

Fifth Grade Physical Science

Supervillain Detention! Properties of Matter

Background Information:

Scientists and engineers need to understand the properties of the materials they use. They choose the best materials for specific projects based on the properties of the materials. For example, civil engineers must have a thorough understanding of the properties of materials that might be used to build roads, dams, or bridges and plan their designs around the materials that will be used.

We can observe the properties of specific materials using our senses (color, reflectivity), and other equipment. The properties requiring more than our senses include hardness, electrical conductivity, density, chemical reactivity, pH, thermal conductivity, response to magnetic forces, solubility and boiling point. These physical properties can be used to identify materials. In general, metals have these characteristics.

- Luster: Metals are shiny when cut, scratched, or polished.
- Malleability: Metals are strong but malleable, which means that they can be easily bent or shaped and can be drawn out to make wire.
- Conductivity: Metals are excellent conductors of electricity and heat and are ideal for electrical wiring.

Magnets are ideal for separating steel from aluminum in recycling situations because they only pick up iron or nickel-based substances. Aluminum and most other metals do not respond.

Students will also test whether the materials react to water or to lime/lemon juice. Rust is formed when the oxygen (in water) combines with iron to forming a new compound called iron oxide. Metals such as aluminum, zinc, and tin are also susceptible to chemical destruction, or corrosion. One way to protect iron is to coat it with special paint that keeps oxygen from reacting with the metal underneath the paint. Another method is *galvanization*: in this process, steel is coated with zinc. The brass brads, hinge pins and screws are made from a metallic alloy that is made of copper and zinc.

Another method for identifying properties of a material involves chromatography. This process is a way of separating mixtures. As the mixture separates, it leaves behind a “thumbprint” that can be used to identify individual components. Ink, plant pigment, blood, drugs, and gases can be separated.

Performance Expectation

PS1-3 Matter and Its Interactions: Make observations and measurements to identify materials based on their properties. Note: There is a common misconception that magnets attract all metals, largely due to the inclusion of steel in metal products.

<https://www.nextgenscience.org/pe/ms-ps1-3-matter-and-its-interactions>

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Science and Engineering Practices

Analyzing and interpreting data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships

Engaging in argument from evidence: Construct and/or support an argument with evidence, data, and/or a model. Use data to evaluate claims about cause and effect. Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Crosscutting Concepts

Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Cause and effect: Students identify and test causal relationships and use these relationships to explain change.

Advanced Preparation:

- You can choose the series of materials that you want students to use.
- It is suggested that you choose at least one that is magnetic, one that will conduct electricity and one that will not.
- Also include one that reacts to water or lemon/lime juice as well. Refer to the chart at the end for more information about expected results.
- Be sure to let students know what their final list of materials will be or change the list on the student sheet.
- Decide if you or the students will make small tape “flags” for the materials with permanent marker. The flags will help students to identify what they are testing.



Materials:

- Small Cups of Water and Lime or Lemon Juice
- Small Ceramic Magnets
- Batteries and Bulbs
- Aluminum Foil
- Sandpaper
- Painters Tape, File Folder Labels (For Flags)
- Permanent Marker
- Common Iron Nail
- Stainless Steel Nail
- Plastic Anchor
- Brass Paper Fastener
- Copper nail
- Galvanized nail
- Aluminum nail
- Hand Lenses
- Wood Dowel or lathe

Resources: https://www.teachengineering.org/activities/view/nyu_matls_activity1
<https://www.explainthatstuff.com/magnetism.html>
<http://www.sciencekids.co.nz/sciencefacts/magnets.html>
<https://www.teachengineering.org/k12engineering/designprocess>

Suggested Implementation:

Collect and display various metallic and non-metallic materials. Examples might include: metal or plastic colander, bowl, waste basket, hangar, tools, kitchen utensils, toys, books, food containers or cans. In small groups or as a class, ask the students to compile a list of some materials' properties that we could use to distinguish metals from nonmetals. On the list of properties, use a marker to indicate which ones we can detect using only our senses. These might include a material's color, texture, how it tastes and how it smells. Ask the students to think about other ways to test materials.

For example, are there tests we could use to tell metals apart from nonmetals in addition to tests of the senses? (magnetic, conducts heat or electricity) Have students share their ideas.

On the student pages, a scenario sets up the challenge for them. Read the challenge together.

Share available materials. Students work in small groups or pairs and complete testing of at least 6 materials that they can use to respond to the challenge. Groups will summarize their findings and determine the best course of action based on their evidence.



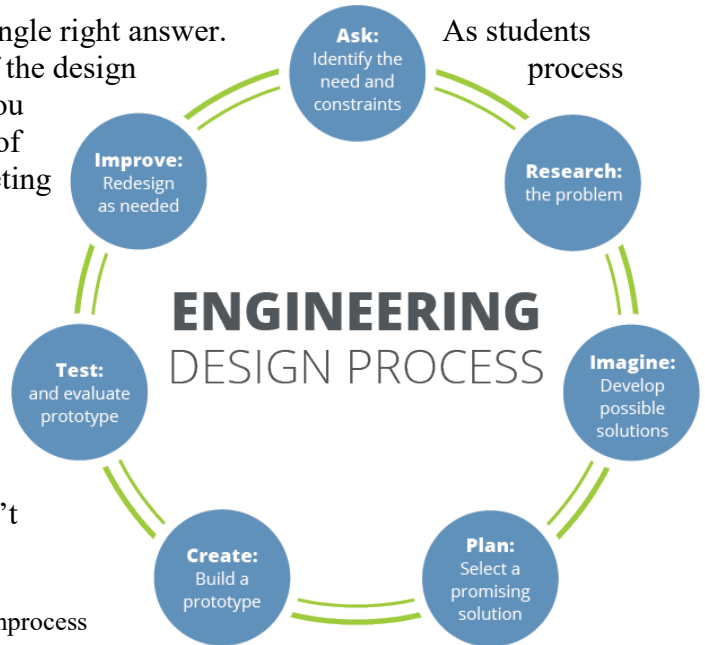
Students may need assistance in setting up for testing electrical. Assist as needed. One idea for conductivity testing is shown here.

Aluminum foil folded into strips works well. These can be taped to the battery and the bulb holder for more stability.

Students may need to keep the water and lemon/lime juice tests overnight in order to see a reaction.

The wide variety of materials means that there are several potential strategies that might work. Dr. Chrono, the local villain, can speed up time and can produce water from her fingers. This might cause some metals to rust and crumble instantly. She can also control metals that are magnetic. Elemento, the hero, is vulnerable to aluminum since it is toxic and makes him weak. His superpower is heat which is used to melt any plastic he touches.

This activity is an open-ended challenge with no single right answer. As students progress through the activity, point out the steps of the design process that they are using. (Research, Imagine, Plan). If you have the students move into the extension activity of building a model room, then they would be completing the Create, Test and Improve parts of the design process.



- Encourage students to think about several ways to solve a problem before choosing one.
- Ask questions like “What have you tried? How did it work? Why do you think it didn’t work? What else could you do?”

<https://www.teachengineering.org/k12engineering/designprocess>

- Engineers keep notebooks to collect data, sketch ideas, design results.
- Engineers present their designs and use evidence to explain why they made the design decision.

After the properties tests are completed for all materials, have students share their results and discuss their findings for each of the materials before they make decisions about which ones to use in keeping Dr. Chrono contained. Use this discussion to gauge students' level of comprehension in distinguishing among metals. Students now draw their ideas of the holding room with their explanation about choices of materials. Have students share their solutions with the class.

Material	Color shiny or dull (Luster)	Hardness (sandpaper scratch?)	Hardness (common nail)	Conducts Electricity	Magnetic	Reaction to Water	Reaction to Lime Juice
Wood Dowel	Dull brown	Yes	Yes	No	No	No	No
Copper nail	Shiny copper	Yes	Yes	Yes	Yes	No	No
Aluminum nail	Dull silver	Yes	Yes	Yes	No	Yes discoloration	No

Plastic screw	Dull white	Yes	No	No	No	No	No
Zinc screw	Shiny silver	Yes	No	Yes	Yes	Yes discoloration	Yes discoloration
Cement Screw (ceramic coated steel)	Dull blue	Yes	Yes	No	Yes	No	No
Common iron nail	Dull silver	Yes	Yes	Yes	Yes	Yes (rust)	Yes discoloration
Brass hinge pin	Shiny gold	Yes	No	Yes	Yes	No	Yes discoloration
Brass screw	Shiny gold	Yes	No	Yes	No	Yes discoloration	Yes discoloration
Brass brads	Shiny Gold	Yes	Yes	Yes	No	Rust on Edge	No
Tempered Hardened Steel nail	Dull silver	Yes	No	Yes	Yes	Yes (Rust)	No
Stainless Steel nail	Dull silver	Yes	no	Yes	No	No	No
Galvanized nail	Dull silver	Yes	yes	Yes	Yes	No	No
Nickel hinge pin	Shiny silver	Yes	no	Yes	Yes	No	No

Debrief:

- What were some characteristics (traits) you observed?
- Why was it helpful to know the about the traits of each item you tested?
- Could you group any objects into categories? Explain your ideas.
- What evidence did you use to make your decision?

Part 2: Dog Days of Summer

Materials:

- Cups
- Pencils
- Kool-Aid
- Chromatography Paper
- Tape
- Dog Days of Summer Power Point
- Water

Advanced Preparation:

- ✓ Make a chromatography strip of the business responsible for the spill.
- ✓ Determine which Kool-Aid solution will be the sample from each of the businesses. Label a cup for each of the businesses: SPLASH Waterpark, Guaranteed Grocery, Gas ‘N Go Blueberry Bakery, and Marvel Marina.
- ✓ Make concentrated solutions from the Kool-Aid. Put the appropriate solution in the correct cup.
- ✓ Use the Dog Days of Summer power point to introduce the scenario. It is a very warm summer day and you are headed to your favorite place – SPLASH Waterpark on Lake STEM. You pass by several of places you like to visit around the lake. But when you get there, SPLASH Waterpark is closed due to a large spill. It is up to you to determine a plan for solving the case. Share that students will be using a process called chromatography to gather their data. It may be helpful to have a model of the chromatography setup for students to view. Assist groups as they work through the investigation.

Debrief:

- Which business is the source of the spill?
- What evidence do you have to support your decision?
- How was the evidence gathered? Explain your ideas.
- Why would chromatography be helpful in a situation like this?
- Is there anything else you would like to know prior to making your decision? Share your thoughts.

Extension Challenge:

Depending on time, have students build a small model of the holding room with simple materials (cardboard, paper, card stock, etc.) and produce an accompanying drawing that will explain their design solution along with the materials that it would be made of in real life using the selected metals from their testing.

Ask them to present their model of a holding room describing all the design choices they made, how the materials properties affected their decisions, as well as the materials properties of the used

materials. Encourage peer critique and discuss their own suggestions for improvement.

Materials:

Candy and water based markers may be substituted for Kool-Aid. Presweetened Kool-Aid will not work for this process.

White coffee filters may be used instead of chromatography paper.