Lesson 2 – Pre-Visit
Build a Better Baseball

Objective: Students will be able to:
- Learn through experimentation how design impacts performance.
- Design and build a better baseball using science, mathematics, and engineering concepts.
- Use the engineering design process to solve a problem.
- Use data collection and analysis to help solve a problem.

Time Required: 2-3 class periods

Materials Needed:
- "Inside a Baseball" sheet (included)
- Printed copies of the "Build a Better Baseball" worksheets for each student (included)
- A standard baseball
- A long roll of white paper
- At least one meter/yard stick
- A variety of art and household materials such as:
  - String, yarn, or ribbon
  - Aluminum foil
  - Modeling clay
  - Cloth rags
  - Plastic bags
  - Cotton balls
  - Paint, markers, crayons
  - Glue
  - Scissors

Vocabulary:
Circumference - The perimeter of a circle
Prototype - An original model on which something is patterned
Standard - Something set up by general consent as a rule for measuring or as a model
Standardize - To make something match a standard
Applicable Common Core State Standards:

**CCSS.ELA-Literacy.SL.9-10.1, SL.11-12.1** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade-appropriate topics, texts, and issues, building on others’ ideas and expressing their own clearly and persuasively.

**CCSS.ELA-Literacy.SL.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

**CCSS.ELA-Literacy.SL.11-12.4** Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

**CCSS.ELA-Literacy.RST.9-10.3, RST.11-12.3** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

**CCSS.ELA-Literacy.WHST.9-10.2, WHST.11-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

**CCSS.ELA-Literacy.WHST.9-10.4, WHST.11-12.4** Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Additional Relevant National Learning Standards:
(Based on Mid-continent Research for Education and Learning)

**Thinking and Reasoning. Standard 2. [Level IV Grade 9-12].** Understands and applies basic principles of logic and reasoning

**Thinking and Reasoning. Standard 4. [Level IV Grade 9-12].** Understands and applies basic principles of hypothesis testing and scientific inquiry

**Technology. Standard 4. [Level IV Grade 9-12].** Understands the nature of technological design
1. To begin this lesson, hold up a standard baseball. Ask students to predict the materials used to make the baseball. Write down student ideas on the board or on a piece of chart paper.

2. Have students pass the baseball around the classroom. Have students predict the weight and circumference of the ball.
   - Weight = 5-5 ¼ ounces
   - Circumference = 9-9 ¼ inches

3. Now show students the "Inside a Baseball" sheet; an image of a baseball that has been cut in half. Refer to students' ideas about the materials needed to make the baseball. Review the following:
   - At the center is a cushioned cork sphere surrounded by 2 layers of rubber; 1 black and 1 red.
   - Next is 4-ply grey wool: 121 yards
   - Then 3-ply white wool: 45 yards
   - Then 3-ply grey wool: 53 yards
   - Next is cotton yarn: 150 yards
   - Finally the cover made from cowhide leather and stitched with 108 red stitches.

4. Discuss that Major League baseballs have to be standardized. Ask students, "Can you think of any reasons why?"

5. Share the following information:
   In the early years of the game (the mid-1800s) baseballs could be very different from diamond to diamond. Some baseballs were very bouncy, built with a solid rubber core. Hitting these "lively" balls, some teams might get dozens of runs per game! Other teams preferred less bouncy balls, built with just fabric stuffing and no rubber core. Referred to as "dead" balls, these balls didn't travel as far or as fast as the lively balls. Home teams could choose which kind of ball they would use: If you had better batters than the other team, you'd choose a lively ball; if your team's strengths were pitching and fielding, you'd choose a dead ball. Eventually, it was decided that choosing the ball gave the home team too much of an advantage. A standard baseball was created.
6. Ask students, "How do you think the standardization of the baseball (making them all the same size, weight and out of the same material) changed the game?"

7. Ask students, "How do you think someone could find out if the baseballs were correctly made or not? What invention might you create to test a ball?"

8. Discuss that each baseball goes through a careful inspection. The inspection process concludes with something called a "coefficient of restitution" (COR) test. Discuss the coefficient of restitution. This is the measure of elasticity of the collision between ball and bat. The mathematic formula is $c = \sqrt{h/H}$

   $c = \text{coefficient of restitution}$

   $h = \text{bounce height}$

   $H = \text{drop height}$

9. When this test is done in a lab, it involves shooting a baseball out of an air cannon at a velocity of 85 feet per second against a wood surface 8 feet away. If each baseball is made correctly, it should bounce back from the wall with a similar speed and distance.

10. Discuss that new inventions and new technology can result in major changes to a game like baseball.

   - The cork center became the standard in Major League Baseball in the early 1910s.
   - In the 1930s, the rubber cushion around the cork was added.
   - In 1938, the Brooklyn Dodgers experimented with yellow baseballs during night games, but eventually dropped the idea.
   - In 1973, Oakland A’s owner Charlie Finley experimented with orange baseballs in spring training. Some players complained that the orange balls were slicker than the usual baseballs. The idea did not catch on.

11. Introduce the activity.
1. Have students set up a "prototype test area" in one corner of the classroom.
   • For each team, tape one roll of paper to the wall.
   • Using a meter stick, make a series of lines every 5 centimeters if you are using metric measurements, or every 3 inches (1/4 of a foot) if you are using English measurements.
   • Make a line at the top to indicate the height at which the prototypes must be dropped, so that it will be the same for each test.

2. Introduce the activity by asking students to imagine that they work for a major sporting goods company, and it is their job to build a better baseball.

3. Divide students into pairs. Provide each student with the "Better Baseball" worksheets and review the project. Teams will:
   • Design a baseball.
   • Create a prototype of their baseball.
   • Test the baseball for functionality.
   • Redesign the baseball based on the test.
   • Create a second prototype.
   • Test the second prototype.
   • Present their findings to the class and compare/contrast results.

4. Students may use any household or art supplies they can find to create their baseballs.
   *Note* Since these baseballs represent new innovations in the sport, they need not necessarily match the standard weight and circumference of a baseball currently in use in the major leagues.

Conclusion:

To conclude this lesson and check for understanding, have students present the final results of their "Build a Better Baseball Challenge." Hold a class discussion in which the different models are compared and contrasted. Finally, have students write a journal entry addressing the effects of using their baseball in a real major league game. What would happen? How might the use of the new baseball change the game?
Inside a Baseball

- Wool Yarn Windings
- Black Rubber
- Red Rubber
- Cork Center
- Cotton String Windings

The Task:

1. As a team, discuss and agree upon a design for the new baseball.
2. Draw a sketch of your design in the appropriate space below.
3. Build a prototype baseball based on your design.
4. Test the baseball for functionality.
5. Discuss and agree upon a redesigned baseball.
6. Draw a sketch of your new design in the appropriate space below.
7. Rebuild your prototype based on your revisions.
8. Test your second prototype.
9. Present your team's findings to the class.
1st Baseball Design:

In the space below, draw the baseball your team agreed upon for your first design. Include your baseball's dimensions (such as circumference and weight), and a list of materials needed to construct it.
Build Your Prototype:

Build a prototype of your first design using your team's chosen materials. Make sure the dimensions of the prototype match the dimensions you stated on your design sheet.

Test Your Prototype

**Step 1:** Have one team member hold the prototype ball against the line at the top of the paper. This is the height at which the prototypes must be dropped, so that it will be the same for each test.

**Step 2:** As one team member drops the ball, the other team member should observe the height of the ball's bounce and record it by marking it on the measuring paper, and recording it on the data table (below).

**Step 3:** Test the bounce of your prototype 4 times. Drop the ball from the same height each time. It is important to let the ball fall out of your hands, and not to push it down with your hands, wrists, or arms.

**Step 4:** Determine the coefficient of restitution for each attempt.

<table>
<thead>
<tr>
<th>Attempt #</th>
<th>Bounce Height (h)</th>
<th>Drop Height (H)</th>
<th>Coefficient of Restitution ((c = \sqrt{\frac{h}{H}}))</th>
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2nd Baseball Design:
After you have tested your original design, redesign your baseball and draw the new
design in the space below. Make sure to note any changes you made to dimensions and
materials.

How is your second prototype different from your first prototype?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Build Your 2nd Prototype:

Build a prototype of your second design using your team's chosen materials. Make sure the dimensions of the prototype match the dimensions you stated on your design sheet.

Test Your 2nd Prototype

Step 1: Have one team member hold the prototype ball against the line at the top of the paper. This is the height at which the prototypes must be dropped, so that it will be the same for each test.

Step 2: As one team member drops the ball, the other team member should observe the height of the ball's bounce and record it by marking it on the measuring paper, and recording it on the data table (below).

Step 3: Test the bounce of your prototype 4 times. Drop the ball from the same height each time. It is important to let the ball fall out of your hands, and not to push it down with your hands, wrists, or arms.

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Analyze Your Results

1. When you tested your first prototype, how well did it work?

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________________________________________________________________________
________________________________________________________________________

2. Which of your prototypes, the first or second, worked better? Why?

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________________________________________________________________________
________________________________________________________________________

3. The one thing we liked about our design was...

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. The one thing we didn't like about our design was...

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. One thing we would still change about our design is...

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________