section of its chassis. Your team realizes that cardboard is lightweight, but also realizes that it is not strong enough or stiff enough for your vehicle. Describe or illustrate below, one way that you could use the cardboard in a composite design so that it would be strong enough and stiff enough to have a chance to win the race.

Discussion and Design

With your group, discuss how you might use the findings from your investigations to help you design your Sprint vehicle. Remember, there are a lot of variables in the design of your vehicle! Your goal from this investigation is to come up with a lightweight, strong and sturdy chassis that can support the systems that will be mounted to it. Here are some points to consider:

- Because it is easier for your motor to push a light car than a big heavy one, you will want your finished car to be as light as possible. But something you must also keep in mind is that a light car can be pushed easily by the wind. Even if the wind does not blow the car over, it may make it harder to go in a straight line, causing friction on the steering line which will slow your car down.
- Your car will need to be sturdy enough to withstand being handled, transported, judged, in as many as a dozen races. It is important not to sacrifice sturdiness to save weight, or your car may fall apart before the winning race!
- One frequently overlooked component of the vehicle design is the choice of glue. Glues vary in strength, weight, and ease of use. Hot glue is quick and relatively easy to use, but you may find that wood glue is stronger and lighter. Some glues will even "eat up" or have a chemical reaction with some materials, leaving you with a hole! It is important to test your choice of glue on some scraps of material to make sure it works the way you want it to.