

Focus on Fabrics: Putting Materials to Good Use

Making the Connection
Women in Engineering Programs &
Advocates Network (WEPAN) Project
Funded by Lucent Technologies Foundation

Environment

Grades 7 & 8 (suggested)

1. This unit explores the differences between natural and synthetic fabrics.
2. It uses the characteristics of fibers to decide which fabric to use for a certain application which is how an engineer might solve this problem.
3. This activity has a resource page that provides background information.

Objective

The goal is for students to understand the basics of engineering associated with the use, selection, and properties of fabrics. A wide variety of natural and synthetic fibers are used in our clothing, home furnishings and in our travel and sports equipment. The specific material chosen for each application depends on how closely the properties of the material match the design needs. This unit focuses on the different characteristics of fabrics and shows students how natural and synthetic fabrics differ from one another. It also allows students the opportunity to weigh the advantages and disadvantages of fabrics when considering the appropriate fabric to be used.

Skills & Standards

1. Develop an understanding of engineering in terms of involving decisions related to advantages and disadvantages of process and products.
2. Analyze a product to determine the need it was designed to meet and the customer(s) it was meant to attract.
3. Invent a product to meet a need.
4. Use science, math and engineering principles to design and optimize the product.

Activity Outline

Materials required per group:

One 8" x 6" sample of 6 types of fabrics. The natural fabrics to be tested are **cotton**, **linen** and **silk**. The synthetic fabric are **polyester**, **nylon** and **rayon**. Write the name of the fabric on the sample with a permanent marker.

Balance, either a beam or an electronic balance accurate to 0.01g.

- watch with a second hand
- 250 ml Beaker
- 1/2 teaspoon
- Scissors
- Paper towels

Time frame:

- Part 1: 50 minutes
- Part 2: 40 minutes

Overview of Presentation

Briefly explain engineering. (See Presenter's Guide for more detail.)

Engineers use scientific information to design and create useful things. In designing and creating, the engineer goes through a problem solving process in which both the math and science are important components.

Introduce the activity to the students.

Have a general discussion about natural and synthetic materials. Many high schools have CD-ROMs or videos showing nylon being made. If available, these demonstrations are worth showing.

Begin the activity.

Before doing the activity, present the '*problem*' and '*who wants to know*'.

Do the activity.

Break the class into groups of 2 or 3 students. As the students work on the activity ask them to note any commonality in the characteristics of natural fibers and in those of synthetic fibers.

Reflect on the activity.

After the activity is completed, spend time discussing what was discovered and learned. Look at all of the characteristics of natural fibers (including those discovered during the activity and those provided on the worksheet). Discuss the advantages and disadvantages of those fabrics. Do the same for synthetic fabrics.

Career Connection

Discuss what types of jobs are involved with developing, producing and utilizing fabrics. Asking '*Who can help you solve the problem*' may get students to think about the type of people who would know.

Activity: The Science of Fabrics

The students will perform tests on samples of synthetic and natural fabrics, analyze the test results, and use the information gathered to decide which fabric would be appropriate for a specific application. The activity has been developed based on a traditional engineering design process which pose key questions – all identified in boldface type, that help the students approach the problem as engineers.

PART 1: TESTING SYNTHETIC AND NATURAL FIBERS

What's the problem? Each fabric has different characteristics. In order to make sure that the proper fabric is used for an application, the characteristics of the fabrics must be studied.

1. Break the class into groups of 2, 3 or 4 students (depending on materials available) and give each group the following:
 - *Worksheet A: Lab Instruction Sheet* and lab materials identified on *Worksheet A*.
 - *Worksheet B: Strength Test Diagram*
2. Have each group perform the three tests on the fabric samples that are described on *Worksheet A*. **The strength test must be done first.** The permeability and absorbency tests are then done on the divided samples of fabric.
3. After the groups have completed the tests come to a consensus as a class about the results.
4. Pass out the attached *Worksheet C: Characteristics of Fabrics*. Have students add the results of their tests to the characteristics already listed.
5. Lead a discussion on the ways that natural fibers differ from synthetic ones. Ask the students whether they think rayon is a natural or synthetic fabric. This will lead to a discussion of the differences between synthetic fibers from chemicals versus those regenerated from cellulose.

PART 2: CHOOSING A FABRIC FOR AN APPLICATION

Who wants to know? The Department of Agriculture is trying to prevent the over or under seeding of crops. They are looking for engineering designs to ensure proper seed spacing. One option utilizes fabrics that have seeds embedded in them.

How can you help solve the problem? Think about the fabric characteristics that would be required for this design. By prioritizing these characteristics and taking into account the disadvantages, the proper fabric for the crop planting can be chosen.

1. Put the students back into their groups.
2. Present them with the following problem: The Department of Agriculture has proposed that fabrics with seeds embedded in them be used to ensure proper seed spacing. Other advantages of this method include no seed loss to birds, a reduction in soil loss, and reducing weeds in the crops.
3. Have the students decide which material the seeded fabric should be made from based on what they know. Each group should be prepared to discuss their choice, backing up their decision with information about the characteristics of the fibers.

Will your suggestion(s) work? Along with justifying a best design, did the students consider the impact to the environment? Is the fabric you selected biodegradable?

Who can help you solve the problem? What type of information or knowledge is needed to understand natural and synthetic fabrics? The structure, composition, and properties are important information to understand these fabrics. Chemical engineers have a strong background in synthetic materials. Specialists in bio-engineering work with natural fibers.

Engineering Summary: Finish with a discussion about how students approached the problem like engineers.

Activity Resource Page

Background Information for Activity Leader

The fibers used in textiles for apparel and home furnishings come from two major sources: natural fibers and synthetic fibers. The natural fibers that come from plants, like cotton and linen, are generally comfortable and absorbent. Animal fibers, like wool, silk and mohair, feel soft and luxurious. Spinning the clean, original material produces natural fibers.

Synthetic fibers are created through a process that results in the usable fiber. Rayon is made up of regenerated cellulose materials (like wood pulp and cotton waste). Even though the cellulose material is natural, it is processed with chemicals to create a thick liquid that can then be spun into fiber. Other types of synthetic fibers are made from chemicals and are not naturally occurring. They include acrylic, nylon, polyester and spandex. These materials are generally easy to care for and are resistant to oils and chemicals. Cellulose based fibers, including acetate and rayon, usually require dry-cleaning.

While there is evidence that some natural fibers were used as long ago as 3,000 to 5,000 BC, synthetic fibers are relatively new inventions. Rayon, the first synthetic fiber, was commercially produced in the 1910. Polyester, which is now the most commonly used synthetic fiber in the United States, was first produced in 1953. New synthetic materials continue to be developed to meet the commercial, industrial and environmental needs of society.

Questions to Ask

As you go through this activity with the students you should have them continually compare and contrast the fabrics. Ask questions that prompt those comparisons.

Explain to the students that engineers can be involved in production, design, development, research, sales and consulting. While they are doing Parts 1 and 2 of the activity, ask them in which engineering role they are involved.

Q: What other characteristics of fibers would be valuable to investigate?

A: Some other characteristics are abrasion resistance, biodegradability, and shape retention.

Q: T-shirts are often made of a 50/50 blend of polyester and cotton. What advantage is there to having a blend rather than a 100% cotton shirt?

A: Two advantages are that adding polyester makes the material less absorbent and more resistant to shrinkage.

Q: Why do the prices of fabrics vary so much?

A: Fabric prices vary because they depend on availability of the raw materials, manufacturing costs, and supply and demand pressures.

TIPS

Involve local experts to enhance the activity. Contact an engineering school at a local university, WEPAN at www.wepan.org, or the Society of Women Engineers at www.swe.org.

Potential Safety Issues

Standard laboratory safety issues when glassware is used.

Students should also exercise care when tearing the fabric since some force is needed.

Vocabulary Words

Synthetic fiber – an artificial fiber produced by combining chemicals or altering natural fibers

Cellulose – long chains of glucose that make up the cell walls of plants

Regenerated – chemical process that turns natural cellulose into a liquid that is then re-treated and extruded as a fiber

Nylon – material based on synthetic resin

Polyester – synthetic material formed from plastic

Rayon – synthetic material based on regenerated cellulose

Expanding the Activity

1. Have the students research the uses and characteristics of some of the other synthetic fabrics, including polyolefin, acetate, and spandex.
2. Have students research the different chemical compositions of synthetic materials.
3. React hexa-methylendiamine with adipoyl chloride to form nylon.
4. Do an interdisciplinary lesson with humanities exploring the history of natural and synthetic fibers.

Additional References

[Http://www.fabrics.net](http://www.fabrics.net)

[Http://www.fabriclink.com](http://www.fabriclink.com)

[Http://www.fibersource.com](http://www.fibersource.com)

Microsoft Encarta 98 Encyclopedia CD. Fiber, polyester, nylon

Extensions for Advanced Students

If the students are more advanced they can design their own experiments to test for strength, absorbency and wrinkle resistance. Be sure to remind the students that the experiments must be able to be replicated by others.

Worksheet A: Lab Instruction Sheet

Materials required:

- 1 set of 6 labeled fabric samples [*cotton, linen, silk, polyester, nylon, rayon*]
- Balance beam or electronic balance accurate to 0.01 g.
- 250 ml beaker
- 1/2 teaspoon
- scissors
- paper towels
- a watch with a second hand

Perform the following tests on each of your fabric samples. **THE STRENGTH TEST MUST BE DONE FIRST.**

Strength

- Make a 1/2 inch cut on the side of the fabric at point A on the fabric (see attached sketch).
- With fingers on the edge of the fabric, pull until the fabric tears. Grade the strength of the fabric using a rubric (1 for tears easily and 5 for will not tear at all).
- Do this for each type of fabric.

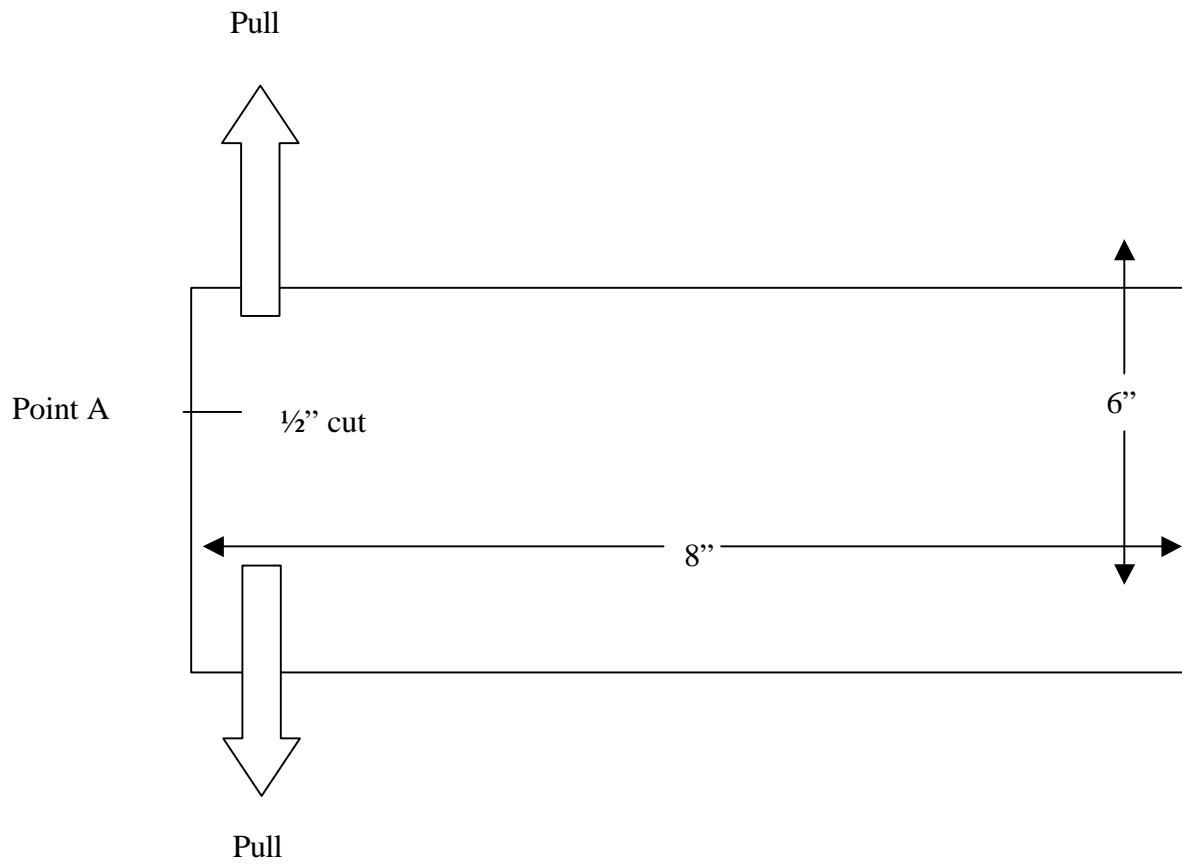
Permeability

- Lay **one** of the fabric sections on a piece of paper towel and put 1/2 teaspoon of water in the center.
- Time how long it takes for the water to permeate through the fabric. Time until no 'bubble' of water remains on top of the fabric.
- Rate the permeability of the fabric using a rubric (1 for very fast permeation and 5 for no permeation).
- Do this on **one** fabric section for each type of fabric.

Absorbency

- **Use the dry fabric samples for this test.**
- Mass (weigh) a section from each of the cloth samples used in this test and record your results.
- Place the fabric in a beaker (~250 ml) of water for 30 seconds.
- Take the fabric out of the water and hold it until it stops dripping.
- Mass (weigh) each of the cloth samples again and record your results.
- Determine how many times its own weight a fabric can hold by dividing the mass (weight) when wet by the mass (weight) when dry.
- Do this for each type of fabric.

Worksheet B: Strength Test Diagram



Worksheet C: Characteristics of Fabrics

(All information, except prices, is from the web-site www.fabriclink.com)

	Cotton	Linen	Nylon	Polyester	Rayon	Silk
Quick drying			X	X		
Resists shrinkage			X	X		
Easily washed			X	X		
Prints well	X	X			X	X
No static problems	X	X			X	
No pilling problems	X	X			X	X
Resistant to*			O,C	C		
Price/yard **	\$3.59	\$5.00	\$5.59	\$8.59	\$8.59	\$15.59
Permeability						
Absorbency						
Strength						

* O = oils, C = chemicals

** Prices are averages and may vary from store to store.