Road and Tire designs

Description:

The main purpose of these activities is to acquaint the students with the different types of roads and their abilities in everyday life. They will also understand that different types of roads makes a difference with tread of tires we use on our vehicles.

North Dakota State Standards:

9-10.1.1 Explain how models can be used to illustrate scientific principles
11-12.1.1 Explain how scientists create and use models to address scientific knowledge
8.2.3 Use basic mathematics and statistics to interpret quantitative data
9-10.2.8 Analyze data found in tables, charts, and graphs to formulate conclusions

Schedule:

9:00-9:30	Brief introduction/Cultural introduction
9:30-10:00	Power Point
10:00-10:30	Computer research for Activity 1
10:30-11:30	Activity 1
11:30-12:00	Computer research for Activities 2-5
12:00-12:30	Lunch
12:30-12:50	Activity 2
12:50-1:30	Activity 3
1:30-2:00	Activity 4
2:00-2:45	Activity 5
2:45-3:00	Wrap Up

Computer Research for Activity 1

Research why cars have different threads of tires and why some wear out faster than others on roads. Also do the road types make a difference and does the cost and time play a part? Make a question sheet

Activity 1

How rubber meets the road.

Lesson Outcome

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.

Rationale / Purpose for Lesson

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.

Objectives

- Learn about engineering design.

- Learn about planning and construction.

- Learn about teamwork and working in groups.

Materials

- Student Resource Sheet
- Student Worksheet
- Water
- measuring cup
- spout

- tape
- 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, pencils

Procedure

1. Show students the various Student Reference Sheets.

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 or play-doh that is about 5" x 10" x 1".

5. Students then carve the clay or play-doh using a plastic knife.

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 or play-doh. 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

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, but a coin is not as accurate. Recently, tire manufacturers have started building in tread wear 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 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?

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

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

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

9. 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.

Computer Research for Activity 2

Research what's the difference between asphalt and concrete?

Activity 2-5

Lesson Outcome

Introduce basic engineering principles, road construction and material science. Students will learn how material properties and strength can be affected.

Rationale / Purpose for Lesson

To understand the different items that are involved in making asphalt and the cost, time associated with it.

Materials

- 5-6 Asphalt Samples from Local Highways
- Magnifying Glasses
- Asphalt worksheet

Procedure

1. Students will read the background information about what goes into making asphalt and the process.
2. Students will choose a highway or street and create a hypothesis about what they believe goes into making that highway. Students will also state characteristics that their chosen roadway needs on the "Asphalt Lab" Worksheet.
3. The teacher will obtain 6 asphalt samples from local highways. Give one sample to each group. The students will observe each sample and decide which highway they think the sample was taken from. They can use magnifying glasses if necessary to get a closer look. Students will write down their observations as well as their guesses on the "Which Highway???"
4. Each group will volunteer to discuss their observations aloud. Each group can compare and contrast their findings with other groups.

Asphalt worksheet

Asphalt is a combination of “aggregate” and “binder”. Aggregates are textures rocks and sand-like materials. Aggregates can come in different sized and textures: coarse, fine or very fine. Most aggregates come from nature: crushed rock or gravel for coarse aggregates; natural sand or finely crushed rocks for fine aggregates. Very fine aggregates are called “fillers”. Common fillers are limestone or cement. The binder is the material that holds (binds) the mixture together. Both tar and a substance called bitumen are used as binders. When the binder is heated to 300 degrees F, it turns into a liquid. When it cools it turns into a hard solid mass. Rocks or aggregate are added to the binder to make asphalt stronger. Engineers select and calculate the correct quantities of each rock size needed to produce a strong asphalt pavement. Calculated percentages of the different sizes of rocks are combined to determine the appropriate blend of rock materials. The mixture of rocks and asphalt binder are then compacted and put through a series of tests, which smash, stretch, and freeze the pavement to determine the best blend of rocks to use in a certain climate. Different measuring techniques are used in the field than in the laboratory. In the field engineers use huge quantities of each rock size and weigh them on scales as large as a garage. In the laboratory, much smaller quantities of each material are needed and ordinary measuring utensils are used.

1. Choose a local highway that you would like to investigate:

____

2. Describe what kind of roadway this is (heavy vehicles, fast cars, a lot of traffic).
____

____

____

____

3. What materials do you think should be put into this highway because of the roadway that you described in question 2? _____________________

Which Highway worksheet

Write down your observations in the correct box of each sample and then take a guess as to which highway you think the sample is from. Be very descriptive when explaining the aggregate and the binder.

Sample #1 Which Highway? ____________	Sample #2 Which Highway? ____________
Sample #3 Which Highway? ____________	Sample #4 Which Highway? ____________
Sample #5 Which Highway? ____________	Sample #6 Which Highway? ____________

Activity 3

Background

When asphalt is heated it changes from a solid to a sticky liquid. Small rocks are mixed into the asphalt. As the mixture cools the asphalt hardens. This asphalt and rock mixture is much stronger than the original solid asphalt and can be used for paving roads. Like the asphalt, the chocolate you use in this recipe becomes a liquid when heated. As you mix other tasty ingredients into your "chocolate asphalt" you'll observe the cookies harden and become stronger as they cool.

Materials

- 1/3 Cup Cocoa Powder or Carob
- 1/2 Cup Milk
- 1/4 Pound Butter (1 Stick = 1/4 Pound)
- 2 Cups Sugar
- 8 Tablespoons Chopped Walnuts In A Plastic Bag
- 8 Tablespoons Flaked Or Shredded Coconut In A Plastic Bag
- 1 Cup Old Fashion Oats In A Plastic Bag
- 1 Cup Quick Cooking Oats In A Plastic Bag
- Medium (2 Quart) Pot Crock Pot Or Other Heat Source (Hot plate)
- Extension Cord
- Large Wooden Spoon
- Ladle
- 1/4 Measuring Cup
- 1/8 Measuring Cup
- Tablespoon Measure
- Steep Sided Bowls or Large Paper Cup
- Sturdy Spoons
- Wax Paper Cut Into 12" squares
- 16 oz. Sealed Can or Rolling Pin

Procedure:

1. Students will create no bake cookies which models asphalt pavement production.
2. Prepare the "chocolate asphalt" in advance. In a medium size pot combine the cocoa powder, milk, butter and sugar. Heat, stirring frequently until the mixture boils for 2 minutes. Pour into the crock pot set at highest temperature. Yields 2 cups (8 1/4 cup portions). Double or triple as needed.
3. Using the measuring cup and tablespoon, measure the following ingredients and pour them into your mixing bowl or paper cup:

- 1/8 cup old fashion oats
- 1/8 cup quick oats
- 1 tablespoon walnuts
- 1 tablespoon coconut

4. Look at the liquid form of the chocolate asphalt in the crock pot. When asphalt binder is heated to 300°F, it is also a liquid. Using the ladle, spoon and measure 1/4 cup chocolate asphalt into the materials mixture.
5. Stir until all of the materials are well coated. Notice - the mixture cools while you stir it, becomes stiffer and starts to stick together. Asphalt behaves in the same manner
6. When the materials are thoroughly mixed, pour the mixture into a mound on a square of wax paper. Cover with a second piece of wax paper.
7. In the field, the pavement is spread with a paver and then rolled into a thin mat with a roller. The roller is very heavy and pushes all of the air out of the pavement. This helps make the asphalt very strong. Use a can or rolling pin to roll your cookie mixture 1/4"-1/3" thick. Can you still identify the different materials in the cookies?
8. Place your hand over the top of the cookie. Do you feel the heat? When asphalt pavement is first rolled out it is still very hot. Just like the asphalt, the cookies will harden as they cool. (Do you think that the cookies would be as strong if you use less edible materials? More edible materials?) When the cookies have cooled and hardened (20-30 minutes), you can peel off the wax paper and eat.

Asphalt Cookies worksheet

In the field, the pavement is spread with a paver and then rolled into a thin mat with a roller. The roller is very heavy and pushes all of the air out of the pavement. This helps make the asphalt very strong. Use a can or rolling pin to roll your cookie mixture 1/4"-1/3" thick. Can you still identify the different materials in the cookies?

____

____

Place your hand over the top of the cookie. Do you feel the heat? ______

When asphalt pavement is first rolled out it is still very hot. Just like the asphalt, the cookies will harden as they cool. Do you think that the cookies would be as strong if you use less edible materials or more edible materials?

____

____

Activity 4

Background

Different characteristics that the students may want to design for:

Strength -	(this can be with larger aggregates or stiffer binder or both)
Noise/Permeability -	(higher permeability = less noise. With a higher permeability, we are also helping to get the water off the roadway surface providing better wet condition surface friction)
Smoothness -	(using smaller aggregates)
Location -	(designing for highways, we take into consideration the amount of traffic volume that the pavement will see. Therefore, they can actually design for traffic volume on something like the turnpike or a traffic volume similar to outside their house.)

Materials

- "Design Your Own Highway!!!" Worksheet
- 6-7 Asphalt samples for the students to examine

Procedure

1. Hand out the "Design Your Own Highway!" Worksheet. Read aloud the directions. The students will be working in groups of 4 to create their own asphalt.
2. Each group will need to pick a local road or highway and then choose the characteristics that they feel that the roadway should have.
3. Students will work as a group and choose characteristics on the chart according to what they feel their highway needs. Students can observe the Asphalt Samples of all the local highways to gain ideas for their highway.
4. Groups can share their ideas aloud with the class.

Design your own Highway

Your team has been hired to lay a new layer of Asphalt on a local roadway. This roadway needs to be both cost efficient as well as appropriate for its conditions. You want to make a good highway at a good price! Below are the characteristics that you need to take into consideration for your roadway! You will be working in the Rutgers Center for Advanced Infrastructure and Transportation to concoct this mixture of aggregates and binders at a later time!

What roadway did the town hire you to lay Asphalt on? _________________

With your group you will be deciding what characteristics your roadway needs to have and what kinds of aggregates and binders you should put into your Asphalt. Circle the characteristics below

Strength	Noise/Permeability
Aggregates — Binder More Strength Large — Very Stiff Medium — Stiff Less Strength Small — Less Stiff	High Permeability = Less Noise Larger Stones Medium Permeability = Medium Noise Low Permeability = High Noise Smaller Stones
Smoothness	**Location**
Smaller Aggregates = More Smooth Medium Aggregates = Medium Smoothness Large Aggregates = Less Smooth	High Traffic Volume Medium Traffic Volume Low Traffic Volume

Activity 5

Background

Give students the task of designing a new road in your town. How long will it be? How wide should it be? How many tons of asphalt will they need to pave the road?

Materials

- “The Cost of Asphalt” Worksheet
- Calculator

Procedure

1. Students will be involved in the task of designing a new road in your town. They will need to decide on a few things before they can do this. Have them fill in the information on the “The Cost of Asphalt” Worksheet.
2. Working in pairs students will decide on a name for their road and decide how long and wide the road will be. They will then need to calculate how many tons of asphalt they will need to pave the road and how much it will cost. Students need to show all of their work in the space provided.
3. After all the pairs have completed the Asphalt Worksheet take volunteers to share what they have decided for their road.

The Cost of Asphalt worksheet

You will be designing a new road in your town. Before you do this – you need to decide on a few important things.

Name the road. ____

How long will it be? _________________feet

How wide should it be? _______________feet

Use this formula, given that one square yard of asphalt that is 6 inches deep weighs about 650 pounds:

(Length (in feet) x width (in feet) ÷ 9 sq. feet/sq. yd) x 650 pounds/sq. yd = total pounds

There are 5,280 feet in a mile. There are 2,000 pounds in a ton.

A two-lane road can be anywhere from 24 feet to 40 feet wide.

Assume asphalt costs about $30 per ton.