Junior Solar Sprint – The Chassis

Student Objective
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 be able to explain how the properties of materials (i.e. weight, shape, stiffness, strength) affect the structure being built
- will be able to 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 be able to 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 substituted)
- 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 team journals

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 team journals.
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.

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Nature of Matter	**Standard 1**	**SC.A.1.3-**	**X**	**X**					
	Standard 2	**SC.A.2.3-**							
Force and Motion	**Standard 1**	**SC.C.1.3-**							
	Standard 2	**SC.C.2.3-**							**X**
Nature of Science	**Standard 1**	**SC.H.1.3-**					**X**		
	Standard 2	**SC.H.2.3-**							
	Standard 3	**SC.H.3.3-**							
Math Standards:	**MA.A.3.3.2, MA,B,1,3,1, MA.B.4.3.1, and MA.B.4.3.2**								

Benchmark MA.A.3.3.2: The student selects the appropriate operation to solve problems involving addition, subtraction, multiplication, and division of rational numbers, ratios, proportions, and percents, including the appropriate application of the algebraic order of operations.
Grade Level Expectations
The student:
Sixth
- knows proportional relationships and describes such relationships in words, tables, or graphs

Seventh
- knows proportional relationships and uses tables, graphs, or "constant ratio" relationships to solve and explain problems.

Benchmark MA.B.1.3.1: The student uses concrete and graphic models to derive formulas for finding perimeter, area, surface area, circumference, and volume of two- and three-dimensional shapes, including rectangular solids and cylinders.
Grade Level Expectations
The student:
Sixth
- uses concrete and graphic models to create formulas for finding the perimeter and area of plane figures and the volume of rectangular solids.

Benchmark MA.B.4.3.1: The student selects appropriate units of measurement and determines and applies significant digits in a real-world context.

Grade Level Expectations
The student:
Sixth
- selects the appropriate unit of measure for a given real-world situation
- knows the approximate nature of measurement and measures to the specified degree of accuracy

Seventh
- selects appropriate units of measurement in a real-world context
- knows that measurements are always approximate and that the degree of accuracy of a measurement depends upon the precision of the instrument
- determines the appropriate precision unit for a given situation

Eighth
- selects the appropriate unit of measure for a given situation
- determines the appropriate precision unit for a given situation.

Benchmark MA.B.4.3.2: The student selects and uses appropriate instruments, technology, and techniques to measure quantities in order to achieve specified degrees of accuracy in a problem situation.
Grade Level Expectations
The student:
Sixth
- selects an appropriate measurement tool
- determines the interval of a scale and reads the scales on a variety of measuring instruments
- measures accurately with the measurement tools

Seventh
- selects a measurement tool appropriate to a given situation
- measures accurately with the measurement tools to the specified degree of accuracy for the task and in keeping with the precision of the measurement tool

Eighth
- selects and uses appropriate instruments, technology, and techniques to measure quantities and dimensions to a specified degree of accuracy.

Benchmark SC.A.1.3.1: The student identifies various ways in which substances differ.
Grade Level Expectations
The student:
Sixth
- knows ways in which substances differ

Seventh
- uses a variety of measurements to describe the physical properties of matter.

Benchmark SC.A.1.3.2: The student understands the difference between weight and mass.
Grade Level Expectations
The student:
Seventh
- understands that weight is the result of gravitational pull on an object.

Benchmark SC.C.2.3.7: The student knows that gravity is a universal force that every mass exerts on every other mass
Grade Level Expectation
The student:
Sixth
- knows that gravity causes an object to have weight

Seventh
- knows that gravity is a force exerted on a mass that causes an object to have weight.

Benchmark SC.H.1.3.5: The student knows that a change in one or more variables may alter the outcome of an investigation.
Grade Level Expectations
The student:
Sixth
- understands the importance of the control in an experiment
- knows how to identify the independent and dependent variables in an experiment
- uses appropriate experimental design, with consideration for rules, time, and materials required to solve a problem

Seventh
- extends and refines knowledge of how to identify the independent and dependent variables in an experiment
- extends and refines use of appropriate experimental design, with consideration for rules, time, and materials required to solve a problem
- uses rules, time, and materials in ways that ensure the identification and separation of variables in an experiment to solve a problem

Eighth
- extends and refines knowledge of how to identify the independent and dependent variables in an experiment
- extends and refines use of appropriate experimental design, with consideration for rules, time, and materials required to solve a problem
- extends and refines use of rules, time, and materials in ways that ensure the identification and separation of variables in an experiment to solve a problem.

Junior Solar Sprint – The Chassis

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.

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						

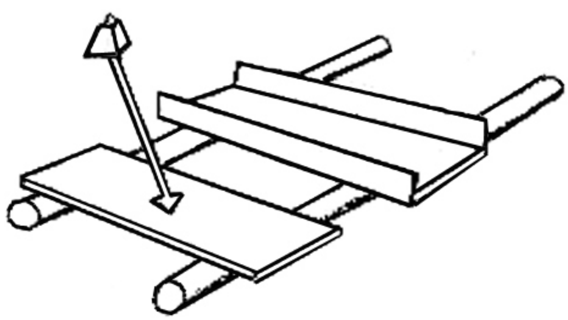
3. Which material was the heaviest per square centimeter?

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.

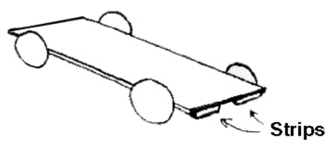
10. Using pieces of card stock or poster board, investigate some methods of increasing their stiffness by folding, bending or bracing the card stock material. Try three different methods, sketching your stiffening method and recording your findings in the chart below

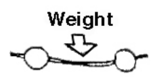
Method of stiffening (sketch)			
Amount of weight before sagging			

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

Orientation

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





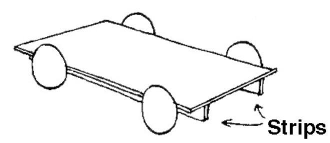


Diagram A *Diagram B*

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, and 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.