Design a Bicycle Helmet

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

1. This activity explores the design of bicycle helmets and helps students to appreciate the role of the helmet layers in protecting the head.
2. Students will design a bicycle helmet to meet a specific application, similar to how an engineer would approach the problem.
3. This activity has a resource page that provides background information.

Sports

Grades 9 & 10 (suggested)

Objective

The goal is for students to understand the basics of engineering associated with safety products. Using a bicycle helmet helps to protect the brain and neck during a crash. In order to do this effectively helmets must have some sort of crushable material to absorb the shock of a collision and a strap system to ensure that the protection stays in place. The exact design of a helmet will depend on the needs and specifications of the user. In this activity students will be introduced to the biomechanical characteristics of helmets. They will be asked to incorporate these characteristics into designs for helmets for various applications.

Skills & Standards

- Analyze a product to determine the need it was designed to meet and the customer's it was meant to attract.
- Produce, use, and evaluate a prototype of the design solution.
- Describe the personal, impact of the designed product.
- Communicate the solution to a problem and justify decisions.

Activity Outline

Materials required:

- 2 sample bicycle helmets
- oak tag or poster board (approx. 20x30)
- markers/colored pencils
- blank transparencies on which to copy attached slides for introduction.

The following are needed if you plan to perform the hardness experiment in Part 1, #4.

- EPS (polystyrene) or styrofoam approx. 10" square
- Thin hard plastic (e.g. cut the plastic from a 2 liter soda bottle to lay flat)
- One 5 pound weight
- Scissors
- Masking tape

Time frame:

Part I: 45 minutes
Part 2: 50 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.
Use the overheads provided to introduce the activity.

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

Do the activity.
Break the class into groups of 3 or 4 students. As the students work on the designs remind them to consider safety, comfort and marketability – with safety being the top priority.

Reflect on the activity.
After the activity is completed, spend time discussing what was discovered and learned. Stress the fact that choices always need to be made in the design process.

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: Designing Bicycle Helmets

Using the slides provided, the presenter will explain the characteristics of bicycle helmets. The students will use this information in developing a helmet design for specific applications. 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 1A: THE STRUCTURE OF BICYCLE HELMETS

What's the problem? All helmets contain the same basic parts to protect the head in an accident. However, helmets are not all alike. They may differ depending on who will use them and for what purpose.
Who wants to know? *(Use slides 1-7)* People who design and manufacture bicycle helmets need to know how to make a helmet protective, functional and marketable at the same time.

1. Ask the students what the purpose of a bicycle helmet is.
2. Ask the students to describe the parts of the helmet. Discuss the purpose of each part.
   - Hard shell
   - Crushable liner
   - Layer of padding
   - Strap system
   - Vents
3. Pass around the sample bicycle helmets so that the students can identify the parts. Have the students note the sticker from the CPSC (Consumer Product Safety Commission) that shows that the helmet meets a safety standard, or the blue SNELL sticker indicating that the helmet has passed more stringent tests.
4. To reinforce the purpose of the hard shell, conduct the following experiment:
   - From shoulder height, drop the five-pound weight onto a piece of EPS.
   - Pass the EPS or styrofoam around the class and have the students note the deformation.
   - Cut a piece of plastic (polyester terephthalate (PET)) from a soda bottle and tape it onto another Piece of EPS or styrofoam.
   - Once again drop the weight from shoulder height.
   - Pass this piece of EPS or styrofoam around the class and have the students comment on the deformation.

Part 1B: DESIGNING A HELMET FOR AN APPLICATION

How can you help solve the problem? Think about the helmet characteristics that are desired for a certain application. By adding these characteristics to the basic helmet, the proper design can be determined for an application.

1. Review slides 8-11 to define the task and evaluation process.
2. Put the students into groups of 3 or 4.
3. Pass out Worksheet A: *Helmet Design Project* (2 pages) and assign each group one of the design challenges.
4. Have students brainstorm ideas.

Part 2: CREATE A POSTER AND CLASS PRESENTATION

Have the students design a helmet to fit the application they are working on and prepare a 2 minute presentation. Each group should create a poster of their helmet design and should be prepared to discuss the choices they made during their presentation. Presenters or teachers will evaluate the project using the score sheet attached.
Will your suggestion(s) work? Examine bicycle helmets that are designed for specific applications. Decide if the classroom design is similar to the commercial product. Check web-sites on bicycle safety to see if there are specially made helmets for these applications.
Who can help you solve the problem? Although expanded polystyrene (EPS) is still widely used in helmets, there have been several new types of foam introduced recently. Chemical engineers would be involved in the development of these new materials. The problem of getting people to wear helmets is an important one. In this regard engineers must be involved in the sales side of the business and not just the design side.
Engineering Summary: Finish with a discussion about how students approached the problem like engineers.

Activity Resource Page

Background Information for Activity Leader

Each year, nearly 1,000 people die from injuries sustained in bicycle crashes, with head injuries accounting for over 60% of these deaths. In addition, many more people survive non-fatal head injuries resulting from bicycle crashes. While some of these survivors may experience only minor headaches or dizziness, others may suffer profound and disabling neurological difficulties.

One effective way to prevent head injury from these accidents is to use a bicycle helmet. Helmets generally consist of two parts: an impact protection system to absorb the force and a strap system to keep the protective layer in place.

Often three layers are used together to provide impact protection. The outer layer is generally a hard shell or a micro-shell made of fiberglass, Lexan or ABS plastic. This shell serves many purposes: it distributes the force of the collision over a larger area; it allows the helmet to slide thereby causing a slower deceleration; it provides a shield against penetration; and it holds the middle layer together. The middle layer is usually a crushable liner that absorbs the shock of the collision. This layer is generally made of expanded polystyrene, also known as EPS. The inner layer, which may be segmented, helps to ensure proper fit and comfort.

Questions to Ask

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 which engineering role they are involved in.

Q: How would you test bicycle helmets to ensure that they are safe?
A: Bicycle helmets are tested in two ways to ensure that they provide the proper protection. Impact protection is measured by dropping the upper half of a helmeted crash-test dummy onto a metal anvil and measuring the force on the "head". The strength of the strap-system is also measured by dropping a weight on the fastened strap.

Q: After an accident do you need a new bicycle helmet?
A: When a helmet's crushable liner is damaged in an accident, the helmet will provide less protection during future impacts.

Q: How can the consumer tell if a helmet is safe?
A: The Consumer Product Safety Commission (CPSC) puts a sticker on helmets that pass their safety tests. A blue Snell sticker may also be found indicating that the helmet has passed even more stringent tests.

TIPS

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

Potential Safety Issues

Presenter should exercise care when he/she is dropping weights onto the EPS or styrofoam and EPS or styrofoam/plastic combination.

Vocabulary Words

Expanded polystyrene – a rigid, foamed plastic that can be used for its insulating or protective properties

Biomechanical – refers to the study of the human body from the mechanical engineering perspective

Crushable – able to compress rather than shatter or crack when a force is applied

Expanding the Activity

1) Have the students research other types of foam that have been used in helmets. These include expanded polyurethane and expanded polypropylene.
2) Some people feel that wearing helmets makes riders more reckless and therefore more prone to injury. Have the students poll other students to see if this is the case. Also check to see if gender plays a part in the findings.

Additional References

Bicycle Helmet Safety Institute (http://www.helmets.org)
Snell/Harborview Studies (http://www.smf.org/report.htm)
Bell Helmets (http://www.bellbikehelmets.com)

Extensions for Advanced Students

If the students are more advanced they can design their own experiments to test bicycle helmets for impact resistance and strap strength. They could then test some low priced or used helmets.

Worksheet A: HELMET DESIGN PROJECT

Your group will be assigned one of the following problems (see next page) that deal with bicycle helmet design.

Your group has 30 minutes to brainstorm the problem and create a poster showing the results of your group work. Your group will have 2 minutes to present their poster to the class.

On side A of your poster, provide:

1. A statement of the problem your group was asked to solve.

2. A list of the needs that the helmet group you were assigned to has.

3. The design changes that must be made to a current helmet to meet the above needs.

4. The marketing techniques you will use to attract members of your helmet group to purchase your redesigned helmet.

On side B of your poster, provide:

A drawing of your newly re-designed helmet that points out the strengths of the design.

(Note: Worksheet A is continued on following page)

Worksheet A: HELMET DESIGN PROJECT

Helmet Design Problems

Task: Prepare a poster and two- minute presentation that explains why the design team feels that helmet design fits the application.

Group 1: People with long hair
People who have long hair (whether they are males or females) sometimes choose to wear their hair pulled back in ponytails so that it is off of their necks. The problem with this is that a ponytail can interfere with the way the helmet sits on their heads. What design change(s) might alleviate this problem?

Group 2: Bald people
People in this group include those who have lost their hair due to age or illness and those who choose to be bald. One problem facing people in this group is that the vents in the helmet cause them to get sun burned lines on their heads? What design change(s) could prevent this from happening?

Group 3: Children aged 5-7
There are two issues for younger children regarding bicycle helmets. The first is getting them to want to wear one. The second is making the helmet easy to put on and remove since young children may have more difficulty with fasteners than older ones.

Group 4: Teen-aged riders
The biggest issue for this group is how do you get teen-agers to wear helmets? Are there design changes that might make helmets more acceptable to this group? What marketing strategies might help in this regard?

Group 5: Bicycle commuters
The largest number of bicycle deaths occurs between the hours of 3 p.m. to 9 p.m. It appears that the commute home from work or school on a bicycle is especially dangerous at this time. What ways could you change the existing helmet to help make this commute safer?

Group 6: Bicycle motocross racers (BMX)
Think about the added dangers faced by people who participate in this sport. What are these dangers? How should the helmet be redesigned to add more protection?

Evaluation Key

3 Superior

2 Good

1 Needs Improvement

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Score Sheet

Group: _____

GROUP EVALUATION				
Objective	***Score***			***Comment***
Problem Statement	1	2	3	
Group Needs	1	2	3	
Design Changes	1	2	3	
Marketing Techniques	1	2	3	
Illustration	1	2	3	
Overall Presentation	1	2	3	

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