Engineer a Sneaker

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

1. This unit explores the types of materials used in the bottom of a sneaker. It connects how engineers think about selecting appropriate materials for design needs.
2. Students build a model using a variety of everyday items with the same characteristics found in actual sneaker soles.
3. This activity has a resource page that provides background information.

Sports

Grades 5 & 6 (suggested)

Objective

The goal is for students to understand the basics of engineering that go into the design of a sneaker. The bottom or sole of a sneaker provides support, cushioning, and traction. In addition the sole is flexible and can have some 'fashion' based functions such as cool colors and added height. The sneaker is a well-engineered product, utilizing a variety of materials to create a highly functional, useful shoe. This unit focuses on having the students select specific design requirements, such as good traction or lots of cushioning, and then select from a variety of materials to build a model shoe with the same design criteria.

Skills & Standards

- Analyze a product's components and their function.
- Recognize a design need or engineering problem.
- Develop, sketch, and discuss possible solutions and select one.
- Select appropriate materials for the solution.
- Construct a working model using a variety of materials.
- Use, evaluate, and suggest ways to improve the object.

Activity Outline

Materials required per group:

- An assortment of sponges, bubble packing material, foam and rubber, as outlined on Worksheet A. Items can be added or substituted.
- Canvas or muslin fabric used for base forms.
- Twine
- Scissors
- Glue
- Masking tape

Time frame:

Part 1: 40 minutes
Part 2: 45 minutes

Conduct Part 2 the next day so prototypes have time to dry.

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 what properties (soft, padded, bouncy, traction) sneaker soles have. If any students are wearing sneakers they can remove them and evaluate them during this discussion.

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

Do the activity.
Break the class up into groups of 4 students. As the students work on the activity ask them to define the specific design outcome, and encourage them to continue to work toward that goal.

Reflect on the activity.
After the activity is completed, spend time discussing what was discovered and learned. Look at the wide variety of final designs. Discuss the advantages and disadvantages of each prototype sneaker. How would the students change their design (and why) if they were going to build another prototype?

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

Activity: Designing and Building a Sneaker

The students will define specific characteristics for their sneaker, select the appropriate materials, and build a model. . 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: MODELING AND BUILDING A SNEAKER

Gather materials for sneaker construction identified on Worksheet A: *Materials and Properties.* Cut out enough fabric bases so that there will be one for each group, with a few extras in case of mistakes (See Worksheet D: *Pattern*).

What's the problem? Sneakers are designed for an assortment of uses. Each use has specific characteristics that must be taken into account before manufacturing the associated sneaker.
Who wants to know? People who design and manufacture sneakers want to make sure that they have not overlooked a major new type of sneaker that would appeal to students.
How can you help solve the problem? Think about the characteristics of your shoes. Is there something that you would like to be different about them? What would it take to create a sneaker with that new property or component? Are there any materials you know about that could be used?

1. Divide the class into groups of 3 or 4 students each, and give every group Worksheet B: *Design Specifications* to complete.
2. Pass out 2 copies of Worksheet A: *Materials and Properties* to each group. Discuss the properties of each material (springy, soft, stiff, sticky, etc.).
3. Pass out two copies of Worksheet C: *Materials and Costs* to each group. Costs are assigned to each item. The designed pair of sneakers needs to be within budget, limiting options and forcing engineering trade-off decisions.
4. Distribute two fabric bases plus a bag that includes the materials that are available for construction of the prototype sneakers. Students can cut or shape materials as desired. If you prefer, a "store" can be set up and students can purchase the materials they will use by completing and submitting Worksheet C.
5. Once the students select the materials that they feel would work best (meet their design criteria) for their prototype sneaker, they should then assemble the prototype sneakers using the glue and tape. Students should be building two matching sneakers.
6. Allow the prototypes time to dry.

Part 2: EVALUATING AND IMPROVING THE DESIGN

1. Distribute the dry prototypes to the original designer(s) and two lengths of twine for tying on the prototypes.
2. If you have time, each group should present their design to the class. The teacher evaluates each design according to #3 below. If time is short, enlist the help of another adult to evaluate half of the groups. Have each group discuss what worked well and how they would improve their model.
3. Test for design success through the following:
   - Height: Measure the student's height with and without the sneakers on.
     Rate height difference on a scale of 1-3 (1 being *least* and 3 being *most*).
   - Traction: Slide around the floor with and without the sneakers on.
     Rate traction ability on a scale of 1-3.
   - Cushioning: Jump up and down with and without sneakers on.
     Rate cushioning on a scale of 1-3.
   - Stiffness: Bend and twist prototype sneakers compared to store bought ones
     Rate stiffness on a scale of 1-3.
4. If students suggested any additional design criteria, have the group discuss and decide what would be Appropriate tests for design success.

Will your suggestion(s) work? Compare your sneaker prototypes to some of the sneakers that students are wearing. How do the materials you used compare to the ones in the store bought sneaker? Are the ideas you've created realistic? What activities are best suited to your design?

Who can help you solve the problem? What type of information or knowledge is needed to design, build and test sneakers?

Engineering Summary: Finish with a discussion about how the students acted as engineers.

Activity Resource Page

Background Information for Activity Leader

The design of today's sneakers is an engineering science that combines physics and biomechanics. The engineering design utilizes materials that provide durability, comfort, cushioning, and stability. Good designs also consider the type of foot (female, male, or child) since the average shape and structure of each has different characteristics. Typically, a woman's foot is narrower and has a higher arch. The inside layout of a well- designed sneaker takes these physical differences into account. Another important component in the design is the consideration of which sport the sneaker will be used to play. Each sport has different footwear requirements. Some need high flexibility, others maximum cushioning or high levels of friction.

Sneakers originated in 1908 and were comprised of a rubber sole with a canvas upper. 1917 brought the introduction of Keds™ brand. In 1922 the technology of creating different models for different needs was introduced. The health and fitness movement of the 1970's created a high demand for sneakers by the public, and in 1979 the concept of cushioning air bubbles in the sole was introduced. Since then the advancing capabilities and creation of new materials has resulted in highly specialized (and expensive) sneakers.

Questions to Ask

As you go through this activity with the students you should have them continually thinking about meeting the design criteria they specified. Ask questions that prompt them to stay on track and to think about the physical properties of the materials they are using.

Q: Which material properties help the sneaker be comfortable when you apply large forces or pressure to your feet?
A: The greatest comfort comes from materials that are cushioning (soft) and have the ability to 'bounce back', or a springiness.

Q: Why is traction important on a sneaker?
A: Traction is created by friction between the base of the sneaker and the ground. Without traction the sneaker will slip, like you were trying to move on an icy surface.

Q: Why do the prices of sneakers vary so much?
A: Sneaker prices vary because they depend on material costs, marketing costs, manufacturing costs, and supply and demand pressures.

Potential Safety Issues

Surface coverings to keep the glue off the desks and floor and to not harm floors when testing. You may wish to set up a special 'test area.'

These sneakers are only prototypes and should not be used for actual wear after the adult supervised testing.

Vocabulary Words

Prototype – a model that is built to test a concept

Stiffness – resistance to being flexed

Cushioning – providing a softening effect to forces

Traction – ability to move a load over a surface

Expanding the Activity

1) Have students create a list of other types of footwear. From this list either discuss the importance of (or create a graph which shows) the same design criteria (height, stiffness, cushioning, traction) for each of these.

Additional References

Http://www.saucony.com/science.htm
"Sneakers : From Start to Finish (Made in the USA)" Samuel G. Woods, Gale Zucker (Photographer)

TIPS

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

Worksheet A: Materials and Properties

This table lists the properties of a variety of everyday items that are appropriate for this activity. All or some can be used. Other items can be added.

Property	Material	Recommended Size
Height	Sponges, 1/4 to 1 inch thick	2” x 3” sections
	Styrofoam, blocks	Any size easily available
	Styrofoam, packing pellets	As individual pellets
	Bubble packing, small or large bubble	2” x 3” sections
Cushioning/Flexibility	Sponges, 1/4 to 1 inch thick	2” x 3” sections
	Rubber tubing (like used for fish tanks)	6” lengths
	Cotton balls, triple size	As individual balls
	Bubble packing, small or large bubble	2” x 3” sections
Traction	SOS / Brillo pads	As individual pads
	Rubber baseboard	6” – 8” lengths
	Sandpaper, 100 grit	3” x 8”
	Rubber gloves	2” x 3” sections

Note: the stiffness/flexibility depends upon which materials have been chosen for the other properties.

Worksheet B: Design Specifications for the Sneaker

It is important to have design criteria in mind when you work on building or creating things. The way things are made and the materials that are used depend upon the desired final design. Work with the students in your group to complete the following exercise.

1. What sport do you want to design a sneaker for?

2. What motions do you think you use in this sport?

_____ _____

_____ _____

3. Have one student in your group actually go through a few of the motions involved in the sport while the other students observe.

5. What are the motions that were used; how did you feet move?

Fast start_____
Fast stop _____
Upward motion _____
Turning motion _____
Jumping up _____
Jumping forward _____
Other motions used _____

6. What types of properties should the sneakers have for this sport?

Flexible _____ or Stiff _____

Slippery _____ or Sticky _____

Bouncy _____ or Firm _____

Other _____

6. What qualities would be needed for a sneaker to make it most effective for this sport?

7. Review the materials list you have and based on the properties for each of those materials, design a sneaker that will be effective for the sport you have selected.

Worksheet C: Materials and Costs

SNEAKER BUDGET

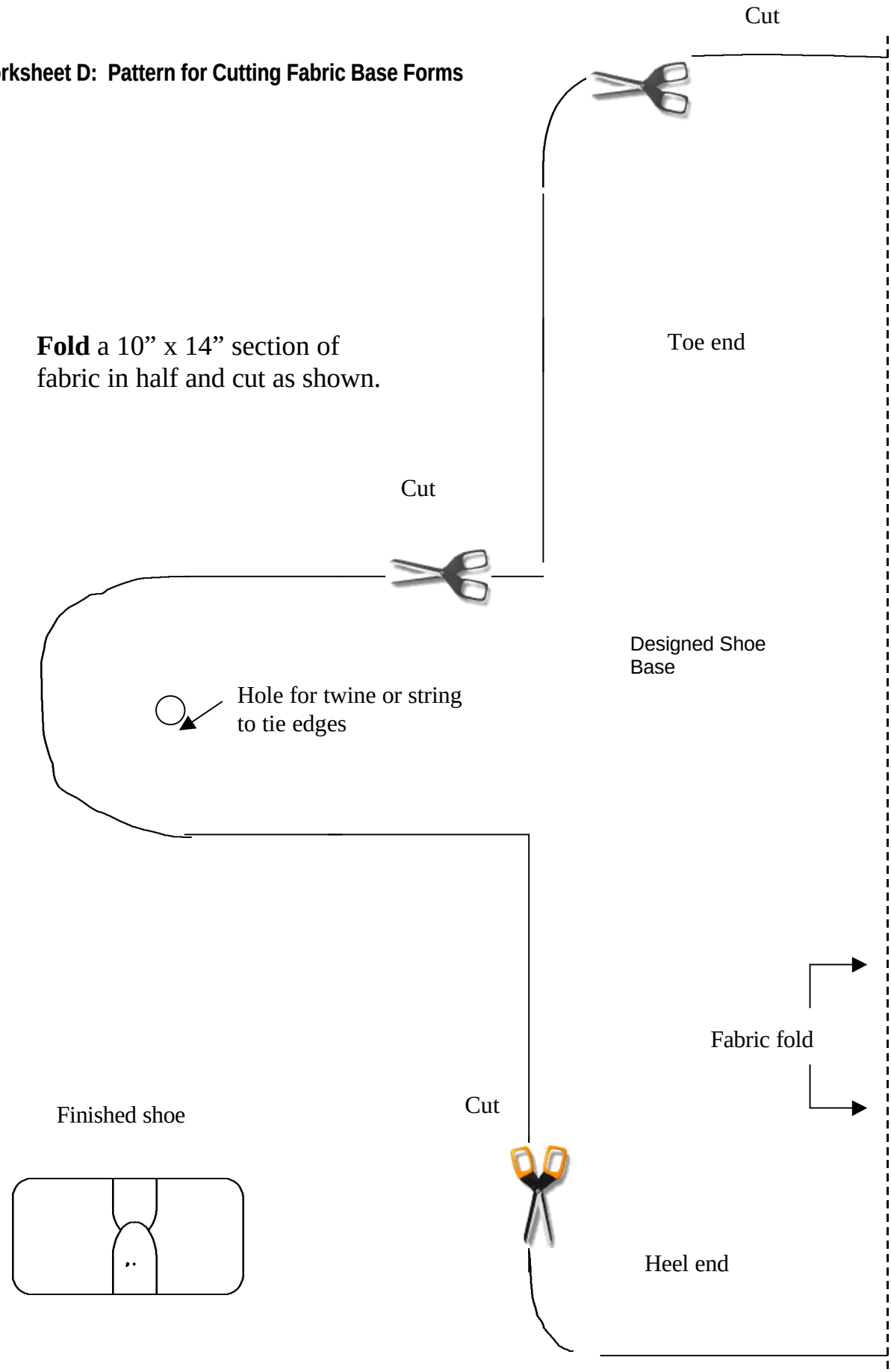
Total amount available to spend per pair of sneakers is $9.00

Material	Cost per item
REQUIRED ITEMS (2 each)	
Rubber baseboard (NEED 2)	90 cents each
String/twine for ties (NEED 2)	20 cents each
Canvas fabric cut into sneaker shape (NEED 2)	1.00 each
OPTIONAL ITEMS	
Cotton ball, triple size	5 cents each
SOS / Brillo pads	50 cents each
Sandpaper, 100 grit	80 cents each
Rubber glove	90 cents each
Sponge, 1/4 to 1 inch thick	50 cents each
Styrofoam, block	25 cents each
Styrofoam, packing pellet	5 cents each
Bubble packing, small or large bubble	75 cents each
Rubber tubing (like used for fish tanks)	30 cents each

Table with list of items for your sneakers

Material List	Quantity	Cost per item	Total for item
		Total for all items =	

Worksheet D: Pattern for Cutting Fabric Base Forms



Fold a 10” x 14” section of fabric in half and cut as shown.