Wind Tunnel Testing

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Lesson Focus

Lesson focuses on wind tunnel tests that engineers in many industries use to when developing products such as airplanes, cars, and even buildings. Teams of students build their own model car out of everyday products and test their design in a wind tunnel made of a fan blowing through a long cardboard box. As an extension activity, students may design an airplane wing for an online wind tunnel.

Lesson Synopsis

The Wind Tunnel Testing lesson explores how wind tunnels provide feedback to engineers about the performance and durability of products such as planes, cars, and buildings. Students work in teams to build their own model of a car, using simple materials, and test their designs in a classroom wind tunnel set up.

Age Levels

11-18.

Objectives

- Learn about engineering design.
- Learn about wind tunnels and engineering testing.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- mechanical engineering and design
- aeronautical engineering testing
- problem solving
- teamwork

Lesson Activities

Students learn how products such as airplanes, cars and trucks are tested in wind tunnels to determine performance and efficiency. Student teams design their own model car and test it in a simple classroom wind tunnel using a fan and long cardboard box. Next, student teams draw their design, build it using low cost materials, evaluate their own work and that of other students, and then present their observations to the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- NASA Wind Tunnels (https://www.nasa.gov/centers/langley/news/factsheets/WindTunnel.html)
- NASA Future Flight Design (https://www.nasa.gov/audience/foreducators/5-8/features/F_Future_Flight_Design.html)
- Flying on the Ground, Wind Tunnels of Glenn Research Center (https://www.nasa.gov/centers/glenn/about/fs05grc.html)
- Interactive Wright 1901 Wind Tunnel (https://wright.nasa.gov/airplane/tunnl2int.html)

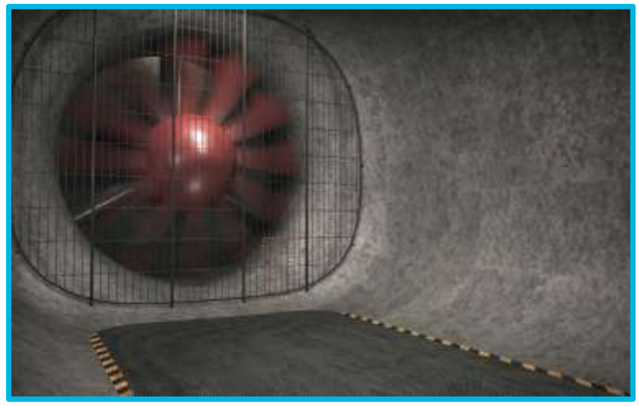
Recommended Reading

- Transonic Wind Tunnel Testing (ISBN: 0486458814)
- The Wright Brothers: A Biography of Aviation's Greatest Pioneers (ISBN: 0316861448)

Optional Writing Activity

- Write an essay or a paragraph about what other manufactured products would benefit from wind tunnel testing.

For Teachers:
Teacher Resource



◆ **Lesson Goal**

The Wind Tunnel Testing lesson focuses on wind tunnel tests that engineers in many industries use to when developing products such as airplanes, cars, and buildings. Teams of students build their own model car out of everyday products and test their design in a wind tunnel made of a fan blowing through a long cardboard box.

◆ **Lesson Objectives**

- Learn about engineering design.
- Learn about wind tunnels and engineering testing.
- Learn about teamwork and working in groups.

◆ **Materials**

- Student Resource Sheet
- Student Worksheets
- Materials to build classroom wind tunnel: Small portable fan, rectangular cardboard box with ends removed, tape to affix box to floor in fixed position. Include a measurement (ruler, markings) to indicate the distance prototype cars move under the force of the wind.
- Materials (wood, plastic) to set up a ramp for testing each car on a 15 degree slope.
- One set of materials for each group of students: tape, string, plastic wrap, foil, popsicle sticks, toothpicks, paperclips, paper, pencils, cardboard, one cardboard tube (from paper towel or toilet paper roll). All materials must be used so that each car weighs the same.

◆ **Procedure**

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework. Divide students into groups of 2-3 students, providing a set of materials per group. Have students visit the following websites to understand how wind tunnels work and the range of engineering applications they are used for:
   a. NASA Wind Tunnels (https://www.nasa.gov/centers/langley/news/factsheets/WindTunnel.html)
   b. NASA Future Flight Design (https://www.nasa.gov/audience/foreducators/5-8/features/F_Future_Flight_Design.html)
   c. Flying on the Ground, Wind Tunnels of Glenn Research Center (https://www.nasa.gov/centers/glenn/about/fs05grc.html)

For Teachers:
Teacher Resource (continued)

◆ Procedure (continued)

2. Have students work in teams to try out the online wind tunnel at http://wright.nasa.gov/airplane/tunnl2int.html. This will provide a better understanding of how the shape of their car will impact results.

3. Explain that students are now an "engineering" team that must develop a new automobile prototype that offers the best fuel efficiency by creating the least drag or resistance to the wind.

4. Students meet and develop a plan for their car. They agree on materials they will need (out of those you have provided), write or draw their plan, and then present their plan to the class.

5. Student groups next build their prototype cars. All materials must be used.

6. Students must ramp test their cars to make sure they can roll prior to testing.

7. The teacher should set up the classroom "wind tunnel" and manage the testing of each car so the wind test is consistent between student teams. Students will measure the distance the prototype car is pushed by the wind; the one the moves the least has the least resistance to the wind.

8. Each student group evaluates the results, completes an evaluation/reflection worksheet, and presents their findings to the class.

◆ Tips

1. Use caution with young children and fan blades.

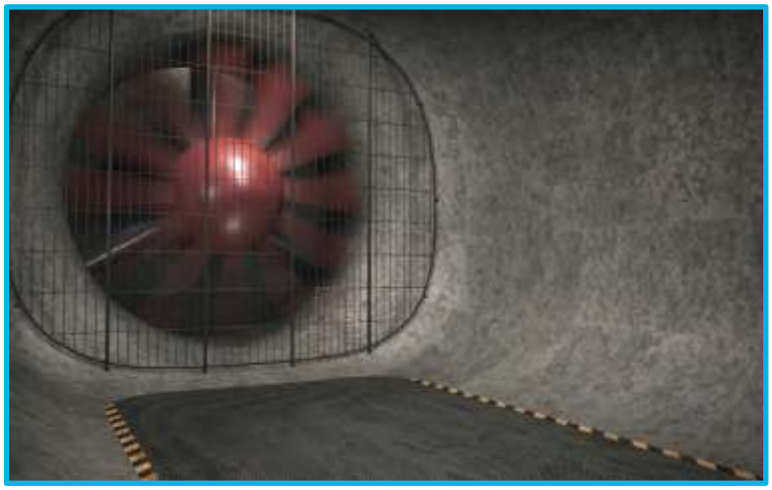
2. If time allows, give students an opportunity redesign their car if they determine that alterations might improve performance.

◆ Time Needed

Two to four 45 minute sessions

Student Worksheet: Wind Tunnel Simulator

You are a team of engineers who have been given the challenge of building a new automobile prototype that offers the best fuel efficiency by creating the least drag or resistance to the wind.



◆ Research/Preparation Phase

1. Review the various Student Reference Sheets, and if internet access is available try out a virtual wind tunnel at http://wright.nasa.gov/airplane/tunnl2int.html.

◆ Planning as a Team

1. Your team has been provided with some "construction materials" by your teacher. You have tape, string, plastic wrap, foil, popsicle sticks, toothpicks, paperclips, paper, pencils, cardboard, one cardboard tube (from paper towel or toilet paper roll) and must use all materials so all cars weigh the same.

2. Start by meeting with your team and devising a plan for your car. Feel how strong the wind will blow in your classroom wind tunnel so you can anticipate how strong your car must be. Your car must hold its form through all wind levels and move the least to indicate it has the least resistance to the wind.

3. Write or draw your plan in the box below, including your projection for the materials you'll require to complete the construction. Present your design to the class, and explain your choice of materials. You may choose to revise your teams' plan after you receive feedback from class.

Materials Needed:

Student Worksheet: Wind Tunnel Simulator

◆ Construction Phase
1. Build your car!

◆ Ramp Test
Your car must pass a ramp test before fan testing. It must roll down a ramp set at an angle of 15 degrees and must roll at least 4 feet before it's "certified" for wind testing.

◆ The Wind Tunnel Test!
1. Observe as your team and other teams test their prototypes in your classroom wind tunnel. You should conduct three tests and average the values you find. Record your team's results in the box below, including points and observations.

Test #1 Results and Observations
Test #2 Results and Observations
Test #3 Results and Observations
Average Results

◆ Re-engineering
If time allows, you may redesign your car if you determine that alterations might improve performance.

Student Worksheet: Evaluation

◆ Reflection

1. What distance did your car move when the wind tunnel was on? How did this relate to the distances of the other model cars in your classroom?

2. What do you think was the aspect of the design of the car that moved the least that made it the most successful?

3. Do you think that engineers have to adapt their original plans during the manufacturing process? Why might they?

4. If you had to do it all over again, how would your planned design change? Why?

5. What designs or methods did you see other teams try that you thought worked well?

6. Did you find that there were many designs in your classroom that met the project goal? What does this tell you about engineering plans?

7. Do you think you would have been able to complete this project easier if you were working alone? Explain how teamwork impacted this project.

8. List several products that you think would benefit from wind tunnel testing

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4 - 9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Position and motion of objects

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understanding about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in society

For Teachers:
Alignment to Curriculum Frameworks

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Motions and forces
- Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Historical perspectives

◆**Next Generation Science Standards Grades 3-5 (Ages 8-11)**

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆**Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Engineering Design

Students who demonstrate understanding can:

- 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.

For Teachers:
Alignment to Curriculum Frameworks

◆**Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆**Next Generation Science Standards Grades 9-12 (Ages 14-18)**

Engineering Design

Students who demonstrate understanding can:

- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

◆**Standards for Technological Literacy - All Ages**

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 2: Students will develop an understanding of the core concepts of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 12: Students will develop abilities to use and maintain technological products and systems.
- Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- Standard 20: Students will develop an understanding of and be able to select and use construction technologies.