Materials

Worksheet 8

A worksheet produced by the Native Access to Engineering Programme

What is material?

The Webster Dictionary defines material as
The substance or matter of which anything is made or may be made.

Everything created by humans is made using some kind of material. Materials are, therefore, very important in our lives. Without materials we wouldn't have tools, clothing or shelter (beyond rocks, caves and trees). In fact, materials are so important that Western historians have defined a number of historical periods - the Stone Age, the Bronze Age, the Iron Age - based on the material used for making tools and weapons at that time.

What material do you think defines the world today?

As much engineering was involved in the making of bricks for a Mayan temple as was involved in the manufacturing of the flame -resistant material in a Formula 1 racing suit.

Source; http://www.colourprep.com/jorge/incas/masonary/masonary.htm

Engineers and Materials

Source: Materials by Design
http://www.mse.cornell.edu/courses/engri111/compo.htm

Because materials are in everything we make and use, engineers who specialize in materials work in all sorts of industries and fields. No matter where he or she works, the most important part of a materials engineer's job is to know what materials to use for which tasks. Sometimes, in order to get exactly the right material for a job, the materials engineer will have to develop a new material or adapt an existing material for a new use.

How do you suppose materials engineers know what material they need for a job?

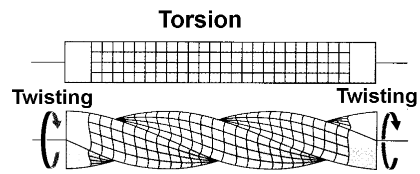
Properties

Can you make a canoe out of stone? Why?
Would you rather sleep on a mattress filled with cotton or one filled with marbles? Why?

Engineers know what materials to use for a specific job, or the type of material they need for a job, because they carefully study the properties of different materials. In other words they study how a material performs under certain conditions. There are a number of different material properties.

Physical properties are measures of a material's size, density, porosity and surface texture.

Mechanical properties are measures of how a material reacts to mechanical forces. Mechanical properties include strength in tension (pulling), compression (pushing), shear and torsion. (Shear is a sliding force and torsion is a twisting force.) They also describe how well a material resists cuts (called hardness), breaks (called toughness) and repeated or constant bending (called fatigue).




Source: http://www.corbis.com

Do you think glass has better hardness or toughness?
Can you think of anything which would have to resist fatigue really well?

Finally, mechanical properties describe how elastic or plastic a material is. Elastic materials are those like elastic bands which can be stretched but return to their original shape. Plastic materials are those like clay which can be molded or pushed into shape.


Source: http://www.corbis.com

Which of these materials is plastic and which is elastic?

A spring
Wet sand
Bubble gum
Cement
Mud

Potholes can appear in road beds or in any rock which has been subject to alternate heating and cooling.


Source: http://www.corbis.com

Thermal properties tell engineers how a material reacts to hot and cold. Some materials, like concrete, tend to expand in the heat and shrink in the cold. When expansion and contraction happen over and over the material may break down; concrete in roads, for instance, may crumble and develop potholes. Some materials conduct heat, others insulate from the cold.

Should the handle of your frying pan be made from a conducting material or an insulating material? What about the cooking surface?

Chemical properties are those properties which tell engineers and scientists how a material reacts with the chemicals in its environment. These days it's important to know how materials will react to acid rain.

Can you think of a chemical property of steel and other metals?

Optical properties indicate how a material reacts to light. Some materials allow light to pass through them, others block light. Colour is also an optical property.

Many sunglasses have special optical properties. Do you know what they are?

Acoustical properties measure the way a material reacts to sound. As with light, a material can either absorb or reflect sound.

What happens when you yell "hello" into a rock canyon? Why?

Electrical properties indicate whether a material will carry electrical charge or not. Materials which carry elctrical charge are called conductors, materials which don't are called insulators.

Why should you wear rubber boots when working with electricity?

Source: http://www.gowrie.k12.ia.us/highsch/mattca/galaxy2.jpg

Magnetic properties tell engineers whether a material will be attracted to a magnet or not.

Traditional materials

The gifts of Mother Earth have been used as materials by Native peoples for thousands of years. These gifts, including trees, animals, soil, rocks and plants, have provided the raw materials for making clothes, tools, weapons, shelter, transportation, musical instruments, decorations and other needs of daily life.

What materials have been used traditionally by your community? Why were these materials used?

Source: CBC
http://www.cbcnews.ca/news/indepth/nunavut

Different nations and peoples used different materials based on what was available in their local environment. Because North America is so big, this often meant that in different areas of the continent different materials were adapted to similar uses. For instance, housing needs were met in a number of different ways using a number of different materials. The Iroquois in the east used young saplings and bark to build long houses. The Inuit in the far north used snow to build igloos. In the southwestern part of North America, Native peoples used adobe soil to make apartment-like buildings. And the peoples of the Great Plains used buffalo hides to drape around wooden poles to build tipis.

Transforming materials

Very few materials are used as they are found in nature; most are transformed in some way to make them stronger, more durable, softer or just generally more useful. In this transformation and adaptation of materials, Native peoples have been master engineers for generations.

The Aborigine people of Australia's Northern Territory play a wind instrument called a didgeridoo. They say the sound it makes is the voice of the Earth and claim it is the world's oldest musical instrument. Traditionally, the long, open-ended didgeridoo pipes are used in ceremonies to accompany singing, chanting and drumming. The Aborigines have been using these instruments for thousands of years.

Source: Aboriginal Art and Culture Centre
http://aboriginalart.com.au/didgeridoo/music.html

Didgeridoo are made from bamboo or Eucalyptus branches which have been hollowed by termites. The branches are cut from these trees and the termite residue is removed; first the branch is soaked in water for a few days to soften the residue, then the residue is either pulled out using a stick or burned out using coals. The next step is to remove the bark and determine if the branch is completely sealed along its length by holding it under water.

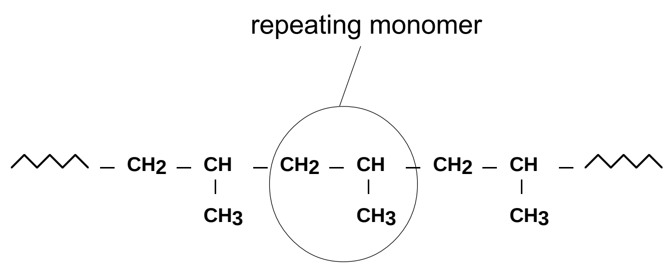
How would holding the branch in water show you there were holes in it?
Why would you want to make sure the branch is completely sealed?

Any holes are sealed with beeswax. Then the branch is cut to a length (usually between 1 and 3 meters) which will produce the desired note. Finally, beeswax may be used to create a mouthpiece. Didgeridoo are still made in this way, although nowadays they may also be made out of synthetic materials like Polyvinyl chloride (PVC).

Polymers

PVC is a polymer. You probably use it (and a whole bunch of other polymers) every day without realizing it. PVC is found in bottles, hoses, pipes, valves, electrical wire insulation, toys, raincoats and boots.

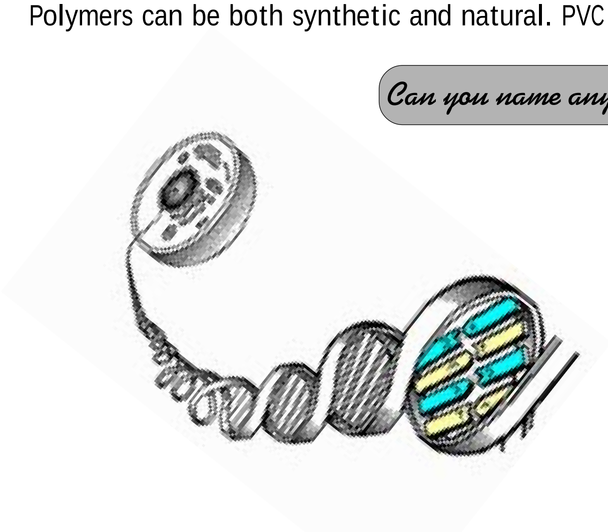
A polymer is a very special kind of material made up of macromolecules. As the name suggests, macromolecules are really big. They are actually long chains, of smaller molecules (called monomers) which repeat themselves over and over again. For instance, in polypropylene, the backbone of the chain is made up of a repeating pair of carbon atoms. One carbon atom has two hydrogen atoms attached to it, while the other has one hydrogen atom and a methyl group attached to it. Polypropylene, a synthetic polymer, is used to make carpet fibers, ropes, liquid containers (cups, buckets, tanks) and pipes.



Polypropylene

Polymers can be both synthetic and natural. PVC and polypropylene are synthetic, as are nylon, rayon and kevlar.

Can you name anything made from these polymers?



You may find this hard to believe, but people (and all living things) wouldn't exist without polymers. DNA and RNA, the basic building blocks of life, are naturally occurring polymers. Other natural polymers are cotton, rubber, starch, leather and cellulose. Aboriginal peoples have used natural polymers to create all sorts of items.

Can you think what some of these items are?

Composite materials

Have you ever heard anyone say "The whole is greater than the sum of its parts?" It means that sometimes when you put two or more things together, the result is much better than any of the individual components. Composite materials are a concrete example of this expression.

A composite is made from two or more other materials. They are put together so that one material is stuck to, in, or between one or more other materials. The resulting combination is a new "composite" material with strength (and/or other properties) the individual components do not have alone. One of the most common composites is reinforced concrete where concrete is strengthened by having steel rods running through it.

Composites have at least 2 layers.

There are many different composite materials. Two with which you might be familiar are:

Duct tape: This versatile tool is made by gluing together cotton mesh and polyethylene tape.

Source: http://www.corbis.com

Source: http://www.corbis.com

Rubber raincoats: The rubberized rain gear you wear while fishing or hunting is a sandwich of rubber latex between cotton cloth. Originally known as Macintosh Raincoats (after the man who invented them) they used to break in the cold and stick in the heat. Today the rubberized part (it may even be Gore-Tex) is made in a different manner so these problems are avoided

Both of these composites are actually polymer composites as rubber, cotton, and polyethylene are all polymers.

Can you think of any other composite materials?

References

Online

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Books

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Math problems

1. Your contracting company is building new, concrete foundation homes on the reserve. Concrete is a composite material made from water, cement, sand and gravel in proportions which vary according to use. For your foundations you want to mix the materials in proportions of 1:2:5 (cement:sand:gravel). Each of the individual materials is delivered by a separate supplier. Unfortunately, they are all about to go on vacation and can only deliver what they currently have in stock to you. The cement supplier sends you 237 tonnes of cement at $20.00 a tonne. The sand supplier can give you 572 tonnes of sand at $12.50 per tonne. Finally, the gravel supplier can deliver 1180 tonnes at $22.50 per tonne.

   You want to make as much concrete as possible from the supplies you have while making sure you waste as little money as possible. How much of each material will you use? And how much money will the left over materials represent?

Cement **Sand** **Gravel**

1 : 2 : 5

2. Your band has started managing a 40 hectare commercial forest. There are an average of 2500 trees per hectare. You are considering two plans for harvesting the trees. The first would harvest 10% of the trees each year. The second would harvest only 5% of the trees per year. You need to let the ground recover for 2 years before you can replant what has been harvested. You should get about 20 natural seedlings from every 10000 trees each year. The trees are fast-growing and take 10 years to reach maturity.

   Your community wants to practice sustainable forestry. The forestry is not sustainable if
   - the number of trees continues to decline in any 5 year period.
   - the number of immature trees (less than 10years old) is ever more than 50%.

   Which plan should you choose?
   Do you foresee any problems for this plan?