POLLUTION SOLUTION

ACTIVITY DESCRIPTION: How does pollution impact our daily lives? Have each student pick a topic in their life that they feel has been impacted by pollution. In this activity, participants will observe how pollution affects their personal lives and then develop strategies on how to combat these effects.

SUPPLIES:
- Internet Access
- Paper
- Writing Utensil

STEPS:
1. Ask students if they believe pollution has impacted their lives? Then give students a couple of minutes to reflect on how it has done so?
2. Have students make a list of how it has affected their life and ask them to brainstorm ideas on how to fix them. Ask them what are real-world solutions they think would solve the problems that they care about most in terms of pollution.
   a. Let them review resources on recycling, different types of energy, various modes of transportation, etc.
   b. Have them watch the following:
      - https://www.youtube.com/watch?v=JywsWktvODc
      - https://www.ted.com/talks/cheryl_holder_the_link_between_climate_change_health_and_poverty
      - https://www.youtube.com/watch?v=DkZ7BJQupVA
3. Now that they've thought about real-world solutions and watched the above videos, have them design a tool that would solve their identified problem. The tool can be drawn out, explained in a paper, or create a mock model of what it would look like. They need to be able to explain why it would solve the problem applying scientific evidence to support their claims.

HOW TO EXPAND:
- Marine Debris
- A creative solution to solve the water crisis in Flint Michigan
- Life Cycle of A Plastic Bottle
Great Pacific Garbage Patch

ADAPTATIONS/GOING VIRTUAL:
- If in person, have students watch the video on a projector or on individual devices
- If virtual, add the video links to your online platform for students to access.

DISCUSSION QUESTIONS:
- What areas do you think are the most heavily impacted by pollution?
- Does pollution impact you personally? Why?
MY FUTURE NEIGHBORHOOD

ACTIVITY DESCRIPTION: Creating a perfect neighborhood. Invent an item that makes your neighborhood better (either more walkable, cleaner, safer, etc.). Students will observe their own neighborhood and think creatively about what kind of invention (real or fake) could improve the general health of their neighborhood.

SUPPLIES:
- Paper
- Writing Utensils
- Post-it Notes

STEPS:
1. Have students imagine what the perfect neighborhood would be. Host a discussion on what would be included or excluded from that neighborhood. Have them observe their surroundings and the areas they live and identify what they consider to be good and bad about them.

2. Either in teams, individually, or as a large group, create a table of things that they observe to be positive and negative in their neighborhood. As a group have students explain why they classified a particular note as positive or negative.

3. Once everything has been discussed, provide 15 minutes for students to develop ideas on what would mitigate the negative aspects they identified. Encourage students to think outside the box on technology or systems that may not exist yet but are based on scientific evidence.

4. After the 15 minutes are up, have students present on what they designed and why they chose to create it.

HOW TO EXPAND:
- Encourage students to build out a mini model of their ideal neighborhood using cardboard, popsicle sticks, and glue

ADAPTATIONS/GOING VIRTUAL:
- If virtual, have students hold discussions with household members.
DISCUSSION QUESTIONS:

- How are people impacted by the environments they live in?
- Why do some neighborhoods have negative health consequences?
Bottled Water Taste Test

**ACTIVITY DESCRIPTION:** These days, when people are thirsty, they often reach for a bottle of water instead of turning on the faucet. In 2003, people in the US spent about $9 billion on bottled water. Why? Some consumers believe that bottled water is healthier than tap water. Others believe it tastes better.

But, some of these bottled waters actually come from a municipal water supply--just like the water coming out of your faucet--and not from a mountain stream. Consider two of the more popular bottled waters: Aquafina (produced by Pepsi) and Dasani (produced by Coke). Both of these brands are processed municipal water. Yet, we pay upwards of $1.39 for these bottles rather than a few pennies for water from the tap. (What does your municipality charge per gallon? _______)

**SUPPLIES:**
- 3 different bottled waters
- Disposable cups
- Blindfold
- Paper
- Writing Utensil

**STEPS:**
1. Conduct a blind taste test with your class to see if they can differentiate between several different water brands. There are a variety of tap and bottled water to sample.

2. Before the taste test, answer the following questions:
   - What are some of the reasons that people drink bottled water?
   - Is the price of bottled water worth it, compared to the price of tap water?
   - How do you think companies choose the names for their water brands?

3. **Let the taste testing begin!** Have the taste testers rate each water based on appearance, odor, flavor and aftertaste. Grade each area on a scale of zero to 10, with zero being the lowest rating and 10 the best.
The highest possible score is 30 points. As this is a blind taste test, you will not know the source of the water until after the scoring is complete.

### Scoring Sheet:

<table>
<thead>
<tr>
<th></th>
<th>Appearance</th>
<th>Odor</th>
<th>Flavor</th>
<th>Aftertaste</th>
<th>Total</th>
<th>Water source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water #1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water #2</td>
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<tr>
<td>Water #3</td>
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<td></td>
</tr>
<tr>
<td>Water #4</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Water #5</td>
<td></td>
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</tr>
</tbody>
</table>

### Analysis:
1. Which water was the most popular?
2. Which water was the least popular choice?
3. Were the results surprising?
4. What is the cost associated with each water? Do you think the price is worth it?

### HOW TO EXPAND:
- Hold a debate with others on the pros and cons of bottled water.
- Breakdown the cost of buying bottled water versus owning your own reusable water bottle.

### ADAPTATIONS/GOING VIRTUAL:
- If virtual, have students run experiments with household members.

### DISCUSSION QUESTIONS:
- What are the environmental impacts of using bottled water instead of tap water?
- Why do you think people choose to buy bottled water?
- What do you think would happen if we continued using bottled water at the rate we do now with no interventions?
Transportation Design Challenges

**ACTIVITY DESCRIPTION:** This activity is composed of three challenges, each addressing a different aspect of how to design an efficient public bus system for a fictitious town while taking into account the benefits and drawbacks of various fuel options.

In attempting these challenges, students will find that there is often more than one way to solve a problem. The purpose of these challenges is for students to reason out their own logical methods for solving a problem using math and computational skills with little initial guidance.

**SUPPLIES:**
- Internet Access
- Video: Buses and Biofuels: Sustainable Transportation
- Computer with internet access and projector
- Rulers (1 per student)
- Calculators (1 per student)
- Scratch paper
- Student Activity Guides (1 per student) *also available in Spanish*
- Teacher Solutions Handout

**STEPS:**
1. Show students the video “Buses and Biofuels: Sustainable Transportation” and discuss.

2. Introduce students to the premise of this activity:
   *Imagine a fictitious town called Solutionville. The citizens of Solutionville want to make sure their community is a healthy and safe place. They decide to start improving their town by giving people more access to public transportation that is both time and energy-efficient. Imagine you are a citizen of Solutionville who has been tasked with helping to design a public bus system that would service the downtown area.*
Ask students to discuss with a partner what conditions they think a public bus system should have to be ‘time efficient.’ What about ‘energy-efficient’? Ask for volunteers to share their or their partners’ thoughts.

4. Before moving on, hold a discussion and create a list of criteria on the board that is student-generated. 
   **Teacher Tip:** You can use this exercise to both check for understanding and prepare students for their first challenge. Be sure students have made a connection between efficiency in time or distance (which is beneficial for commuters on public transit) and the savings in fuel that occurs when routes are efficient. Sample discussion questions for creating shared criteria:
   - What reasons might a person have for driving their own car from place to place instead of taking public transportation?
   - Why do you think a person might try to find a shortcut to get from one place to another?
   - What other factors do you think you should consider when designing your public transportation system? (E.g., environmental impacts)

5. Divide students into pairs, hand out one Student Activity Guide: [https://www.calacademy.org/sites/default/files/assets/docs/pdf/flipsideenergy_transportation_studentactivityguidev2.pdf](https://www.calacademy.org/sites/default/files/assets/docs/pdf/flipsideenergy_transportation_studentactivityguidev2.pdf) (for the specific challenge) to each student, and briefly explain the challenge.

6. Assign a time limit to the challenge, and make sure this is clear to students.

7. Make sure to leave enough time at the end of each challenge for students to present their methods to their classmates. If you like, you can have students work through the problems on a large piece of butcher paper that can be displayed on the wall for others to see.

**HOW TO EXPAND:**
You can extend this learning experience by having your students explore the public transportation system that exists in your community. How energy or time efficient is it? What impacts does it have on the environment or community, if any? Challenge your students to write a letter to your local government officials with recommendations for improvements.
   - If your community does not have an extensive public transportation system, your students can explore the school bus system instead.
Challenge your students to solve some of the math problems in this lesson by writing and graphing equations using Desmos free HTML5 graphing calculator

ADAPTATIONS/GOING VIRTUAL:
Activity can be done at home.

DISCUSSION QUESTIONS:

● How would you define ‘efficiency’? Is there more than one kind of ‘efficiency’? Why do you think we would want to make a public bus system efficient?

● How does public transportation impact a community? What are the potential health benefits?

● How do different energy sources used for powering buses compare? What are the benefits and drawbacks of each? What factors did you take into account in deciding how to power your public bus system?

● Why do you think we might care how much carbon a particular fuel might produce when used? Why do we care about cost?
WHAT CAUSES ROCKS TO SLIDE DOWN A SLOPE?

**ACTIVITY DESCRIPTION:** Landslides are powerful geological events that happen suddenly, causing fear in people who live in areas with unstable hills, slopes, and cliff sides. Landslides damage the surrounding habitat and can destroy homes in their path. But what causes landslides? Can slides happen on any slope, or do slopes have to have certain characteristics, such as a steep angle and a specific material mass? In this geology science project, you will learn about the different types of landslides and the characteristics of slopes and masses that unleash landslides.

**SUPPLIES:**

- Table
- Pennies (4)
- Clear adhesive tape
- Optional: Metric ruler or tape measure
- Protractor
- Clipboard, hard board
- Sandpaper, any grit (1 sheet). It should be at least half as long as the clipboard.
- Paper towels (1 sheet)
- Scissors
- Lab notebook
**STEPS:**

a) Make a taped stack of pennies.
   i) Take a piece of tape a little longer than the length of four pennies lined up next to each other (about 9 centimeters [cm] long) and centrally place two pennies so that they are touching, side by side, as shown in Figure 5.

![Figure 5](image.png)

*Figure 5.* Set two pennies side by side on a piece of tape (about 9 cm long).

b) Set one penny on each of the pennies on the tape so that you have two stacks of two pennies each, as shown in Figure 6.

![Figure 6](image.png)

*Figure 6.* Stack one penny on each of the pennies on the tape.
c) Then wrap the tape long-ways completely around the pennies so that they are held in place, still stacked and side by side, as shown in Figure 7. The tape should slightly overlap on the top side.

![Figure 7. Fold the tape over the pennies.](image)

2) Attach a strip of paper towel to the bottom of the stack of pennies.
   a) Cut out a strip of paper towel that is slightly longer than the length of one of the stacks of pennies, and the same width as the pennies (the strip should be about 5 cm to 6 cm long and 2 cm wide), as shown in Figure 8.

![Figure 8. Cut a small strip of paper towel that is slightly longer than the stack of pennies.](image)

b) Take the taped stack of pennies and make sure the rough, exposed tape edges are on the top, and the smooth side is on the bottom.

c) Using two small pieces of tape, tape the paper towel strip long-ways on to the bottom of the stack of pennies so that both edges of the strip curve around to the top side and are taped there.

   Do not put any tape on the bottom side, which should be completely covered by the paper towel strip.
Figure 9. You should end up with a stack of pennies with a paper towel strip on the bottom of it.

Testing the Model Landslide

1. Securely tape the protractor along the edge of the table so that the zero angle mark of the protractor is aligned to the edge.
2. Place the clipboard on the table so the end of the clipboard is lined up with the zero mark of the protractor. Your setup should now look similar to Figure 10.

Figure 10. Experimental setup for modeling landslides.

3. Place the prepared penny stack on the clipboard, touching the clip at the top, as shown in Figure 11. Make sure the stack is placed so that the rough tape edges are facing up (and the paper towel strip is touching the clipboard).

Figure 11. Place the stack of pennies at the top of the clipboard, touching the clip.
4. Holding onto the clip, slowly and steadily lift the clipboard, as shown in Figure 12, making sure to lift only one side. The bottom of the board should stay put at the zero point on the protractor.
   1. You can loosely tape the clipboard at the zero point or you can gently place one finger on the bottom of the board to make sure the bottom does not lift and that the bottom edge of the clipboard stays at the zero position.

Figure 12. Slowly lift the clipboard, making sure the bottom part of it stays in place.

5. Stop tilting the board when the penny stack slides at least halfway down the clipboard. Note the angle (in degrees, or °) of the top side of the clipboard on the protractor in your lab notebook in a data table like Table 1. This is the angle of repose.

6. Repeat steps 3 to 5 nine more times for a total of 10 trials. Note the angle of repose of each trial in your lab notebook in the data table you created in step 5.
### Table 1

<table>
<thead>
<tr>
<th>Clipboard Surface</th>
<th>Average Angle of Repose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>Plain Clipboard</td>
<td></td>
</tr>
<tr>
<td>Clipboard with Paper Towel</td>
<td></td>
</tr>
<tr>
<td>Clipboard with Sandpaper</td>
<td></td>
</tr>
</tbody>
</table>

#### Table 1.

Make a data table like this in your lab notebook to record angle of repose data for the three different clipboard surfaces you test. You will do ten trials for each surface. Record the angle of repose in degrees (°).

7. Now take a paper towel sheet and clip it onto the clipboard. (If the sheet has a rectangle cut out of it, arrange it so that the rectangle is at the bottom.) Using a paper towel mimics added resistance forces on a real slope. Resistance forces could be vegetation or different kinds of underlying rock.

8. Repeat steps 3 through 6 with the penny stack, but this time slide it down the paper towel sheet. Lift the clipboard in the same way and with the same speed as in steps 3 through 6. Record all of the data in your lab notebook. Note any differences that you see in how the penny stack moves down the paper towel surface compared to the bare clipboard surface.
9. Lastly remove the paper towel from the clipboard, take a sandpaper sheet, and clip it onto the clipboard. Using a sheet of sandpaper mimics adding more resistance forces on a real slope.

10. Repeat steps 3 through 6 with the penny stack, but this time slide it down the sandpaper sheet. Lift the clipboard in the same way and with the same speed as you did previously. Record all of the data in your lab notebook.

Analyzing Your Data

1. Average the angles of repose for each clipboard surface (separately) over the ten trials. In your lab notebook, record the data in a data table like Table 2.
   1. For example, if in the ten trials for the plain clipboard you got angles of repose of 20°, 21°, 20°, 19°, 21°, 20°, 20°, 19°, 22°, 21°, the average angle of repose would be 20° (since that is the sum of these numbers divided by ten, which is the total number of trials).

<table>
<thead>
<tr>
<th>Clipboard Surface</th>
<th>Average Angle of Repose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain Clipboard</td>
<td></td>
</tr>
<tr>
<td>Clipboard with Paper Towel</td>
<td></td>
</tr>
<tr>
<td>Clipboard with Sandpaper</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Calculate and record the average angle of repose for each test condition in your lab notebook in a data table like this one.

HOW TO EXPAND:

1. Make a bar graph using the data from Table 2.
   1. You can plot your data on graph paper,
   2. Label the x-axis (the horizontal axis) ”Clipboard Surface” and the y-axis (the vertical axis) ”Average Angle of Repose.”

2. Analyze your graph. Do you see a correlation between the average angle of repose and the clipboard surface? Based on your data, do you think the surface of the slope affects the angle of repose? Is your data in agreement with what you expected? Can you explain your results in terms of friction?
3. If you think of the plain clipboard as a sandy hill, the paper towel covered clipboard as a rocky hill with some grass, and the sandpaper covered clipboard as a hill covered in dense vegetation, what can you extrapolate about hill coverings and the likelihood of landslides? What role would the slope of the hill play in the likelihood of a landslide?

ADAPTATIONS/GOING VIRTUAL:

- If virtual, have students run experiments with household members.

DISCUSSION QUESTIONS:

- One source of erosion is the loss of vegetation from the slope. Why do you think the loss of vegetation can result in erosion?
- How does gravity cause an object to go down a hill?
- What factors might affect an angle of repose?
- How does friction between two objects affect how the objects move?
- How do you think landslides made out of solid objects move compared to landslides made out of fluid-like mud?
WHEN DISASTERS STRIKE

**ACTIVITY DESCRIPTION:** In this activity, participants can either work independently or collaboratively in groups. The goal is to build a town, any town they want that will survive a disaster. The town must include homes, businesses, streets, and schools. What you won’t tell them is what disaster to expect, when to expect, and how often to expect it.

During the activity participants will have to keep track of resources they have (water, food, shelter, money, etc.). As the facilitator, you can set the number of resources each group has, for example, one group may only have enough clean water for their whole town for two days.

**SUPPLIES:**
- Playdough
- Legos
- Pipe cleaners
- Boxes
- Pencils
- Markers
- Paper Plates
- Dice

**STEPS:**
1. Have participants get into groups and decide the name of their town and where it will be located/what type of town it is.
2. Next, give them five minutes to decide how they will design their town and why they want to design it that way.
3. After they’ve submitted their loose plans they’ll have fifteen minutes to build their towns out of the supplies you’ve provided and they will need one di.
4. Once they’ve built their towns, have groups roll the dice they have. If the a group rolls the following:
   a. 1 they experience a flood (¼ resources)
   b. 2 they experience a hurricane (¼ the resources are lost)
   c. 3 tornado hits (¼ of the resources are lost)
   d. 4 they send aid to one of the other groups (this diminishes their resources by ⅓)
   e. 5 nothing happens
f. 6 a wildfire breaks out – and they have to evacuate half the town (½ the resources are lost)
5. After the first roll, they will have five minutes to try to rebuild their town and prepare it for what will happen next with the resources they have left. During this process have them think about what they need for their town to survive?
6. Have them repeat steps 4-5 three times. Once groups have finished, have a discussion on what happened and why? How does this relate to real-world situations like Hurricane Katrina? The Wildfires or hurricanes? What steps could be taken to mitigate the challenges towns and cities experience?

HOW TO EXPAND:
- Read the book “Salvage the Bones” By Jesymn Ward
  - After reading, write down three questions you have based on the reading. Then have a conversation with those around you about the themes within the book and ask them the questions you developed earlier.

ADAPTATIONS/GOING VIRTUAL:
- If virtual, have students host the game with household members.

DISCUSSION QUESTIONS:
- What are the most challenging aspects of living in an area that has experienced a disaster?
- How does a disaster impact a community?
- Are there communities that face a higher rate of disasters and does this impact the health of its community members?
GOO-BE-GONE: CLEANING UP OIL SPILLS

ACTIVITY DESCRIPTION: Have you ever seen news coverage or other pictures of an oil spill in the ocean and wondered how all of that oil could be cleaned up? Oil spills can devastate wildlife by covering them with oil, and they can damage our precious water resources by contaminating them with oil. Part of the problem of dealing with oil spills is that the oil can be challenging to clean up. In this science project, you will test the absorptivity of different materials (called sorbents) to discover which ones are best at removing oil from water.

SUPPLIES:

- Newspaper
- Large plastic garbage bag
- Liquid measuring cup, 4-cup size
- Four or more sorbents that you want to test (3 cups of each)
  - Examples include: cotton, hair, fur, straw, corn cobs, corn husks, polypropylene pads, shop towels, and bird feathers.
- Scissors, if sorbent needs to be cut into smaller pieces
- 3 Paper or glass bowls, 12-oz size
- Vegetable oil (1 gallon)
- Pitcher of water
- Dry measuring cup, 1-cup size
- Reusable mesh coffee filter
- Stopwatch/ timer/ clock that shows seconds
- Liquid soap
- Lab notebook
- Graph paper

STEPS:

1. Spread newspaper onto your work surface, to make cleanup easier.
2. Open your garbage bag and put it close to the liquid measuring cup.
3. Prepare your sorbents one at a time so you can keep your workspace uncluttered.
1. Cut large sorbents into small, thumb-sized pieces so that they can easily fill a measuring cup. Figure 2, below, shows examples of prepared sorbents. Prepare at least three cups of each sorbent you want to test this way.

2. Use caution when crushing or smashing coconut husks. Wear eye protection and gloves, and cover the coconut with a large towel or place it in a burlap bag before smashing it. Be sure to only smash the coconut on a surface that you have permission to hammer on.

![Figure 2. Four prepared sorbents (clockwise from top left): shop towels, coconut husk, hair, and cotton.](image)

4. After you have prepared your first sorbent, divide it into three piles of 1 cup each and place each pile in a glass or paper bowl.

5. In your lab notebook, make a data table, like Table 1, below, for each sorbent to record your results. Be sure to fill in your tables with the actual names of the sorbents you are testing.
<table>
<thead>
<tr>
<th>Sorbent 1 Name (for example, <em>Fur</em>)</th>
<th>Total Water and Oil Level (A)</th>
<th>Remaining Water Level After Removing Sorbent (B)</th>
<th>Remaining Oil Level After Removing Sorbent (A-B)</th>
<th>Ratio of Remaining Water Divided by Remaining Oil (B / (A-B))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1 (using first cup of sorbent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 2 (using second cup of sorbent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 3 (using third cup of sorbent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. In your lab notebook, make a data table like this one for each sorbent you want to test. Fill in your data table (in the top left corner) with the actual name of the sorbent you are testing.

6. Pour 3 cups of water into the liquid measuring cup.
7. Slowly add 1 cup of vegetable oil. Do the oil and water separate or mix?
   a. Note: In some trials, a layer of bubbles may form between the water and oil layers. If this happens, wait a few minutes until the bubble layer mostly disappears.
8. Put 1 cup of your first sorbent into the reusable mesh coffee filter. Lower it slowly into the water-oil mixture and gently move it from side to side for a few seconds until the sorbent is completely submerged, as shown in Figures 3 and 4. You may need to slowly lower the filter below the surface of the liquid in the measuring cup for liquid to easily get into the filter.

![Figure 3. Testing hair as a sorbent.](image)

9. After the sorbent has been submerged in the liquid, start your stopwatch or timer (or note what time it is on your clock).
10. After 30 seconds, lift the filter with the contents of the sorbent inside and hold it just above the surface of the water-oil mixture for 30 more seconds to drain.
11. Dump the contents of the mesh coffee filter into the plastic garbage bag.
12. Get down level with the liquid measuring cup and read and record the total water and oil level (measure A, as shown in Figure 4).
13. Measure and record the remaining water level (measure B, as shown in Figure 4).

14. Wash out the mesh coffee filter and measuring cup with soap and water.

15. Repeat steps 6–14 for the remaining piles of your first sorbent.

16. Then repeat step 6–15 for the rest of the sorbents you chose.

17. Now calculate the remaining oil after removing the sorbent (by subtracting B from A) for each trial and record it in your data table.

18. Calculate the ratio of remaining water to remaining oil for each of the trials and record it in your data table.

19. Average the ratios for each sorbent (for the three trials for each sorbent) and record them in a new data table, like Table 2, below.

Figure 5. Measure point A and point B after removing sorbent.
Table 2. In your lab notebook, make a new data table like this one and record the average ratios for your trials with each sorbent. Note that this data table shows several sorbents you may have tested, but you only needed to test at least four sorbents in this science project.

<table>
<thead>
<tr>
<th>Sorbent Name</th>
<th>Average Ratio of Water to Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Sorbent</td>
<td>3</td>
</tr>
<tr>
<td>Fur</td>
<td></td>
</tr>
<tr>
<td>Hair</td>
<td></td>
</tr>
<tr>
<td>Straw</td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td></td>
</tr>
<tr>
<td>Corn Husk</td>
<td></td>
</tr>
<tr>
<td>Polypropylene Pads</td>
<td></td>
</tr>
</tbody>
</table>

**How to Expand:**

- Make a bar graph of your results.
  - Plot the average water-to-oil ratios (on the y-axis, or the vertical axis) vs. the sorbents you tested (on the horizontal axis, or the x-axis). Make a bar for each sorbent you tested.
Analyze your results. The higher the ratio, the better the sorbent was at removing oil.

○ Are any sorbents less than the starting ratio of 3? This means that the sorbent absorbed more water than oil and would not be a good candidate for cleaning up oil spills.
○ Which sorbents have the highest average water-to-oil ratio? These would be the best sorbents for oil out of the different sorbents you tested.

ADAPTATIONS/GOING VIRTUAL:

● If virtual, have students run experiments with household members.

DISCUSSION QUESTIONS:

● What characteristics make a good sorbent?
● Is a sorbent enough to clean up an oil spill?
● How do oil spills affect your life? Why are they considered a problem when they happen?
CREDIT/SOURCES:

BOTTLED WATER TASTE TEST
1. http://eeinwisconsin.org/resource/about.aspx?s=101723.0.0.2209

TRANSPORTATION DESIGN CHALLENGES
1. https://www.calacademy.org/educators/lesson-plans/building-better-buses-transportation-design-challenges

WHAT CAUSES ROCKS TO SLIDE DOWN A SLOPE?

GOO-BE-GONE: CLEANING UP OIL SPILLS
1. https://www.sciencebuddies.org/blog/environmental-education-stem-project-roundup
OVERVIEW

Polychlorinated biphenyl (PCB), a dangerous chemical, was illegally dumped along North Carolina highways in 1978. When the dumping came to light, state officials selected the mostly Black community of Afton, Warren County, for a landfill to store the contaminated soil. This site did not meet EPA guidelines for hazardous waste landfills. Residents fought the landfill's construction through legal action and protests. More than twenty years later, community members held the State to its promise to decontaminate the site. The situation in Warren County sparked a national landmark study of hazardous waste landfill siting in poor communities of color and is recognized as the birthplace of the environmental justice movement.

THE COMMUNITY

State officials selected Warren County as the site for PCB-contaminated soil in June 1979. Sixty percent of Warren County’s population of about 16,000 was Black in 1980, versus 22% in North Carolina overall. Warren County was also one of the poorest counties in the state, ranking 97 out of 100 for income.

THE HAZARD

PCB is a chemical used in coolants and lubricants for transformers. Studies completed in 1975 showed elevated stomach and liver cancer rates resulting from PCB exposure. The Toxic Substance Control Act of 1976 banned the manufacture of PCB in the U.S. The 1976 Resource Conservation and Recovery Act guides the disposal of existing PCB, which can be very costly. In 1976, a trucking company hired by Ward Transformer Company sprayed 31,000 gallons of PCB-contaminated oil...
The illegal dumping was discovered in 1978, but the contaminated soil remained along roadsides until September 1982. The population living near the contaminated soil reported an increase in miscarriages and birth defects. Fourty-thousand cubic yards of PCB-contaminated soil were taken to a 142-acre landfill near Afton in Warren County in 1982.

In 1979, the state proposed four options approved by the Environmental Protection Agency (EPA) to dispose of the contaminated soil. These options were: centralized in-state burial of the waste, in-state burial within each county, transporting the soil to another state for disposal, and transporting the soil to incinerators. Because of cost, the state decided to bury the waste in-state. All but two of 90 potential landfill sites were disqualified from consideration based on failure to meet EPA requirements for the landfill. The remaining locations were Warren County land and a sanitary landfill in Chatham County. Chatham County residents opposed the PCB landfill, so the county withdrew its offer to allow PCB burial there.

At a public meeting in 1979, the state asked the EPA for waivers of three regulations at the Warren County site: elimination of the requirement for 50 feet between the landfill and groundwater, elimination of an artificial liner, and elimination of underliner leachate collection. At another meeting, an EPA advisor told the public that nothing would leak from the landfill, so distance to groundwater did not matter. However, Warren County residents hired their own soil expert who reported that the soil could not be compressed to create a protective layer and had a high chemical exchange capacity, so groundwater would be contaminated. Still, the EPA granted the waivers for the location later in 1979.

When the EPA approved the landfill permit application, Warren County filed a federal lawsuit to prevent the purchase of the land and construction of the landfill. The courts temporarily prevented construction, but allowed the state to purchase the land. In 1981, the courts ruled against the county and said that the design for the site was safe and the process for site selection was sound.

“It was a true testament of how the state and community came together. And it wasn’t an easy task. It was a lot of man-hours . . . that will never probably be accurately recorded. People . . . came and really pushed the state to live up to their word. Because if it wasn’t for that, [there] would still be PCBs in the landfill today. But because of people dedicated to the cause, it was done. And that was true perseverance.”

– Community Member
LEGAL RESPONSE (continued)

In 1982, the local chapter of the National Association for the Advancement of Colored People (NAACP) filed suit in district court, saying the site was not safe because the Warren County land failed to meet several EPA regulations and other sites were likely more suitable for the landfill. The NAACP suit alleged that Afton’s poor, rural, and mostly Black residency was a driving force in the state’s siting decision. The lawsuit was denied a month later because previous cases did not cite race as a factor. However, a 1983 report from the General Accounting Office showed that race and low income appeared to be associated with hazardous waste siting.

COMMUNITY RESPONSE

In 1979, residents formed Warren County Citizens Concerned About PCBs to fight the siting and construction of the landfill. Residents held rallies and protests of the landfill. The first truckload of soil that arrived at the landfill in September 1982 was met by 400 to 500 protesters. State highways patrol arrested 55 people on the first day, but the protests continued for the next six weeks while the soil arrived. During this time 523 arrests were made, including juveniles, senior citizens, and U.S. Congressman Walter Fauntroy.

A week after the last truckloads of contaminated soil arrived at the landfill, Governor James Hunt promised to detoxify the landfill when the technology became available. The landfill was capped in late November 1982. Three months later, gas from decomposing vegetation in the landfill caused bubbles in the liner and gurgling sounds. The liner was vented, and the state proposed a drainage system to remove the water.

“I walked to the landfill . . . with my mom. And when havoc started, we got separated. And I was just screaming, ‘Don’t bring the trucks in. I don’t want to die from cancer.’ And they picked me up, and they picked my mom up, and at that point in time I was still screaming. And I was the only child actually on the adult paddy wagon to go to jail that day.”

– Community Member
DISCOVERIES AND PROGRESS

By 1993, there were about 13 feet of water trapped in the landfill. The Department of Environment, Health, and Natural Resources proposed a $200,000 project to install a new water pump to relieve water pressure on the landfill liner. In 1994, the state Division of Solid Waste Management tested the landfill for the first time since its construction and found trace amounts of dioxins in monitoring wells uphill and downhill from the landfill. Warren County residents demanded a full cleanup of the site. In 1997, an independent advisor to the Joint Warren County/State PCB Working Group said there was evidence that the landfill was leaking and contaminating air and soil. Despite the evidence of dangerous chemicals in the community, the EPA and the state maintained that the site was safe.

In response to demands from Warren County residents, Governor Hunt included $15 million in the state budget in 1998 to clean up the Warren County landfill. PCB removal began in 2002, and at the end of 2003, the PCB landfill closed after $18 million in cleanup efforts. The soil from the site was decontaminated to 10 times cleaner than federal standards.

"Now that the PCB dump is cleaned up, that was one site looked at to revitalize and use . . . . And I saw the potential of that. We could turn around something that’s negative and make it a positive and show others that just by working together and having a vision and being consistent and sacrificing, we can move mountains."

- Community Member

Warren County PCB Landfill detoxification.
Source: Warren Family Institute, Inc.
Photographer: Bill Gallagher

This is part of a series of stories about how communities in North Carolina have faced environmental health concerns. Sources include articles from The News & Observer (Raleigh, NC) and interviews with community members. A longer version with references is available on our website. Published September 3, 2006.
Building Better Buses: Transportation Design Challenges
Teacher Solutions: Challenge #1

Map of Downtown Solutionville

Rules
1. Bus(es) must start from AND end at the bus depot.
2. You can have as many buses running as you like, but all bus stops must be serviced.
3. Bus(es) can only pick up passengers on the right side of the road. Pay attention to the side of the street that the bus stop is on!

Note: The solution drawn on the map above is only one possible solution to Challenge #1 and assumes there is only one bus in the fleet. It is not necessarily the best (most energy or time-efficient) solution. Below is one possible way students might calculate distance and time for this particular solution (all distances have been measured using the scale bar):

- Distance from Depot to Stop 1: ~1.36 mi
- Distance from Stop 1 to Stop 2: ~1.03 mi
- Distance from Stop 2 to Stop 3: ~0.81 mi
- Distance from Stop 3 to Stop 4: ~0.88 mi
- Distance from Stop 4 to Stop 5: ~1.13 mi
- Distance from Stop 5 to Stop 6: ~0.88 mi
- Distance from Stop 6 to Stop 7: ~0.88 mi
- Distance from Stop 7 to Depot: ~1.8 mi

Total distance: ~8.77 miles

Time of complete circuit:
(8.77 miles ÷ 0.5 mile/minute) + (1 minute/stop × 7 stops) = ~24.5 minutes
1. Use ratios to solve:
Which is more fuel efficient: a bus powered by E85 biofuel or a bus powered by regular gasoline?

<table>
<thead>
<tr>
<th>Bus 1: E85</th>
<th>Bus 2: Regular gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance driven = 108 miles</td>
<td>Distance driven = 243 miles</td>
</tr>
<tr>
<td>Fuel used = 36 gal ÷ 2 = 18 gal</td>
<td>Fuel used = 36 gal x (3/4) = 27 gal</td>
</tr>
<tr>
<td>Fuel efficiency = miles per gallon</td>
<td>Fuel efficiency = miles per gallon</td>
</tr>
<tr>
<td>= 108 mi ÷ 18 gal</td>
<td>= 243 mi ÷ 27 gal</td>
</tr>
</tbody>
</table>

= 6 mi/gal

**A bus running on regular gasoline is more fuel efficient compared to a bus running on E85 biofuel.**

2. Use ratios and cross-multiplying to solve:
How the carbon dioxide produced by a bus burning regular gasoline compares to the carbon dioxide produced by a bus running on E85 biofuel for the same distance driven.

- First, decide on a distance. Here, we’re going to choose 6 miles, the distance a bus can travel on 1 gallon of E85 biofuel. This makes it easy to calculate how many kilograms of CO₂ are produced by a bus running on E85:

  Fuel efficiency of a bus running on E85 = 6 mi/1 gal

  \[
  \frac{10 \text{ gal E85}}{12 \text{ kg CO}_2} = \frac{1 \text{ gal E85}}{? \text{ kg CO}_2}
  \]

  \[
  12 \text{ kg CO}_2 \times 1 \text{ gal E85} \div 10 \text{ gal E85} = 1.2 \text{ kg CO}_2
  \]

- There are several ways to solve for how many kilograms of CO₂ are produced by a bus traveling 6 miles on regular gasoline. One way is to use the same method as above to solve for the CO₂ produced by a bus traveling 9 miles (1 gallon) on regular gasoline, then divide the answer by 1.5 since 9 miles is 1.5 times longer than 6 miles:

  Fuel efficiency of a bus running on regular gasoline= 9 mi/1 gal

  \[
  \frac{5 \text{ gal gas}}{45 \text{ kg CO}_2} = \frac{1 \text{ gal gas}}{? \text{ kg CO}_2}
  \]

  \[
  45 \text{ kg CO}_2 \times 1 \text{ gal gas} \div 5 \text{ gal gas} \div 1.5 = 6 \text{ kg CO}_2
  \]

  Regular gasoline releases 5 times as much CO₂ as E85 for the same distance traveled!
3. Use ratios and canceling out units to solve:
How the cost of running buses on E85 biofuel compares to running buses on regular gasoline for the same distance.

• Let’s pick 9 miles for our distance. We know it will cost $X for a bus running on regular gasoline to go 9 miles, since this is the distance the bus can travel on 1 gallon of gasoline, and gas costs $X/gal.

• If a bus needs 1 gallon of E85 to drive 6 miles, then it needs 1.5 gallons of E85 to drive 9 miles since 9 is 1.5 times larger than 6:

\[
\frac{6 \text{ miles}}{1 \text{ gallon E85}} = \frac{9 \text{ miles}}{1.5 \text{ gallons E85}}
\]

• Therefore, we can just multiply the price per gallon of E85, $Z, by 1.5 and compare our result to the price per gallon of regular gasoline, $X:

\[
\frac{\$Z}{1 \text{ gallon E85}} \times 1.5 \text{ gallons} = \$Y
\]

for a bus to travel 9 miles on E85 compared to $X on gasoline.

Building Better Buses: Transportation Design Challenges
Teacher Solutions: Challenge #3

1. Use a variety of methods to:
   a. Minimize CO$_2$ emissions produced by your bus system.
   b. Minimize the cost of your plan.

• For this Challenge, students can use very similar methods to optimize their bus system plan as they did in Challenges #1 & 2. Encourage students to draw pictures or tables, pay attention to their units, and use dimensional analysis to help them figure out their calculations.

• Students might find it confusing to do calculations for 50/50 electricity since they might not understand how to think about it. You can give them an example, such as how to figure out how many pounds of coal are needed for a bus to drive 10 miles on 50/50 electricity. In this example, students can think of the bus as traveling 5 miles using 100% coal (which has a cost and produces CO$_2$) and 5 miles on wind power (which is free and doesn’t produce CO$_2$).

• Instead of grading students on how well they were able to optimize their solutions, focus on the methodologies students used to come up with their solutions. Students should be able to explain their thinking as well as their problem solving strategies. There is no one correct answer to this Challenge.
• If your students struggle with ratios, encourage them to draw the ratio as a picture (e.g., by representing each variable with a symbol). Alternatively, you can give your students physical items to use to represent the variables and create ratios, like marbles, coins, or pieces of candy.

• The specific numbers reported in the solutions above may not be the same numbers your students come up with, depending on the conditions they choose to start with (e.g., how many miles they choose as the distance their buses travel).

• Give your students plenty of extra scratch paper so that they have a lot of room for problem solving and for making mistakes.

• Need more examples of math and computational problem solving and modeling? Check out these additional resources:

  ▪ **Mathematics Assessment Project: Classroom Challenges**
    The Mathematics Assessment Project aims to bring the Common Core State Standards (CCSSM) to life in a way that will help teachers and their students turn their aspirations for achieving them into classroom realities.

  ▪ **California Mathematics Project: K-8 Modeling Resources**
    The California Mathematics Project (CMP) is a K-16 network dedicated to providing students a rich, rigorous, and coherent mathematics curriculum taught by competent and confident mathematics teachers who foster ALL students’ proficiency in mathematics—achieving equity in quality. CMP enhances teachers’ mathematical content knowledge and pedagogical content knowledge that is aligned to the California Mathematics Standards and Framework.
Building Better Buses: Transportation Design Challenges

Challenge #1: Design an ‘efficient’ public bus system

Name: ___________________________ Date: ___________________________

**Introduction:** The citizens of Solutionville want to make sure their community is a healthy and safe place for families to live. They decided to start by giving people more access to efficient and convenient public transportation. Imagine you are a citizen of Solutionville who has been tasked with helping to design a public bus system that would service the downtown area.

**Your Challenge:** Design a bus route system for downtown Solutionville. Your teacher will tell you your time limit for this Challenge.

1. **On your own,** draw your bus routes on the Map of Downtown Solutionville using arrows to indicate the direction of the buses.

2. Try to **minimize** both the **distance traveled** by the buses and the **amount of time** people have to wait at any one bus stop.

3. Make sure your routes obey the Rules listed on the map.

4. **Calculate the total distance** driven by all buses after all bus stops have been serviced once.

5. **Indicate how long** the longest complete bus circuit takes. Assume buses drive at an average of 30 mph (equal to 0.5 miles per minute) and spend one minute at each stop.

6. **Compare** your route to your partner’s. If you have time, work together to try another system of routes.

**What You Will Need**

* Partner
* Ruler
* Calculator
* Pencil/eraser
* Scratch paper

**Tips and Hints**

- Although all roads in Solutionville are two-way, to simplify your measurements, you can assume buses drive down the exact middle of the street.

- If you make mistakes or find your map is getting too messy, ask your teacher for a second copy.
Rules
1. Bus(es) must start from AND end at the bus depot.

2. You can have as many buses running as you like, but all bus stops must be serviced.

2. Bus(es) can only pick up passengers on the right side of the road. Pay attention to the side of the street that the bus stop is on!

= Bus stop
= Bus depot entrance/exit

0.25 mi
Name: _______________________________ Date: _______________________________

Notes, measurements, and calculations

Total Distance of All Routes: __________

Time of Longest Complete Bus Circuit: _________
Building Better Buses: Transportation Design Challenges

Challenge #2: Compare fuels: Biofuel vs. Regular Gasoline

Name: ___________________________ Date: ___________________________

Introduction: There are several different kinds of fuels used to power things like cars, trucks, and buses. Regular gasoline and diesel fuel made from petroleum have long been used to run many of our vehicles. Biofuels made from vegetable oils aren’t new, but their popularity has grown in recent years. E85 is one type of biofuel made from 85% corn ethanol and 15% regular gasoline. When deciding which fuel to use to power a vehicle, it’s important to think about how much energy the fuel can produce, how much it costs, and its impacts on the environment.

Your Challenge: Present to your fellow citizens of Solutionville an analysis of how E85 biofuel compares to regular gasoline as options for fueling the community’s buses.

1. With your partner, read about the Bus Test Drive Experiment on the next page, and use the information in it to figure out which fuel is more efficient: E85 biofuel or regular gasoline.

2. With your partner, use the Transportation Fuel Cards and any other information you know to calculate:
   • How the carbon dioxide produced by a bus burning regular gasoline compares to the carbon dioxide produced by a bus running on E85 biofuel for the same distance driven.
   • How the cost of running buses on E85 biofuel compares to running buses on regular gasoline for the same distance driven.

3. With your partner, write a short article for the local paper, The Solutionville Inquirer, comparing E85 biofuels vs. regular gasoline in terms of cost, energy-efficiency, and impacts on the environment and the community.

What You Will Need

* Partner
* Calculator
* Pencil/eraser
* Scratch paper
* Bus Test Drive Experiment
* Transportation Fuel Cards: E85 Biofuel and Regular Gasoline

Tips and Hints

• It can be helpful to organize the information you need to solve a problem in a way that is easy for you to visualize and keep track of. Examples of organizational structures include: tables, lists, maps, pictures, flow charts. You can also cut out the transportation fuel cards so that you can easily arrange them or move them around.
Bus Test Drive Experiment

You want to compare how the fuel efficiency of a bus running on E85 biofuel compares to the fuel efficiency of a bus running on regular gasoline. You obtain two buses that are identical except that one is powered by E85 and one is powered by regular gasoline. You drive the bus running on E85 until the 36-gallon gas tank is half empty and your odometer says you drove 108 miles. You then drive the bus running on regular gasoline until the gas tank is ¾ empty (¼ full) and your odometer says you drove 243 miles.

Using this information, which bus is more fuel-efficient: the bus running on E85 biofuel, or the bus running on regular gasoline?

Notes and calculations:
E85 is a biofuel made out of 85% ethanol and 15% gasoline that can be used to power cars, trucks, and buses. Ethanol biofuel can be made from a variety of crops, such as corn or sugarcane. Below you’ll find more information about E85 that you might find useful for your calculations:

Burning 10 gallons of E85 releases about 12 kg of CO₂.

1 gallon of E85 costs about $______.

Gasoline, or ‘octane,’ is a kind of fossil fuel that is commonly used to power cars, trucks, and other kinds of vehicles. Fossil fuels formed over millions of years from the decaying remains of ancient plants and animals. Below you’ll find more information about gasoline that might be useful for your calculations:

Burning 5 gallons of gasoline releases about 45 kg of CO₂.

1 gallon of regular gasoline costs about $______.
Building Better Buses: Transportation Design Challenges

Challenge #3: Grid or No Grid?

Introduction: In some cities, public buses are not powered by gasoline or any other type of fuel that must be pumped into the bus to make it run. Instead, these buses run on electricity! This electricity can either be produced by coal, renewable energy sources like wind power, or some combination of both.

Your Challenge: As a knowledgeable and well-informed citizen of Solutionville, you have been put in charge of deciding how to power your new public bus fleet. You can use any combination of regular gasoline, E85 ethanol, and electricity produced from 50% coal and 50% wind power.

1. You can use the routes you designed in Challenge #1.
2. You should try and minimize $CO_2$ emissions produced by your bus system.
3. You should try and minimize the cost of your plan.
4. With your partner, prepare a short presentation of your final plan to present to your fellow residents of Solutionville at the next Town Hall meeting.

What You Will Need

* Partner
* Ruler
* Calculator
* Pencil/eraser
* Scratch paper
* Transportation Fuel Cards: E85 biofuel, regular gasoline, and 50/50 electricity

Tips and Hints

* It can be helpful to organize the information you need to solve a problem in a way that is easy for you to visualize and keep track of. Examples of organizational structures include: tables, lists, maps, pictures, flow charts. You can also cut out the transportation fuel cards so that you can easily arrange them or move them around.
Electricity can be produced in a variety of ways, such as burning coal, utilizing renewable energy sources like the wind or sun, or through a combination of these ways. Below you’ll find more information about coal and wind energy that you might find useful for your calculations:

Wind energy is free!

Wind produces no CO₂ emissions.

1 ton of coal costs about $______. (1 ton = 2000 lbs)

Burning 100 lbs of coal releases about 70 kg of CO₂.

It takes 36 pounds of coal to power a bus the same distance as 3 gallons of regular gasoline.