Innovation: Materials Properties

Introduction	Engineers make choices about construction materials based on a **material's properties** and how it will perform a designated task.
Level	Grades 3-12
Time	This activity can be done in one 45-minute class period or as part of a class period and a homework assignment.
Lesson Preparation	You may want to gather different materials (e.g., wood, metal, stone, plastic, glass, fabric, etc.) to use in your introduction. Photocopy worksheet
Prior Knowledge Required	Students should be familiar with the engineering design process.
Background Information	The properties inherent in materials make them suitable for different jobs. Understanding how materials behave in their natural state and under certain conditions helps us understand why objects are made of specific materials.
Vocabulary	• Innovation: the alteration of what is established by the introduction of new elements or forms. **Innovation** differs from **invention** in that innovation refers to the use of a better and, as a result, novel idea or method, whereas invention refers more directly to the creation of the idea or method itself. **Innovation** differs from **improvement** in that innovation refers to the notion of doing something different rather than doing the same thing better.
Anticipated Student Preconceptions/ Misconceptions	Students may mistakenly believe that: • Temperature is a property of a particular material or object. (Metal is naturally co oler than plastic). • Heat and temperature are the same. Heat is energy that is transferred from one body to another as the result of a difference in temperature. Temperature is a measure of hotness or coldness expressed in terms of any of several arbitrary scales like Celsius and Fahrenheit.
Frameworks	Massachusetts Curriculum Frameworks Grade 4: Physical Science Engineering Design 3-5 ETS2-1 – Recognize that technology is any modification of the natural or designed world done to fulfill human needs or wants. These modifications can be improvements to existing technologies or the development of new technologies. Grade 5: Physical Science Matter and Its Interactions 3-5 PS1-3 – Make observations and measurements to identify substances based on their unique properties, including color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility.

	Grade 6: Technology/Engineering Materials, Tools, and Manufacturing MS ETS2-1- Analyze and compare properties of metals, plastics, wood and ceramics, including stiffness, strength, ductility, hardness, thermal conductivity, electrical conductivity, and melting point. MS ETS2- - Given a design task, select appropriate materials based on specific properties needed in the construction of a solution.

Guiding Question	How do the properties of different materials make them more suitable for some jobs than others?
Objectives	At the conclusion of this lesson, students will be able to: • Identify the properties of a particular set of materials • Decide which material is best suited for a specific task.
Activity	Class Discussion 1. What are some of the things engineers take into consideration when designing or innovating a new object (car, building, cell phone, etc.)? [cost, machines, labor force, raw product, construction materials] 2. What does the term "properties of materials" mean? [characteristics or features of a material] 3. What are some properties or characteristics that we could use in describing different materials? [soft, hard, measurements, bendable, strong, cost, accessibility, etc.] 4. For example, what are the properties of bubble gum? [smooth, sticky, pliable, etc.] What are some of the uses best suited for that those characteristics? [creating a watertight seal, chewing, etc.] 5. Why is it important for engineers to pick the right material for the job? [They want a material whose properties fit the job's requirements, i.e., durability, strength, hardness, flexibility…] 6. (Optional discussion for older kids – younger kids can follow the specifications on the worksheet.) Your assignment is to design a new reusable "to-go" coffee cup. Let's make a list of what the coffee cup needs to do. What specifications must it meet? [keep liquid warm, microwaveable, reusable, etc.] Have students choose five specifications from the list that their product needs to fulfill. These next steps can be done in class, or as a homework assignment: 7. Pass out the worksheets and review the assignment. Students should use their textbooks or Internet research to determine the properties of the materials options. 8. Once they have researched the materials' properties, they should choose a material

	for each part of the cup and justify their choice with a rationale from their research. 9. As a class, discuss the students' findings and designs.
Assessment	Worksheet – see rubric.
Differentiation Suggestions	For students with different learning styles, you could have them work in groups to do research and choose the materials. For step 4 of the activity: Instead of talking about bubble gum or silly putty in the abstract, bring in some samples and have kids play with them. Alternatively, you can pick another type of material (wood, brick, cloth, metal wire, etc.), bring them in to the classroom and have students touch them and figure out what the properties are.
Adapting the Activity for Other Grades	Younger students may work in groups to do research and choose the materials. Younger students may also enjoy this online game for "testing" materials' properties. http://www.sciencekids.co.nz/gamesactivities/materialproperties.html For kid-friendly information and online activities: http://www.bbc.co.uk/bitesize/ks2/science/materials/material_properties/read/1/ For more information and lesson ideas: http://www.primaryresources.co.uk/science/pdfs/rsc_tc_nc1.pdf Have students draw a picture of their cup, or make a prototype out of found objects.
Bibliography	Hewitt, Sally. *Amazing Materials*. New York: Crabtree Publishing Company, 2007.

Grading Rubric

	4	3	2	1
List of Properties and what tasks materials would be good for	Lists multiple properties or tasks	Lists one property or task	Lists properties but no tasks, or tasks but no properties	No properties OR tasks given
Justification of materials selection for cup components	Gives the material and a good justification for choosing it	Gives the material and a partial explanation	Gives the material with an inadequate explanation	Gives only the material and no explanation

Innovation: Materials Properties

Choose the best materials to use as you design a new reusable "to-go" coffee cup. It needs to meet the following specifications, which will affect the types of materials you'll select. Research the materials options and write down their properties and the tasks for which they would be good. Then, label each part of the cup – lid, insulation, exterior – with the material you would use and explain why you chose each material.

Suggested research websites:
http://www.bbc.co.uk/bitesize/ks2/science/materials/material_properties/read/1/
http://engineershandbook.com/Materials/index.htm

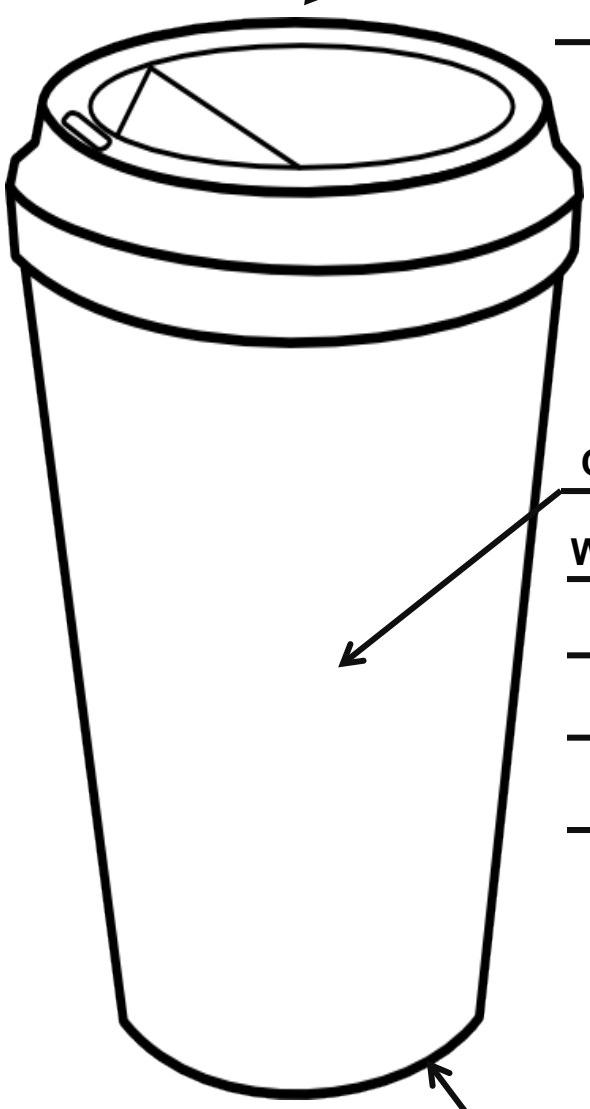
Your "to-go" cup must meet the following specifications:

- Must be microwaveable
- Must keep liquid warm
- Must not be hot to the touch
- Must be reusable
- Must have a 3D decoration (positive or negative) applied to it

Materials options	Properties	Good for these types of tasks:
High-temperature plastic		
Low-temperature plastic		
Stainless steel		
Styrofoam		
Cardboard		
Ceramic		
Leather		

Lid – Material:

Why:



Cup Insulation– Material:

Why:

Cup Exterior – Material:

Why:

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Choose the best materials to use as you design a new reusable "to-go" coffee cup. It needs to meet the specifications chosen by your class, which will affect the types of materials you'll select. Research the materials options and write down their properties and the tasks for which they would be good. Then, label each part – lid, insulation, exterior – with the material you would use and explain why you chose each material.

Suggested research websites:
http://www.bbc.co.uk/bitesize/ks2/science/materials/material_properties/read/1/
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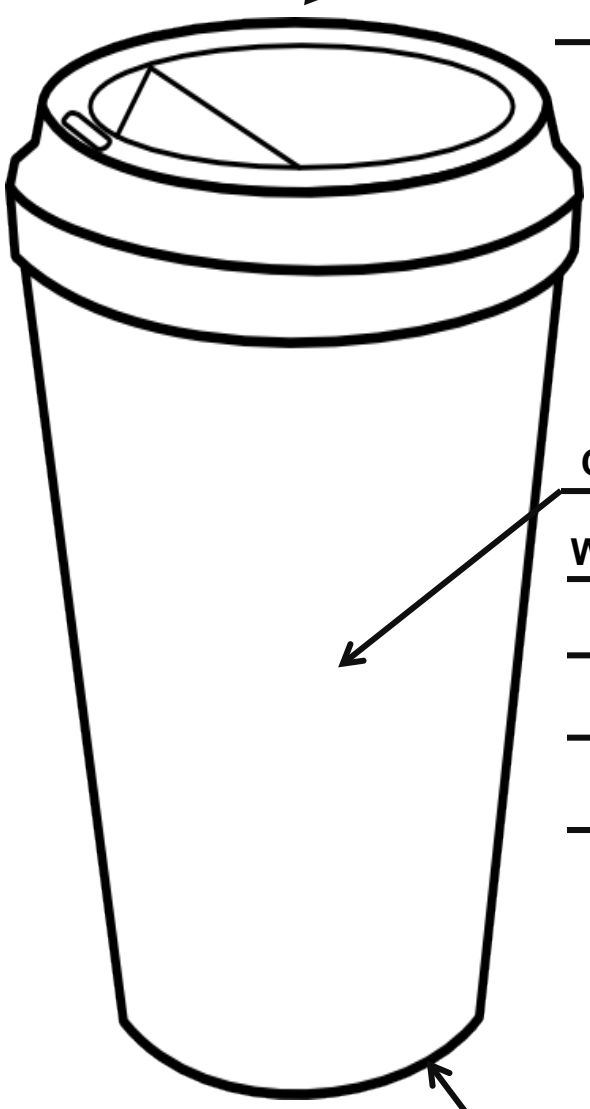
Your "to-go" cup must meet the following specifications:

- _____
- _____
- _____
- _____
- _____

Materials options	Properties	Good for these types of tasks:
High-temperature plastic		
Low-temperature plastic		
Stainless steel		
Styrofoam		
Cardboard		
Ceramic		
Leather		

Lid – Material:

Why:



Cup Insulation– Material:

Why:

Cup Exterior – Material:

Why: