How the Rubber Meets the Road

Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on how engineers design tyre treads to increase safety and reliability. Students are presented with the challenge of designing a new tyre 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.

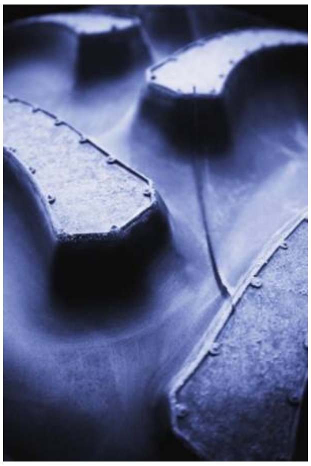
Lesson Synopsis

The "How the Rubber Meets the Road" lesson explores how engineers design tyre 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 tyre slippage in heavy rain by forcing water to flow out to the side of the road -- away from the tyre. 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 tyre, evaluate the effectiveness of all the systems developed by student teams, and present their findings to the class.

Year Levels

Year 7 – Term 2, Year 8 – Term 2, Year 10 – Term 3

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 tyre 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)
- Illinois Math and Science Center Library of Tyre Treads (https://www3.imsa.edu/programs/e2k/curriculum/68csi/tyre/tyrelib)
- Tyre Safety (http://www.toyotires.com.au/tyre-care-safety/tyre-safety.htm)
- Tread design (http://www.ctyres.co.uk/tyre_info/tyretreaddesign.html)
- Curriculum Links (www.acara.edu.au)

Supplemental Reading

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

Optional Writing Activity

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

Optional Extension Activity

- Visit a local tyre store as a class and explore the different tyre treads and applications. Have the store explain the importance of tyre pressure with regard to safety and performance.
- Organize a tracing experience, where either the teacher or adult volunteers trace different tyre treads to show in the classroom.
- Explore online sites showing examples of hydroplaning such as:
    - The University of Pittsburgh, PA Engineering Department (www.engr.pitt.edu/ssc/hydroplaning.html)

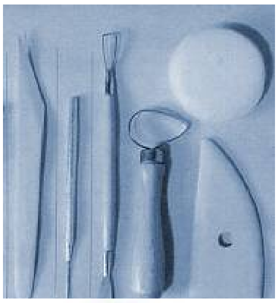
How the Rubber Meets the Road

For Teachers:
Teacher Resource

◆ Lesson Goal

The "How the Rubber Meets the Road" lesson explores how engineers design tyre 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



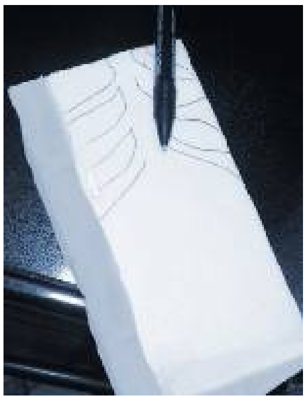
- Learn about engineering design.
- Learn about planning and construction.
- Learn about teamwork and working in groups.

◆ 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 (modeling 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 tyre tread pattern out of clay that will route over 50% of incoming water to the sides of the tyre 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 13 x 26 x 5cm.

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 tyre 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.

◆ 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.

How the Rubber Meets the Road

Student Resource:
Why Tread Matters

Tyre tread is critical to the safe operation of a car, motorcycle, or bicycle. Engineers design tyre tread to achieve a balance between safety, comfort, noise, vibration, and strength. There are many factors to consider in tyre 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 tyre) that will have top traction. The tyres 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 tyre pushes water away from the tyre so that more of the tyre surface is touching the road and not hydroplaning. Hydroplaning is when a layer of water manages to get between the tyre 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 tyre. But the range of shapes and patterns of possible designs are really limitless.

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

◆ **Testing Tyre 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 tyre experiences wear. Tyre tread depth measurement tools are an important tool to gauge safety. Some people use a coin for this task, but a coin is not as accurate. Recently, tyre manufacturers have started building in treadwear indicators so consumers can quickly see if they need to replace the tyre. These indicators can look like little raised sections (at approximately 1.6 mm) that are found at the bottom on the deepest tyre grooves. When these seem to be even with the exterior of the tyre, it's time to get new tyres!

How the Rubber Meets the Road

Student Worksheet:
Design Your Own Tyre Tread Pattern

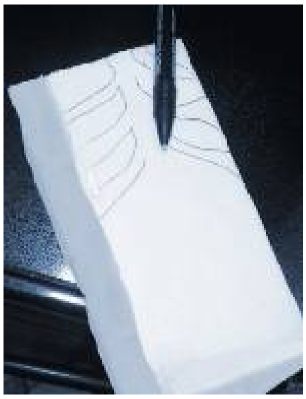
You are a team of engineers who have been given the challenge to develop a unique tyre tread pattern out of clay that will route over 50% of incoming water to the sides of the tyre to prevent hydroplaning. As a team, you'll need to preserve at least 60% of the surface of the "tread" so that the tyre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

How the Rubber Meets the Road

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 tyre 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 tyre "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.

How the Rubber Meets the Road

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 tyre 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 tyre 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.

How the Rubber Meets the Road

For Teachers:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Australian Curriculum in Science

	Year Level					
	5	**6**	**7**	**8**	**9**	**10**
Science Understandings			Changes to an object's motion is caused by unbalanced forces acting on a object **(ACSSU117)**	Energy appears in different forms including movement (kinetic energy), heat and potential energy, and causes change within a system **(ACSSU115)**		The motion of objects can be described and predicted using the laws of physics **(ACSSU229)**
Science as a human endeavour			Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **(ACSHE223 – Yr 7); (ACSHE226 – Yr 8)**		Advances in scientific understandings often rely on developments in technology and technological advances are often linked to scientific discoveries **(ACSHE192 – Yr 10)**	
Science Inquiry Skills			Summarise data, from student's own investigations and secondary sources, and use scientific understandings to identify relationships and draw conclusions **(ACSIS130 – Yr 7); (ACSIS145 – Yr – 8)** Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the methods **(ACSIS131 – Yr 7); (ACSIS146 – Yr 8)** Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate **(ACSIS133 – Yr 7); (ACSIS148 – Yr 8)**		Use knowledge of scientific concepts to draw conclusions that are consistent with evidence **(ACSIS204 – Yr 10)** Evaluate conclusions and describe specific ways to improve **(ACSIS205 – Yr 10)** Communicate scientific ideas and information for a particular purpose **(ACSIS208 – Yr 10)**	

Science Achievement Standards

Year 7

By the end of Year 7, students describe techniques to separate pure substances from mixtures. They ***represent and predict the effects of unbalanced forces, including Earth's gravity, on motion***. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. ***Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society.***

Students identify questions that can be investigated scientifically. They plan fair experimental methods, identify variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions. They ***summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations***.

Year 8

By the end of Year 8, students compare physical and chemical changes and use the particle model to explain and predict the properties and behaviours of substances. They ***identify different forms of energy and describe how energy transfers and transformations cause change in simple systems***. They compare processes of rock formation, including the time scales involved. They analyse the relationship between structure and function at cell, organ and body system levels. Students examine the different science knowledge used in occupations. They explain how evidence has led to an improved understanding of a scientific idea and describe situations in which scientists collaborate to generate solutions to contemporary problems.

Students identify and construct questions and problems that they can investigate scientifically. They consider safety and ethics when planning investigations, including designing field or experimental methods. They ***identify variables to be changed, measured and controlled. Students construct representations of their data to reveal and analyse patterns and trends, and use these when justifying their conclusions***. They explain how modifications to methods could improve the quality of their data and apply their own scientific knowledge and investigation findings to evaluate claims made by others. They ***use appropriate language and representations to communicate science ideas, methods and findings in a range of texts types.***

Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They ***explain the concept of energy conservation and represent energy transfer and transformation within systems. They apply relationships between force, mass and acceleration to predict changes in the motions of objects***. Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses and independently design and improve appropriate methods of investigation, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data. When ***analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty***. Students evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views, the quality of methodology and the evidence cited. They ***construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes***.