Properties of Materials Introduction

Overview:

Student observe and classify the properties of various materials and consider why they might be useful for different purposes.

Essential Question.

What are the properties of materials and why are useful?

Background:

Materials are types of **matter**. Some are pure like a piece of aluminum and some are **mixtures** of materials such as a fiberglass skateboard. Some are natural and some are made by people. Matter can exist in different **states** such as **solid**, **liquid**, **gas.** Materials have various **properties** such as **flexibility**, **conductivity**, or **elasticity** which make them useful for different purposes.

Research Connection:

Materials scientists seek to create new materials that perform in a certain way under specific conditions. Sometimes improving one characteristic interferes with another. Many trials and variations are required to get the right combination. Engineers work on bringing research breakthroughs that are discovered at the laboratory scale to a larger scale which can be manufactured and incorporated into products.

NGSS Standards:

Standard Number	Standard text
2-PS1-1	Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
2-PS1-2	Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.* [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.]

Materials:

Sample materials to test

- Ceramic tile or solar cell
- Popsicle stick
- Wood blocks, large and small
- Paper clip
- aluminum foil

- iron strip, nail or piece of flashing
- copper foil
- Plastic bag
- Thermoplastic- broken into small chunks in hot water in a cup
- sponge
- Sugar cube
- Wet clay or modeling clay
- Styrofoam
- Spring or plastic ruler
- Happy ball / sad ball /super ball

Tools

- magnet
- Multimeter or LED and battery
- Scale
- Water bucket
- cups

Procedure:

Introduction

Ask if students know what a material is (a kind of matter). Have student brainstorm what is a property of a material. Distinguish properties that change with temperature and have to do with the phase of matter (such as liquid, solid or gas) and properties. Possible properties include hardness, toughness, strength, stiffness, elasticity, plasticity, absorbency, waterproof, magnetic, melting point

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Arrange materials and tools for each property station. Print out the property station instruction card for each. Pass out the worksheet to pairs of students. Students take their material sample around to each station and fill in the sheet.

1. Compressibility- Squeeze and test with vacuum chamber. Rubber toys, foam
2. Conductivity- Test with multimeter. Graphite, copper, aluminum
3. Magnetic- touch the sample with a magnet. Copper, aluminum, iron screw
4. Malleability / Plasticity- Squeeze material and make impression of coin, clay, rubber, foam
5. Density- Will it float in water?
6. Elasticity- Squeeze balls and drop them to measure bounce. Sad ball, super ball, rock
7. Flexibility – extend object over edge of table and add weight to end, balsa, plastic ruler, aluminum pan strip.
8. Melting / Softening – Place sample in hot water then mold it by hand. Thermoplastic, hot glue stick, butter?
9. Solubility- does it dissolve in water? Salt, sugar, white sand

Discussion

1. Gather the group together with their datasheets. Engage them in a discussion about classifying material based on their properties. In each case consider how to predict whether a material will have a certain property. Ask what each material would be good for? What useful product could you build with it?
    a. Questions to ask the students:

i. What is a material? - matter from which things can be made.
ii. What are some properties materials can have?
    - What is compressibility?
        - reduction/expansion in volume
        - how squishy a material is
        - Some examples of a compressible material? - rubber
    - conductivity
        - Can electricity flow through the material?
        - Examples of conductive material? - copper
    - magnetism
        - Can a magnet stick to it?
        - What materials are magnetic? - other magnets, iron
    - malleability
        - what does it mean for a material to malleable? Can you deform the material into a different shape without breaking?
        - Examples: play dough, clay
    - density
        - what is density? how heavy a material is per unit volume.
        - Dense materials - lead
        - non-dense materials - foam
    - elasticity
        - what is elasticity? - when you deform a material it will return to its original shape after you stop applying a force to it
        - elastic materials - rubber bands
        - non-elastic - clay
    - flexibility
        - how bendy is a material?
        - example - plastic
    - melting/softening
        - when you apply heat, will the material melt or get softer?
        - examples - ice
    - solubility
        - can it be dissolved
        - examples - water/sugar
        - non-examples - sand

2. Which materials conduct electricity? All the metals.
3. Which materials were magnet? Just the iron nail, These are known as ferrous metals. copper and aluminum are good conductors but are not magnetic.
4. Which materials float in water? Which materials were most dense? Does it matter if you have a big chunk or a small chunk? Styrofoam and wood float, the other sink regardless of the amount. Floating depends on density not mass. A large tree will float as well as a block. A rock of any size will sink.
5. Which materials were elastic? One of the rubber balls, the other didn't bounce, some of the plastics, the popsicle stick bends. Metals tended to deform and stay that way.
6. Which materials were moldable or plastic. Modeling clay, thermoplastic when it was hot.

Extensions:

Couple this exploration with a design challenge. Pick the best material for an invention using the properties.

Resources:

Print the station direction cards and fold them in the middle.

http://www.primaryresources.co.uk/science/pdfs/rsc_tc_nc1.pdf

http://www.pbs.org/wgbh/buildingbig/lab/materials.html materials interactive

Sources:

Polydoh thermoplastic

https://www.amazon.com/Moldable-Coloring-granules-Polymorph-plastimake/dp/B01N6Q9NVL/ref=sr_1_13?keywords=thermoplastic&qid=1547851828&sr=8-13&th=1

happy sad balls

https://www.amazon.com/gp/huc/view.html?ie=UTF8&newItems=C2ad05cbb-ae0b-4e2e-a984-a1ed18adf4ea%2C1

Properties of Materials Observations

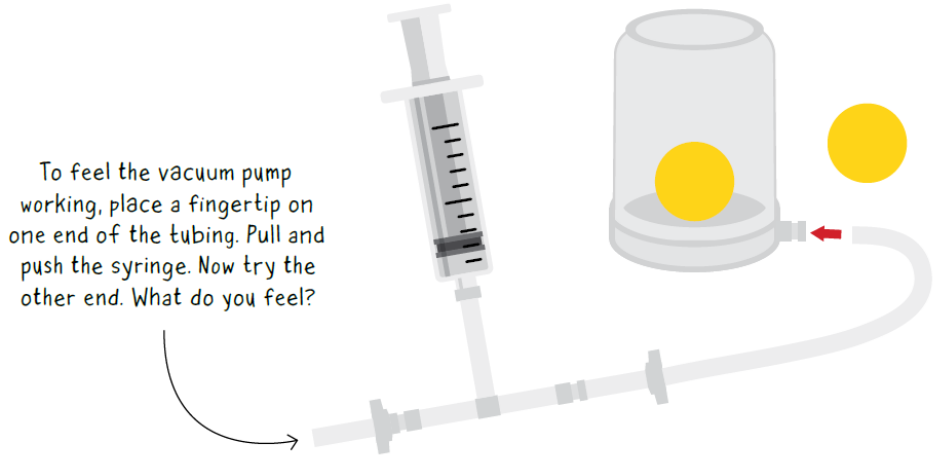
Record the name of each sample material and the results of the test.

Property	Sample 1	Sample 2	Sample 3	Possible Uses
Compressibility				
Conductivity				
Magnetic				
Malleability				
Density /Float				
Elasticity				
Flexibility				
Melting / Softening				
Solubility				

Compressibility

Can the material be flattened by pressure and then spring back when the pressure is removed. Sometimes this means it the material contains air which can be compressed.

1. Test the material by squeezing or pushing it to apply pressure. Observe if it flattens out.
2. You can also test compressibility by removing air pressure with a vacuum. Place the object in the vacuum chamber. Hold the lid in place so the black O-ring is in contact. Insert the vacuum hose. Draw out and back with the syringe several times. The lid should be locked now and can't be removed. Continue pumping and observe what happens
   to the object.
3. Record your results.



Electrical Conductivity

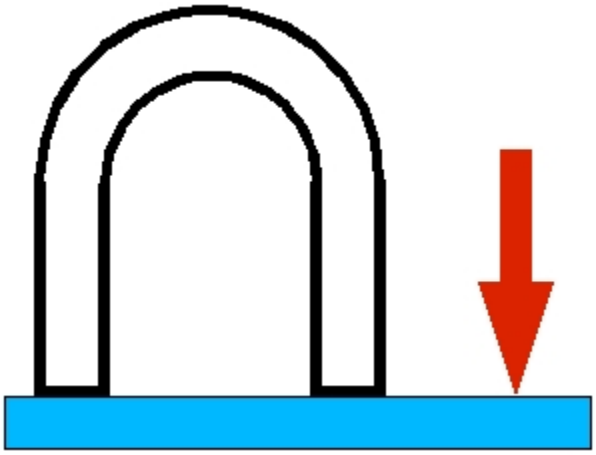
How easily does the material conduct electricity? Test the material by using the resistance setting on a multimeter.

1. Rotate the selector dial to the ohms (resistance) range.
2. Turn on the meter.
3. Touch the leads together and observe what happens on the display. This is what happens when there is 100% conductivity or a short circuit.
4. Touch the leads to either side of an object and look at the display. If you are in the right on the meter range you may be able to detect that some materials have a higher resistance than others.
5. Test each of the materials at your station.
6. Record your results.

Magnetic

Is the material attracted to a magnet?

1. Touch the horseshoe magnet to each material.
2. Record your results.



Malleability or Plasticity

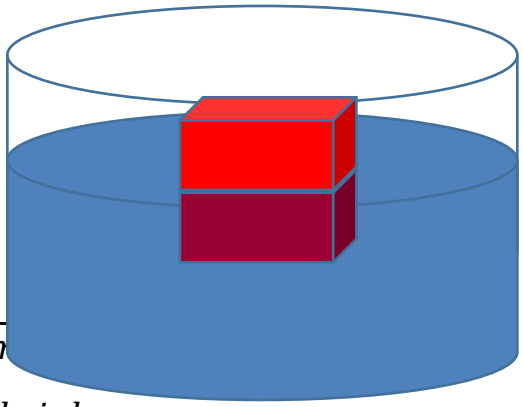
Can the shape of the material can be changed without breaking? Can you mold it by hand?

1. Squeeze a sample of the material. Does it hold the new shape?
2. Press the material down against a coin. Does the coin leave a pattern?
3. Record your results.

Density / Floating

How much mass for a given volume is there for the material or object? A solid piece of material or object that is denser than water will sink. If it less dense than water it will float. If an object is hollow it will less dense than the material it is made of. This is why you can build a boat out of metal which would normally sink in water.

1. Use the scale to measure the mass of an object and record the result.
2. Measure the dimensions of the object.
3. Test the object to see if it floats.
4. Repeat with other objects provided.
5. Try floating a boat made out of aluminum foil.
6. Try floating a small square of aluminum.
7. What makes the difference about



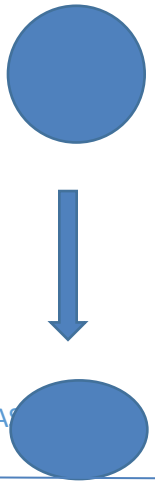
$$Density = \frac{Mass}{Volum}$$

$$Density > 1 \; will \; sink$$

Elasticity or Stretchiness

How easily does the material deform and then return to its original shape? Elastic materials tend to bounce when they are dropped because they store energy when they are squished-- and then release the energy when they go back to their original shape. Compare the super balls with the black “happy/sad” balls.

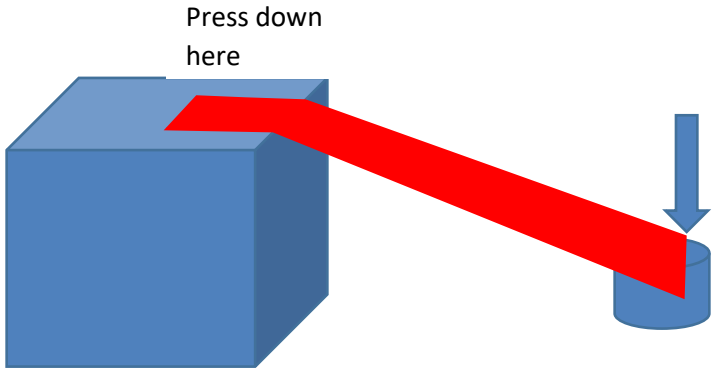
1. Press down on the material. Does it spring back when you stop pressing?
2. Drop the object from a height of 3ft. Record how far it bounces.
3. Record your results.



Flexibility

This is how easily the material can bend without breaking.

1. Press down on one end of the sample on the edge of the table.
2. Attach a weight on the extended end.
3. Record how far it bends
4. Remove the weight. Does it return to its original position?
5. Try other samples.



Melting Point / Heat softening

What happens to the texture as the material is heated? Some materials such as water go directly from a hard solid to a liquid. A thermoplastic becomes more and more plastic or malleable as it gets hot but then become solid when it cools.

1. Place a piece of the thermoplastic in the cup of hot water. Wait one minute.
2. Remove the blob with a spoon. Squish it or mold it form a new shape.
3. Let it cool down for 5 minutes and try bending the object you have made.
4. Repeat the experiment with a different plastic material.
5. Record your results.

Solubility

Does the material dissolve in water? Some materials dissolve very quickly others may take a long time.

1. Place a spoonful of salt in a clear cup filled with water.
2. Stir it with a spoon. Record the results.
3. Repeat with each of the sample materials.
4. Record your results.