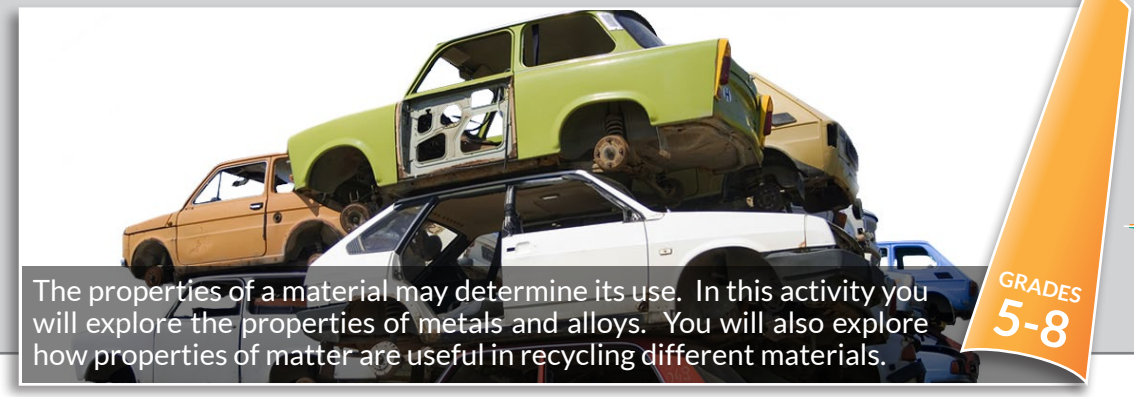
Smash Science



The properties of a material may determine its use. In this activity you will explore the properties of metals and alloys. You will also explore how properties of matter are useful in recycling different materials.

GRADES 5-8

ISRI
Voice of the Recycling Industry

JASON Learning

PREPARE:

Time Required: 2 class periods (90 minutes) without extensions

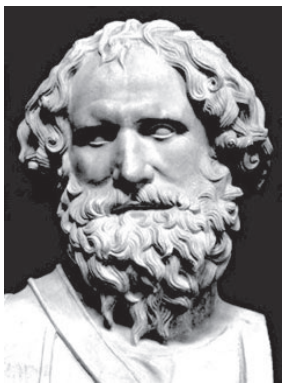
- Gather materials (refer to activity pages).
- Divide students into groups of 3-4.
- Make copies of the Smash Science student data sheet.
- Be prepared to project images from the ISRI teacher pages.
- Confirm students will have access to computers and internet.

MOTIVATE:

- Show students several Google images of cars being crushed in a scrapyard.
- Ask them what materials are in the "block" of scrap that once represented the car. Most will respond "metal." But what kind of metal? Explain to students that some of the metals might actually be mixtures of different metals. Introduce the term, alloy. An alloy is a metal containing two or more metallic elements. If a car is to be recycled properly, the metals and other materials must be separated. How is this done? To help them answer this question, tell students that they will do an investigation of their own!

TEACH:

- Explain to the students that each type of matter, such as a metal, has its own physical properties. Have them name a few as a class. Density is one of the properties that help us identify materials. Have students recall what the formula for density is (mass/volume). Each metal, like copper has a certain density. Other metals have different densities. If you mix two or more metals, the density of the mixture will be somewhere between the densities of the pure metals.
- Tell students the story of Archimedes and the King's Crown to give a legendary example of how density was used to identify metal:



In ancient times a King commissioned a crown to be made of gold. The result was a beautiful crown—but the King suspected that he had been defrauded. He thought that perhaps his crown was an alloy—a mixture of gold and a lesser metal. He asked the famous "philosopher" Archimedes to devise a test that might tell him if the crown were pure gold. Archimedes was stumped at first. But while sitting in the bathtub, he got an idea. He jumped from the tub and ran through the streets naked shouting "Eureka!" He measured the density of the crown, and compared it to the density of gold. In fact, the crown was a less expensive alloy and the king had been defrauded.

- Introduce students to a modern problem that is analogous to Archimedes' challenge. Over the past 100 years, the alloy composition of the U.S. penny—which many people believe to be made of copper—has been changed several times. Explain that students will design a procedure to determine in which year the composition of the penny changed.
- Have students conduct activity. Provide guidance as needed while students are designing their procedures. Emphasize sample size must be large enough for accuracy (if students can measure the density of 5 or 10 at a time, accuracy will increase). Let students discuss and determine why with guidance as needed. Students also need to make sure they begin with the same amount of water in the graduated cylinder.
- HINT: Depending on the number of groups, divide the pennies so that each group finds the density of 3-4 years and then they can share their data. If this is done, the procedure needs to be the same for each group – class can come to a consensus on the design.
- Younger students may need more guidance. Have them share ideas but then you can give them the procedural instructions if necessary. Here is an example:
  1. Use a balance to find the mass of 10 pennies. Record the mass in the data table.
  2. Add 50 mL of water to a graduated cylinder. Gently place the 10 pennies into the water. Record the level of the water in the data table.
  3. Subtract 50 mL from the level with the pennies. That is the volume. Record this value in the data table.
  4. Divide the mass of the 10 pennies by the volume to get the density. Record this value in the data table.
- Help students understand the current state of automobile recycling and the potential for future research.
- Show images from Teacher Pages. The last photo in the series provided is what recyclers call "Fluff." It includes the seats, fabric, plastic, and a little bit of metal. Ask students to generate ideas on how to separate the "fluff" (density, magnetism, and dissolving with chemicals).

REFLECT/ASSESS

Students should be able to:

1. Compare class data and list some potential sources of error. Why is it better to have more than one penny in each sample?
2. Identify the year in which the penny changed. What evidence do they have to support this claim?
3. Construct an explanation for why the penny's density changed. What do they think was done to penny and why?
4. Hypothesize how different metals and materials in a car might be separated in order to recycle as much as possible. Students should make a list of the steps involved. Students should explain how the experiment they conducted relates to this (idea of using density to sort and identify the metals and alloys).

EXTEND

Have students use the internet to investigate the cost of zinc and copper and calculate the absolute value of the 1980-penny vs. the 2000-penny.

Have students conduct research to determine some of the environmental impacts of disposing cars in a landfill instead of recycling. Are any of the materials toxic to humans or the environment? Have students try to find out where people should take their old and broken down cars in the local community.

JOURNAL QUESTION

Have students further consider the story of Archimedes and the Golden Crown. Archimedes realized while sitting in his very full bathtub that the volume of water that spilled out on the floor was equal to the volume of his body. How did this information help him solve the problem of the fake crown?

WEBLINKS

US Penny Characteristics https://www.usmint.gov/coins/coin-medal-programs/circulating-coins/penny

Smash Science

Background

National, state, and local standards ask students to develop an understanding of the properties of matter. The unique properties of metals and their alloys form the basis for recycling. But in many areas the entire car is still crushed, wasting valuable metals and other materials, polluting groundwater and filling landfills.

When a car is crushed, it becomes very difficult to recover the materials of which it is made. The problem is not only separating alloys but many other kinds of materials. Metals can be separated by pulverization and magnetism. Alloys are separated by heating and then differentiation by melting point and density. But that's not the end. A wide variety of other material, some highly toxic and some quite valuable, can be recovered from a car. To recycle a car rather than smash it, these steps must be followed:

- Drain all fluids including oils, coolants, refrigerants, and fuel.
- Remove the battery and catalytic converter which may be recycled separately.
- Remove tires. (Rubber must be separated from steel. The rubber can be used for paving and other secondary products.)
- The car can now be crushed and pulverized. Once the material is in small bits, the metals can be separated by den-sity. Ferrous metals can separated from non-ferrous by magnetism. Alloys can be separated by heat. There are more components of the auto that can and should be recycled. At the present time, most plastics and other fibers are left in landfills. But there is a potential to recycle these components as well.

Answers to Reflect and Apply

1. Why is it important to have more than one penny of a certain year? **Some pennies may be worn or corroded, and this could affect its mass.**
2. What year did the alloy formula of the penny change? **It changed during the year 1982. Students may find varied values for that year but there is a definite change.**
3. Construct an explanation for why the penny's density changed. What do you think was done to penny and why? **The penny used to be made up of copper, but it is now an alloy – a combination of two different metals. It is now 97% zinc! Answers as to why may vary – the extension activity challenges students to research this.** You can direct students to US Penny Characteristics.
4. Examine the pie chart that lists the materials in a modern car. Brainstorm how you might separate the materials in order to recycle as much as possible. Make a list of steps. Which of these materials do you think are most valuable and why? **The sequence of steps necessary to recycle the components of a car may vary, but students should reflect the understanding that fluids and toxic materials must be removed first and that metals can be separated by den-sity, melting point, and magnetism.** Which of these materials are most valuable? **Answers will vary, but in general metals are non-renewable resources.**

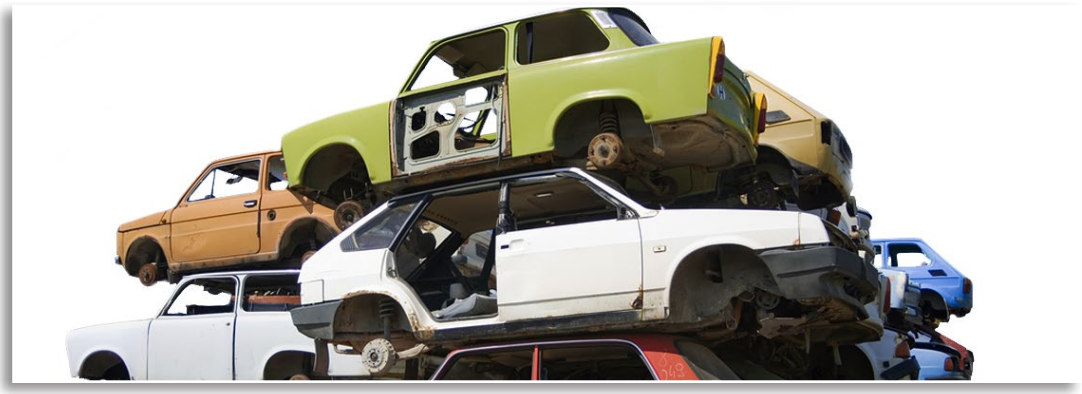
Answer to Journal Question

In figuring out how to calculate the volume of an irregularly shaped object, Archimedes was able to then calculate the density (density = mass/volume).

32,000 metric tons of iron and steel

Aluminum

“Fluff” (seats, fabric, plastic, and a little bit of metal!)



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Smash! An old automobile is crushed for recycling. But wait! There are valuable metals, electronics, even rubber from old tires that can be re-used. And there's battery acid, gasoline and oil that can harm the environment if left to sit in a land fill. How are these materials reclaimed? In many areas, the entire car is still crushed, wasting valuable metals and other materials, polluting groundwater and crowding land fills. In this activity, you will investigate how individual metals and alloys might be sorted and separated during the recycling process by experimenting with the penny!

Materials:

- Student data sheet
- 5-10 pennies from each of the years between 1980 and 2000 (ideally, 10)
- 100mL graduated cylinder
- water
- balance (digital scales or triple beam)

Part I: Collect Data

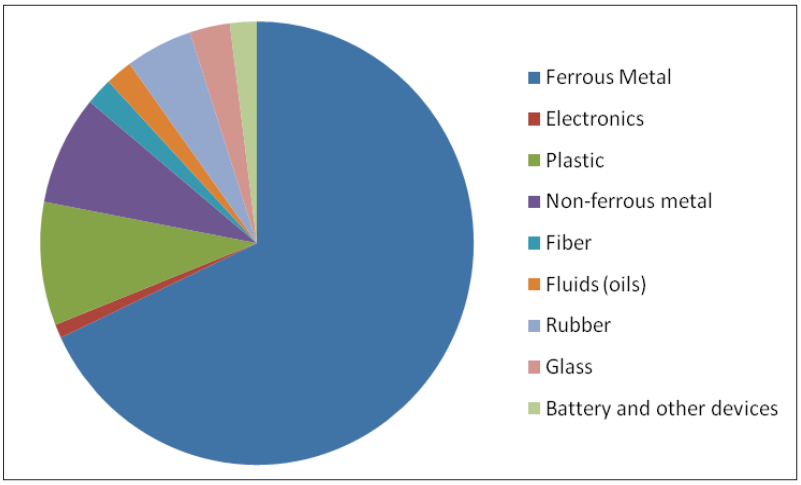
1. Collect pennies from the years 1980 to 2000. Bring them into class to "pool" so that eventually, each team will have at least 5-10 pennies from each year.
2. Make initial observations about the pennies and make a prediction as to how or if you think the composition of these pennies may have changed over the years. Make a list of measurable properties.

Part II: Determine Density

1. In your teams, discuss how you might determine whether or not the density of the penny has changed through time. What is the formula for density and what would you need to know?
2. Share your ideas through class discussion, and then write a procedure for conducting this experiment on a separate piece of paper. Consider any potential sources of error and what you need to do to minimize this.
3. Calculate the density of pennies for each year from 1980 to 2000, and record in your table.
4. Compare with class data.

Reflect and Apply

1. How did your data compare to the rest of the class's? List some potential sources of error. Why is it better to have more than one penny in each sample?
2. What year did the penny change? What evidence do you have to support this claim?
3. Construct an explanation for why the penny's density changed. What do you think was done to penny and why?
4. Examine the pie chart that lists the materials in a modern car. Brainstorm how you might separate the materials in order to recycle as much as possible. Make a list of steps. Which of these materials do you think are most valuable and why?



Extension

Investigate why zinc may have been used to make the penny. Use the internet to investigate the cost of zinc and copper and calculate the absolute value of the 1980-penny vs. the 2000-penny.

Conduct research to determine some of the environmental impacts of disposing cars in a landfill instead of recycling. Are any of the materials toxic to humans or the environment? Try to find out where people should take their old and broken down cars in your local community.

JOURNAL QUESTION

Archimedes realized while sitting in his very full bathtub that the volume of water that spilled out on the floor was equal to the volume of his body. How did this information help him solve the problem of the fake crown?

Student Name: Period:

Data Table for Determining Density

Year of pennies	Mass (g) of pennies	H2O level with-out pennies (mL)	H2O level with pennies (mL)	Volume of pennies (mL)	Density= mass (g)/volume (mL)
1980					
1981					
1982					
1983					
1984					
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