How the Rubber Meets the Road

Lesson Focus

Lesson focuses on how engineers design tire treads to increase safety and reliability. Students are presented with the challenge of designing a new tire tread that will be safe when driving in rainy conditions. Student teams will design and construct a sample tread out of clay, then test and evaluate the effectiveness of the design, evaluate their results, and present their findings to the class.

Lesson Synopsis

The "How the Rubber Meets the Road" lesson explores how engineers design tire tread patterns to achieve safety in a range of driving conditions. Students work in teams to design a pattern of grooves or "tread" to reduce tire slippage in heavy rain by forcing water to flow out to the side of the road -- away from the tire. They then create a model of their tread using clay, and evaluate their models with a water test. They'll measure how much water is deflected away from the tire, evaluate the effectiveness of all the systems developed by student teams, and present their findings to the class.

Age Levels

8-18.

Objectives

- Learn about engineering design.
- Learn about planning and construction.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes

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

- engineering
- problem solving
- teamwork

Lesson Activities

Students learn how tire tread patterns are developed and changed over time to achieve safety and efficiency in a range of driving conditions. Students work in teams to develop a new tread pattern to prevent hydroplaning in heavy rain -- first on paper and then by building a clay model. Teams evaluate their own systems and that of other students, and present their findings 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)
- Center Library of Tire Treads (https://www.biologyjunction.com/tire%20tread%20patterns.html)
- Pep Boys Tire Tread Types (www.pepboys.com/auto-care/tires/tread-type)

Supplemental Reading

- Tire and Wheel Technology (ISBN: 0768003717)
- A Rubber Tire (How It's Made) (ISBN: 0836862953)

Optional Writing Activity

- Write an essay or a paragraph about how material science and engineering has impacted tire performance over the last hundred years.

Optional Extension Activity

- Visit a local tire store as a class and explore the different tire treads and applications. Have the store explain the importance of tire pressure with regard to safety and performance.
- Organize a tracing experience, where either the teacher or adult volunteers trace different tire treads to show in the classroom.

For Teachers:
Teacher Resource

◆ Lesson Goal

The "How the Rubber Meets the Road" lesson explores how engineers design tire tread patterns to achieve safety in a range of driving situations. Students work in teams to draw a pattern to reduce slippage in heavy rain, and then create a model of their tread using clay. Student teams then test their own models with water, and evaluate the effectiveness of all the systems developed by student teams.

◆ Lesson Objectives

- Learn about engineering design.
- Learn about planning and construction.
- Learn about teamwork and working in groups.

◆ Materials

- Student Resource Sheet
- Student Worksheets
- Water, measuring cup and spout, tape, and divided basin (or three small containers) for testing and measuring the water that is gathered at the bottom, and on each side; tread depth measuring device (can be a ruler, or an actual tread measuring device).
- One set of materials for each group of students:
  - Paper, card board, clay, plastic knives or kid-safe clay carving tools, pencils

◆ 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.

2. Divide students into groups of 2-3 students, providing a set of materials per group.

3. Explain that students must carve or shape a unique tire tread pattern out of clay that will route over 50% of incoming water to the sides of the tire to prevent hydroplaning. In addition, less than 40% of the surface material may be carved away in order to achieve this goal.

4. Students meet and develop a plan for their new "tread." They must consider the path the water will take, and also how deeply they will carve into the clay for their test model. They first draw the design on paper and then transfer it -- using a pencil -- to a block of clay that is about 5" x 10" x 2".

5. Students then carve the clay using plastic instruments or kid-safe clay carving tools.

6. Student teams then present their plan to the class, explaining their predictions for how their design will work. They will present the depth of the new tread and their hypothesis for how efficiently their pattern will whisk water to the sides of the tire to prevent hydroplaning.

7. All "treads" are then tested by pouring two cups of water through the carved clay. The teacher may decide to do the testing, appoint a team of testers, or allow students to test their own designs. Note, the "tread" should be secured with tape at about a 25 degree angle, which will help make the tests of all teams more consistent. Measure the water collected at the bottom container, as well as the water collected from the right and left side to determine the percentage that was pushed away to the side. Pouring through a spout may assist in making the flow of water at a speed so it doesn't splash out. Students keep track of the data and measurements on a student worksheet, while the teacher is responsible for pouring the water to ensure fair testing among all teams.

8. Student teams record their results, complete an evaluation/reflection worksheet, and present their findings to the class

◆ Time Needed
Two to three 45 minute sessions

◆ Tips
For younger students, you may choose to do the carving yourself, or perhaps do this lesson as a joint project with an older class -- working together -- and have the older students do the carving for the younger ones.

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Student Resource: Why Tread Matters

Tire tread is critical to the safe operation of a car, motorcycle, or bicycle. Engineers design tire tread to achieve a balance between safety, comfort, noise, vibration, and strength. There are many factors to consider in tire design including materials used. In this lesson, we'll focus closely on the tread design.

Engineers work in teams to come up with design for tread (or the patterns of grooves on the exterior of the tire) that will have top traction. The tires need to hold on to the pavement or road surface in a range of weather and road surface conditions. They need to grip the road as a car turns or comes to a quick stop.

An important aspect of tread design is how the tire pushes water away from the tire so that more of the tire surface is touching the road and not hydroplaning. Hydroplaning is when a layer of water manages to get between the tire and the road -- the water can actually push the car off the road leading to loss of control and possible accidents. Some engineers develop tread designs with center channels and v-shaped grooves to flush water out the back and sides of the tire. But the range of shapes and patterns of possible designs are really limitless.

Engineers then use a variety of tools to design and test tire tread design, including computer programs that allow them to virtually carve patterns in the tire and then perform tests in virtual rainstorms or snowstorms. They also ultimately test actual tires in all sorts of real weather conditions.

◆ Testing Tire Tread

For a family car or truck, it is important to check the depth of the tread frequently. Even the best engineered tread design becomes less effective as the tire experiences wear. Tire tread depth measurement tools are an important tool to gauge safety. Some people use a coin for this task. Recently, tire manufacturers have started building in treadwear indicators so consumers can quickly see if they need to replace the tire. These indicators can look like little raised sections (at approximately 1.6 mm or 1/16") that are found at the bottom on the deepest tire grooves. When these seem to be even with the exterior of the tire, it's time to get new tires!

Student Worksheet: Design Your Own Tire Tread Pattern

You are a team of engineers who have been given the challenge to develop a unique tire tread pattern out of clay that will route over 50% of incoming water to the sides of the tire to prevent hydroplaning. As a team, you'll need to preserve at least 60% of the surface of the "tread" so that the tire will be able to grip the road firmly.

Step 1: Meet as a team and discuss the problem you need to solve. Then develop and agree on a pattern you will use for your tread. You may each want to come up with a simple idea, and then select the best aspects of each design to develop a group pattern. Draw the pattern in the box below, and be sure to indicate not only the shape of the grooves, but also how deep your grooves will be carved into the "tire."

Student Worksheet (continued):

Step 2: Transfer your team's design to the clay block using a pencil.

Step 3: Carve your design plan into the clay block provided to you, using plastic utensils or kid-safe clay tools.

Step 4: Use the table below to predict how your tread will perform in the water test.

	Predicted average results
Amount of water in middle/bottom container	%:
Amount of water in left container	%:
Amount of water in right container	%:

Step 5: As a group, present your engineering teams' plan to the class. Explain why you chose the patter you did, and explain what you think will happen when you test your design. Be specific and anticipate the percentage of water that will end up flowing to the left and right containers instead of flowing straight through to the bottom container. Also explain how you decided on the depth of the grooves and whether they are a consistent depth throughout the design.

Step 6: Testing time! Your teacher will have set up a testing station for the treads. Your teacher will decide if you will test your own treads, or if a team of "testers" will be appointed to do the work. The testers will pour water through the top of the tire and then you'll measure and record how much water ended up being pushed to the left or right container as opposed to being gathered in the bottom container. Your tire "tread" will be held using tape at about a 25 degree angle, so the flow of water will be consistent from team to team. Measure the water collected at the bottom container, as well as the water collected from the right and left side to determine the percentage that was pushed away to the side.

Student Worksheet (continued):

Step 7: Mark your results in the box below. You may try your test up to three if you didn't get the results you wanted on the first try -- but you'll have to average your results. Include both the actual amounts of water gathered and the percentage of all water for each container.

	Test 1	Test 2	Test 3	Average of completed tests
Amount of water in middle/bottom container	Amt: %:	Amt: %:	Amt: %:	%:
Amount of water in left container	Amt: %:	Amt: %:	Amt: %:	%:
Amount of water in right container	Amt: %:	Amt: %:	Amt: %:	%:
Total water gathered	Amt:	Amt:	Amt:	

Step 8: Complete the following evaluation/reflection questions and present your findings to the class.

1. Did you succeed in creating a "tread" that could route over 50% of incoming water to the sides of the tire to prevent hydroplaning?

2. If you did not reach the goal, what would your team have done differently?

3. How did your predictions for your tread performance vary from your actual results?

Student Worksheet (continued):

4. Did you test your "tread" more than once? If so, how do you think that averaging your test scores impacted your overall results?

5. What was the most significant design different of your "tread" as compared to those of the other student teams?

7. Describe a feature of another teams' "tread" that you thought was particularly inventive. Why?

8. What impact do you think the depth of the pattern have on your teams' outcome.

9. Do you think you would have been able to complete this project easier if you were working alone? Explain…

10. How do you think engineers test tire tread designs in the real world? Consider computers, test driving tracks, and other options. And, also discuss how making a prototype might, or might not, be useful.

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

- Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

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

- Properties of objects and materials

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design

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

- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

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

- Properties and changes of properties in matter
- 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

- Natural hazards
- Risks and benefits
- 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

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

- Science and technology in local, national, and global challenges

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

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

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

The Nature 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 7: Students will develop an understanding of the influence of technology on history.

For Teachers:
Alignment to Curriculum Frameworks

◆**Principles and Standards for School Mathematics (ages 6 - 18)**

Data Analysis and Probability Standards

Instructional programs from prekindergarten through grade 12 should enable all students to:

- formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
- develop and evaluate inferences and predictions that are based on data.

◆**Common Core State Standards for School Mathematics Grades 3-14 (ages 8-10)**

Measurement and data

- Solve problems involving measurement and estimation.

- CCSS.Math.Content.3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).1 Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.2

- Understand ratio concepts and use ratio reasoning to solve problems.

- CCSS.Math.Content.6.RP.A.3c Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

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

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 11: Students will develop abilities to apply the design process.
- Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- Standard 18: Students will develop an understanding of and be able to select and use transportation technologies.