



#### Activity Description & Estimated Class Time

Throughout the guide, teaching tips are in red.

This activity requires two 50-minute periods. Students will use cards describing various physical properties of materials to solve design challenges using materials with appropriate physical properties.

#### Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- Different materials have different physical properties that can be measured and compared.
- Students demonstrate this knowledge and understanding by solving design challenges that require choosing materials with physical properties appropriate to specifications.

#### Correlations to NC Science Standards

4.P.2.1 *Compare the physical properties of samples of matter (strength, hardness, flexibility, ability to conduct heat, ability to conduct electricity, ability to be attracted by magnets, reactions to water and fire).*

#### Brief Science Background

All types of materials have several specific, consistent, and measurable properties. A physical property of a material is a characteristic that all samples of that material have, regardless of size or shape, and that characteristic can be quantified. A few examples of the nearly endless list of physical properties are:

- any piece of pure gold having a certain volume always has the same mass
- a strip of rubber can be stretched by a measurable amount, and it will return to its original length after the stretching force is removed;
- at sea level, pure water begins to boil at 212° F.

Other characteristics are not properties of matter. For example, some materials are expensive, like gold. Some are rare, like diamonds. People assign different prices to gold at different times, so the cost of gold is neither innate nor consistent. Diamonds are made under unusual conditions, but the way they are made and their scarcity are not innate physical properties of the diamond material itself.



## Part 1 – Why Is It Made of That? –50 minutes

### Materials

#### Materials for the Whole Class

- to project for the class: BLM 1

#### Materials for groups of 3 students

- one set of Materials cards
- one Design Assignment card
- several blank sheets of drawing paper (to be supplied by the teacher)

### Preparation

1. Photocopy and cut out two sets of the four Design Assignment cards (8 cards total). Be prepared to give one card to each team, at random.
2. Prepare the Materials cards so that each team can have one complete set of twelve different cards.

### Procedure

1. Give each team a Materials card set. Ask each team to group the materials based on categories that make sense to them. After students have grouped their cards, ask one student from each team to visit two or three other groups to try to figure out the other groups' categories. Switch and let another member of the team do the same. Ask students to comment on particularly interesting groupings or categories they saw.
2. Ask students to consider all of the cards and all of the different groupings, and challenge them to come up with something that all the materials have in common. Accept all answers. If students have not noted that all of these materials are used to make things, make a comment to that effect. Also point out that all the materials have physical properties that make them useful for some things, but not for others.
3. Call attention to the glass in a window and ask what properties that are listed on the glass card make it good for a window material? **Transparent, waterproof.**
4. Ask student teams to come together and work as groups of 6 at a table. Ask the table group to list as many different types of packaging that they can think of. When they finish, ask each table for an item on its list. Ask those students for properties of these packaging materials that make them useful for their purpose. **Examples:**
  - **aluminum cans are strong and waterproof and transfer heat quickly so drinks cool down quickly in the refrigerator**
  - **cardboard is lightweight, can hold lightweight foods like cereal and crackers, and the box has room for printed information**
  - **toys often come in clear plastic so you can see what's inside, and the plastic can be shaped around the toy to hold the parts in place.**
5. Give each team one of the Design Assignment cards and a few blank sheets of drawing paper. Explain that they are to create a new product according to the description on the Design Assignment card using any materials in the Materials cards. Emphasize that they may *only* use materials found in their card set. Answer any general questions. Tell teams that they have twenty



Procedure  
cont...

minutes to complete the assignment, and you will tell them when five minutes are left.

6. When the twenty minutes are up, have teams working on the same challenge get together and compare designs.

### Wrap-Up

Project some of the completed designs and ask the groups who worked on them to state which properties of the materials they chose were most important to their designs. Post the labeled diagrams from each group for the class to inspect.

**Look for physical properties of the materials (rather than, for example, what the material itself is made of, how it is made, or what it costs) and the usefulness of those properties to the design. Check to see if students described how the properties of the materials they chose met the specific design requirements stated in the Design Assignment card.**

### Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions before an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following “test items” to the class. Ask them to write responses in notebooks.

Project BLM 1, which lists pairs of functionally similar items, and ask students to compare and contrast each pair of the items based on the properties of the materials they are made of. In their writing, students should include:

- the object’s intended use
- the material (or materials) it is made of
- the properties of the material that are important to the object’s intended use
- the circumstances under which, and the reasons why, they would choose one over the other

The pairs of objects are:

- clear plastic cup and a glass
- pencil and a permanent marker
- writing paper and a paper towel
- candle and a flashlight

### Answer Key

**Most cords of electrical appliances have a plastic insulator material on the outside and metal wires inside. Most wires in a house or apartment are made of copper with a plastic insulator material wrapped around them.**



## Part 2 – What Can I Make With This?

### Materials

#### Materials for the Whole Class

- to project for the class: BLM 4

#### Materials for groups of 3 students

- One set of Materials cards
- One copy each of BLM 2 and BLM 3

### Preparation

1. Prepare a set of Materials Cards for each group of 3 of students. You will have a teacher set of cards to use to fill in any missing cards.
2. For each team of three, make one copy each of BLM 2 and BLM 3.

### Procedure

1. Give out the Materials Card sets. Ask teams to check their card sets against the inventory sheet to be sure all cards are present with no duplicates. Ask teams to shuffle the cards, turn them face down, and draw three cards at random. Explain that their task is to design something useful that is not a work of art using only the three materials on the cards they chose.
2. Hand out copies of BLM 2, on which students are asked to draw a picture of their design and label the materials used.
3. Give out copies of BLM 3. Explain that after labeled drawings are complete, students should use BLM 3 to list their three materials and describe how the properties of each make it useful for the object they designed.
4. Set a time limit of twenty minutes for the whole task, and let students know when five minutes remain.

### Wrap-Up

Ask students to post their designs when they are finished. Assign each team two other designs to review. For each design, ask them to pick what they think is the most important property of each of the materials used in the object.

### Answer Key

**In student reviews, look for recognition of physical properties that make a material useful for a given purpose. Both the property and the use should be described.**

### Guided Practice

Project the concept cartoon shown in BLM 4. Ask students to think about the ideas expressed in the cartoon, and decide which of these they agree with and which they do not. Have them write down what they think. Afterward, discuss this as a whole class.

### Answer Key

As students discuss what the three cartoon characters are saying, point out any mention they make of innate properties of aluminum. You might ask, “what about aluminum makes it good for baseball bats?” **It is lightweight, hard, and strong.** Try to guide students toward understanding why the character is correct in saying “Some properties of aluminum are that it has a certain hardness and it melts at a certain temperature.” Point out that every piece of the aluminum



baseball bat has the same hardness, and would melt at the same temperature. The fact that it can be used to make different things might be a result of some properties, but this is not a property itself. Also, the fact that it can be painted is not a measurable property of aluminum.

**BLM 1**

- Clear plastic cup and a glass
- Pencil and a permanent marker
- Writing paper and a paper towel
- Candle and a flashlight

**BLM 2**

Name \_\_\_\_\_ Date \_\_\_\_\_

Title of your Design Challenge \_\_\_\_\_

**Draw Your Design Here (Label all Materials)**

A large, empty rectangular box with a thick black border, intended for drawing a design. The box occupies most of the lower half of the page.

**BLM 3**

Name \_\_\_\_\_ Date \_\_\_\_\_

Title of your Design Challenge \_\_\_\_\_

<b>Materials</b>	<b>Important Properties</b>

BLM 4

A property of aluminum is that it can be painted.

Some properties of aluminum are that it has a certain hardness and it melts at a certain temperature.

A property of aluminum is that a lot of different things can be made from it.



**Materials Cards** (made on card stock, 10 sets included in each kit)

## **Cardboard**

### *Physical Properties*

- non magnetic
- heat insulator
- electrical insulator
- burns
- falls apart in water
- bends easily
- not strong
- light weight

### *Other Information About This Material*

- inexpensive
- made from trees
- used for packaging

## **Concrete**

### *Physical Properties*

- non magnetic
- poor conductor of heat
- electrical insulator
- fire resistant
- waterproof
- can't bend or change shape once hardened
- very strong
- can be poured into any shape when liquid

### *Other Information About This Material*

- made from a mixture of sand rocks, cement, and water
- one of the most common building materials in the world

**Materials Cards**

**Glass**

*Physical Properties*

non magnetic  
good conductor of heat  
electrical insulator  
melts at high heat  
waterproof  
not flexible  
breaks easily (brittle)  
transparent

*Other Information About This Material*

made from melted sand  
used for windows

**Plastic**

*Physical Properties*

non magnetic  
heat insulator  
electrical insulator  
burns or melts  
waterproof  
can be flexible or rigid  
very strong for its weight  
light weight

*Other Information About This Material*

inexpensive  
can be made into any shape or color  
made from oil  
used for many things

**Materials Cards**

**Steel**

*Physical Properties*

magnetic  
heat conductor  
electrical conductor  
melts at high temperatures  
waterproof but can rust in water  
can be flexible (paperclip) or not bend (bridge support)  
very strong  
heavy

*Other Information About This Material*

can be made into many shapes  
made from rocks containing iron ore  
used for building large structures and many other items

**Aluminum**

*Physical Properties*

non magnetic  
good heat conductor  
electrical conductor  
melts but does not burn at very high temperatures  
water proof  
flexible when thin  
strong  
light weight  
does not rust

*Other Information About This Material*

made from rocks that contain bauxite (aluminum ore)  
used for soda cans, aluminum foil, and airplanes

**Materials Cards**

**Ceramic**

*Physical Properties*

non magnetic  
poor conductor of heat  
electrical insulator  
fireproof  
waterproof  
not flexible  
strong but breaks easily (brittle)

*Other Information About This Material*

can be molded into any shape  
made from clay that is baked  
used for dishes, coffee cups, bathroom sinks, and toilets

**Fabric**

*Physical Properties*

non magnetic  
heat insulator  
electrical insulator  
burns  
absorbs water  
very flexible  
medium strong  
light weight

*Other Information About This Material*

made from natural and man-made fibers  
used for clothing

**Materials Cards**

**Styrofoam**

*Physical Properties*

- non magnetic
- heat insulator
- electrical insulator
- melts and burns easily
- water proof
- limited flexibility (breaks if bent too far)
- not strong
- light weight and shock absorbing

*Other Information About This Material*

- can be made in any shape
- made from oil
- used for packaging and insulating

**Wood**

*Physical Properties*

- non magnetic
- heat insulator
- electrical insulator
- burns
- absorbs water
- flexible when thin
- strong

*Other Information About This Material*

- rots over time
- made from trees
- used for building, furniture, toys

**Materials Cards**

**Leather**

*Physical Properties*

non magnetic  
heat insulator  
electrical insulator  
burns  
absorbs water  
very flexible  
strong

*Other Information about This Material*

made from animal skins  
used for shoes, clothing, furniture

**Rubber**

*Physical Properties*

non magnetic  
heat insulator  
electrical insulator  
burns  
waterproof  
flexible  
strong  
stretches and returns to original shape

*Other Information about This Material*

made from oil and tree sap  
used for car tires, balls

**Design Assignment Cards** Photocopy 2 sets of this page and the next. Give one card to a team.

Your group is challenged to design A Fireproof and Waterproof Document Box

Product Requirements:

The box should be heavy so it can't be easily carried away by thieves. The contents inside the box must not be allowed to get hot even if there is a fire in the building. The box must also be waterproof because fires are often put out with water. It should be large enough to hold all of a family's important documents and valuables. It should have a lock and a way to open and close the box.

Draw a picture of your box design and label all of the parts. Provide a list of the materials used in your design. Next to each material, explain what properties of the material are important to your design. Your design may only use the materials found in your set of Materials Cards. Use no other materials in the design.

You have 20 minutes to complete this task.

Your group is challenged to design Boots for Gold Panners

Product Requirements:

Modern day gold prospectors must spend long hours in the very cold water of mountain streams. They do not have to walk far, but they must walk over sharp and slippery rocks. They often need to stand in two feet of fast-moving water, so some additional weight in the boots would help prevent their feet from being pushed out from under them by the force of the water.

Draw a picture of your boot design and label all of the parts. Provide a list of the materials used in your design. Next to each material, explain what properties of the material are important to your design. Your design may only use the materials found in your set of Materials Cards. Use no other materials in the design.

You have 20 minutes to complete this task.

**Design Assignment Cards continued...**

Your group is challenged to design A Bearproof Cooler Box for Camping

**Product Requirements:**

The box should be heavy so it can't be carried away easily by a bear, but it must be light enough for two people to carry around a camp site. The contents inside the box must not be allowed to get hot even on a warm day. It must be waterproof in case of rain. It should be large enough to hold food for a group of three people for two days. It should have a lock and a way to open and close the box easily.

Draw a picture of your box design and label all of the parts. Provide a list of the materials used in your design. Next to each material, explain what properties of the material are important to your design. Your design may only use the materials found in your set of Materials Cards. Use no other materials in the design.

You have 20 minutes to complete this task.

Your group is challenged to design A Shipping Container for Very Heavy and Very Delicate Computer Equipment

**Product Requirements:**

The container should be as light as possible because shipping costs are determined by the weight of the container and its contents. The computer equipment inside the box cannot be allowed to get hot or wet if left out in the weather.

Draw a picture of your container design and label all of the parts. Provide a list of the materials used in your design. Next to each material, explain what properties of the material are important to your design. Your design may only use the materials found in your set of Materials Cards. Use no other materials in the design.

You have 20 minutes to complete this task.



## Appendix

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### Common Student Preconceptions About This Topic

Most students, even in high school, are confused about the word “matter.” Its definition as any substance that has mass and occupies space is too abstract for young children, and too vague for older ones. Instead, most simply translate matter as “stuff.” While not a scientific term, to children, stuff has mass and volume, although they would not use those words to describe it. “Stuff” is a tangible concept that helps children develop the idea that there are many different types of stuff in the world, and that different types can be distinguished from one another by their physical properties.

‘Material’ is another word that many children are confused about. For most, they first encounter the word as fabric for making clothes. Later, their scope may broaden to include ‘building materials’, and ‘art materials’. The scientific definition of material is any type of matter that can be observed or detected, which to children, is not really any different from their notion of matter. Thus, they (appropriately) equate “matter,” “material,” and “stuff.”