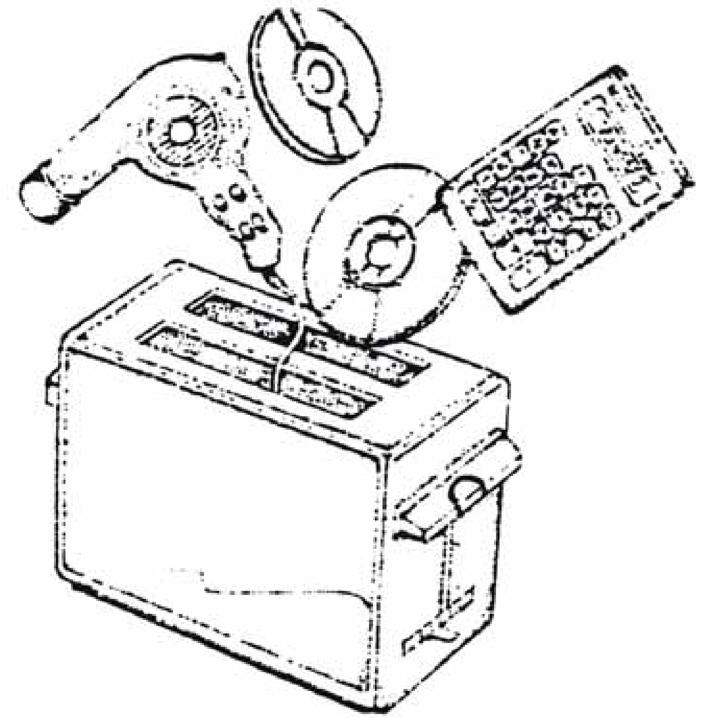


Product Dissection:
An Engineer's-Eye View of Your Toaster

Technology touches today's teens, from their compact disc players to their hair dryers and pocket calculators. Rarely, though, do they consider how machines and technology-and the engineering that makes them possible-affect their lives.

Grade Level

This exercise is for high school students. It can easily be adapted for 6th-8th grades.

Objectives

The overall objectives of this exercise are to allow the students to see first-hand the:

- Connections between science and engineering.
- Impact that engineers (the creators) have on the lives of people (the customers/users). Engineering is done for people.
- Engineering is a team effort.

Overview of Exercise

This exercise, done in teams of two or three students, is designed to give students an opportunity to take a machine or device apart; this is referred to as "dissection". We often take for granted how machines affect our lives, and seldom consider the inner workings of these devices. We also fail to acknowledge the engineers who designed and built them.

Materials

On a per team basis (teams are comprised of two or three students):

- Machine or device for each team (see notes below)

- Disassembly kit (tools needed for taking the device apart, any written instructions necessary for disassembly plus several sheets of paper for note taking); 1 per team. The specifics of the kit will depend upon the device that you choose to use, but keep the tool set simple (e.g., a single screw driver).

- Large piece of butcher paper (optional)

Assistants. While the exercise can be run effectively with a single instructor, it makes the entire experience much more personal if there are a number of assistants (sometimes referred to as coaches) who can aid the student teams through the disassembly stage. Assistants can be the regular classroom teacher, undergraduate/graduate engineering college students, and/or other practicing engineers. You and your assistants will want to become thoroughly familiar with the device to be dissected as well as general administration of the exercise in advance of the class session. Using assistants will help give students a broader picture of "what engineers look like", so if possible strive for diversity in your assistant pool; you might also consider selecting assistants who represent different engineering disciplines. For a class of 30 students, two assistants plus the instructing engineer work well. Recommended prerequisites for device selection are that it:

- Can be taken apart with simple tools (e.g., screwdrivers, snap fits).

- Is of a size that two or three students can work around and on it (not so small that one needs a magnifying glass to see, or so large and heavy that it is difficult to move and hold).

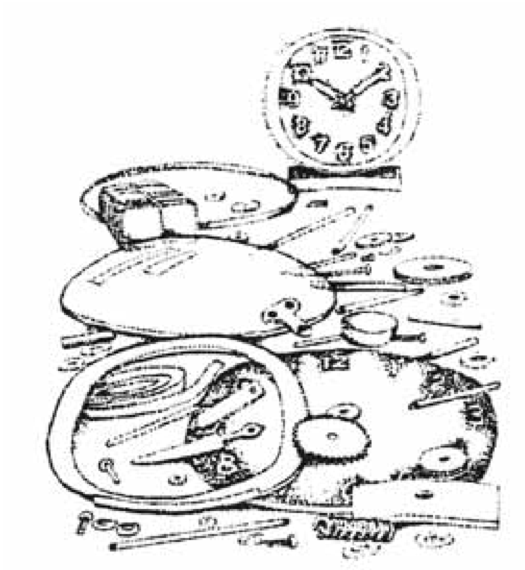
- Has a number (e.g., at least 4, but not more than 30) of mechanical components (e.g., springs, gears, bearings) inside.

- Has an electrical aspect to it (e.g., it is battery powered). This prerequisite is desirable but not necessary.

- Costs less than $10/device. The reasons for this are twofold: to keep overall cost of the exercise down and to allow students to see the amount of engineering involved even in relatively inexpensive devices works. A very important part of the exercise is for the teams to see how the external function of the device is achieved internally. Does not require detailed disassembly instructions.

Items that typically cost less than $5 each:
- Wind-up toy (e.g., cars, animals)
- VCR tape (to be compared with a cassette tape)
- Shaver (e.g., a variety of disposable shavers)
- Ball point pen
- Electrical outlet
- Stapler
- Disposable camera
- Mechanical pencil
- Electrical switch
- Flashlight

Other suggested devices/machines:
- Clock
- Power drill
- Electric toothbrush
- Hair dryer
- Smoke detector
- Timer
- Manual drill
- Food scale
- Tape recorder
- Fishing reel
- Electric razor
- Bathroom scale
- Pencil sharpener
- Jack (e.g., car)
- Toaster
- Telephone
- Lawn sprinkler



Where to find devices (and other ideas):

- Hardware stores
- Target stores
- Surplus or outdated equipment manufactured by your employer
- Drugstores
- Toy stores (e.g. Toys 'R Us)
- K-Mart
- Salvage yard

Lesson Outline

Prior to your session with the students, you need to become the "expert" with the device. Take it apart and put it back together enough times so that you have a good feel for the difficulties involved. If there is some aspect of the disassembly or reassembly that is particularly tricky, consider creating a simple handout on the procedure. In addition, go over the exercise with your assistants and with the regular classroom teacher. Discussing the exercise with the teacher will help you:

1. Determine likely questions.

2. Learn the class size and determine the number of teams.

3. Decide how to divide the class into groups. (A really organized teacher might have the class already arranged in their groups when you arrive. This might be particularly important to ensure that well-balanced teams are formed; the teacher knows her/his students best).

4. Become familiar with the curriculum (e.g., it would be terrific if the teacher could discuss pertinent science principles in advance of the dissection exercise so that when the engineer arrives and asks what science or scientific principles were used in the device, the teacher has already introduced some of those principles).

Now for your class visit.

1. Introduce yourself and any assistants working with you to the class. As part of this introduction mention briefly any products with which you have been involved as an engineer. This should take no more than five minutes.

2. Ask the group to generate a list of all of the machines that they have touched today. Write the list on the blackboard or the butcher paper-or better yet, have a student list the items. The basic idea is to get the students to start recognizing that engineered products are a part of their every lives. This should take no more than 5 minutes.

3. Divide the class into teams of two or three students per team.

4. Distribute the products to be dissected and associated kits, one per team. Selecting a device to be explored by the teams is where the bulk of your preparation will be spent. It is recommended that all teams be working on the same type of product/device: (e.g., wind-up toy), but you could have half of the team dissecting one brand/design, and the other half a different brand/design.

5. Have the student teams take about five minutes to "play" with their device (e.g., push buttons, turn it on) and write down the answers to the following questions:

    - What does the device do?

    - How many parts are inside?

- What science/scientific principles were used in this machine?

- How many engineers do you think were involved in making this machine'? What types of engineers are involved?

6. Have the teams, spend no more than 20 to 25 minutes taking the device apart AND putting it back together. The associated kit should contain the tools necessary to disassemble the device (e.g., screwdriver, magnet for collecting screws). Warn the teams when their work period is half over so that they can start reassembly. Their explorations should aid them in answering

- What does the device do and how does it do it? (Especially encourage sketching in answering this question).

- How many parts are inside?

- What science/scientific principles were used in this machine (e.g., chemistry in batteries and materials. physics in electromagnetism and load transfer, biology in human factors)?

- How many engineers do you think were involved in making this machine? What types of engineers were involved?

- What other machines would you expect to find similar components in?

- How do you think it was assembled? How much do you think it cost to build?

Remind the students that they are responsible for disassembling and reassembling the device as well as answering the questions (in words or sketches).

As the student teams are disassembling you and your assistants should wander among the groups, lending suggestions when they seem to be having a difficult time understanding a particular aspect of the device, or asking them probing questions about what they are seeing. Do not assume that all of the students have been taking things apart since they were little and know even which way to turn the screwdriver to remove a threaded fastener.

7. Have everyone stop working and have one member of each team orally present the team’s answers; record the answers on the blackboard or butcher paper. Butcher paper is nice in that it leaves the classroom with an artifact of the experience.

   You might have the first group report on Question #1 and then have the second group answer Question #2-adding any details to the answer for Question #1, etc. When talking about the types of engineers involved in creating the device, be sure the list reflects the breadth of the engineering profession (e.g., materials engineers, industrial engineers, environmental engineers, etc.).

Extensions

You could leave the devices in the classroom for further exploration and/or complete reassembly. Also suggest other devices/ machines that students might like to take apart, and where they might find inexpensive examples (e.g., secondhand stores, garage sales). They could even "play doctor" with machines that no longer function in terms of diagnosing what is wrong. All ages like the idea of "sanctioned" disassembly. With middle school students you may want to focus more on the science integral to the device than the specific roles that engineers played in its creation (if only because career decisions are a bit more remote for this age); you might also talk with the classroom teacher beforehand concerning the level of career readiness of the students.

Suggested Reading

The Way Things Work by David Macaulay Houghton Mifflin Company, 1988.

How Things Work by the Editors of *Consumers Guide*, Publishers International, 1990.

This activity provided by
The Synthesis Engineering Education Coalition, Funded by the National Science Foundation, the coalition is charged with the task of reshaping undergraduate engineering education while increasing the participation those currently underrepresented in technical disciplines. Member universities include Cal Poly-San Luis Obispo, Cornell, Hampton, Iowa State, Southern, Stanford, Tuskegee, and the University of California at Berkeley. (For more information about this exercise, contact Dr. Sheri Sheppard in the Design Division of the Mechanical Engineering Department at Stanford University,
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