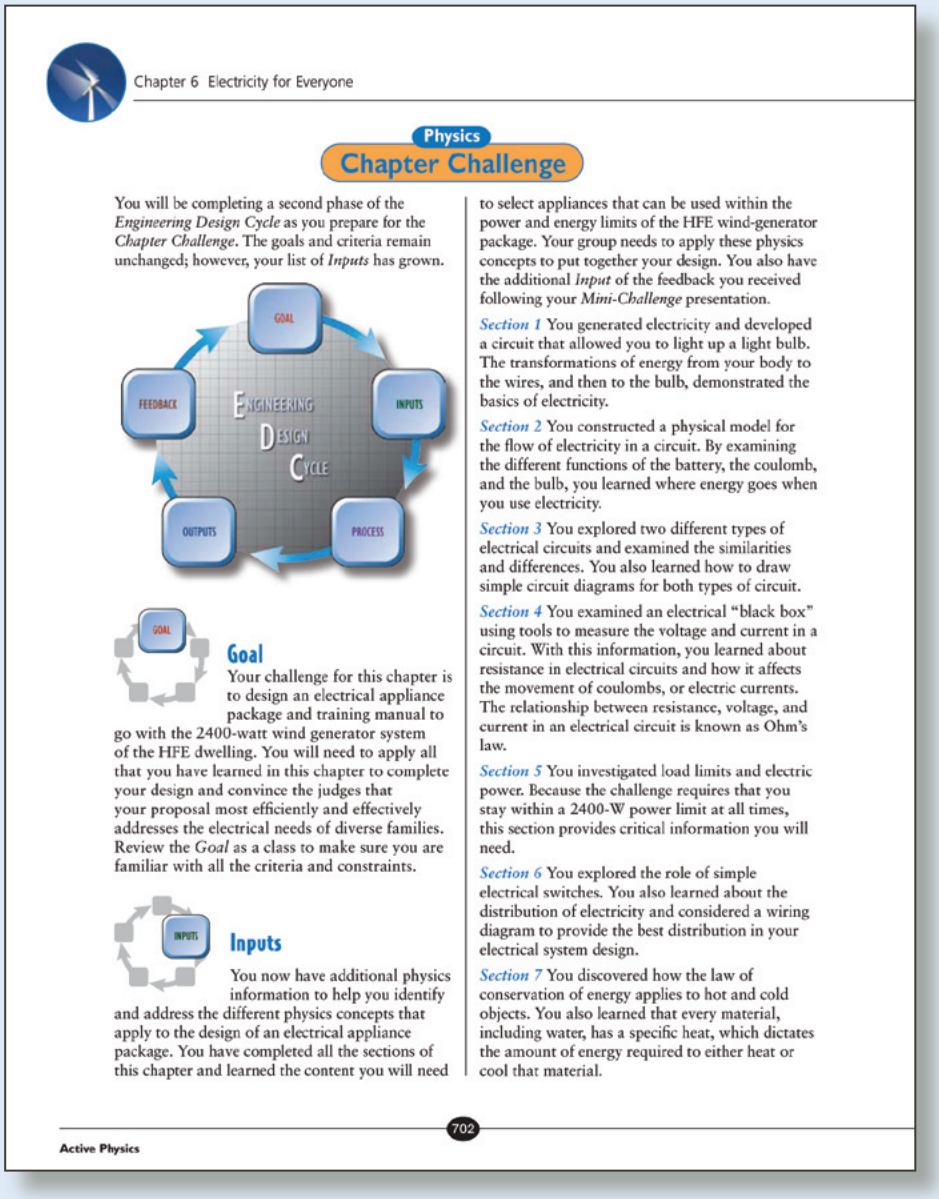
Physics Chapter Challenge

Consider using the *Blackline Master* of the *Engineering Design Cycle* as a focal point of the discussion. Let students know that they will be completing the second phase of the *Engineering Design Cycle* and review the cycle, specifying how each part of the cycle pertains to the *Chapter Challenge*.



Chapter 6 Electricity for Everyone

Physics

Chapter Challenge

You will be completing a second phase of the *Engineering Design Cycle* as you prepare for the *Chapter Challenge*. The goals and criteria remain unchanged; however, your list of *Inputs* has grown.

Goal

Your challenge for this chapter is to design an electrical appliance package and training manual to go with the 2400-watt wind generator system of the HFE dwelling. You will need to apply all that you have learned in this chapter to complete your design and convince the judges that your proposal most efficiently and effectively addresses the electrical needs of diverse families. Review the *Goal* as a class to make sure you are familiar with all the criteria and constraints.

Inputs

You now have additional physics information to help you identify and address the different physics concepts that apply to the design of an electrical appliance package. You have completed all the sections of this chapter and learned the content you will need to select appliances that can be used within the power and energy limits of the HFE wind-generator package. Your group needs to apply these physics concepts to put together your design. You also have the additional *Input* of the feedback you received following your *Mini-Challenge* presentation.

Section 1 You generated electricity and developed a circuit that allowed you to light up a light bulb. The transformations of energy from your body to the wires, and then to the bulb, demonstrated the basics of electricity.

Section 2 You constructed a physical model for the flow of electricity in a circuit. By examining the different functions of the battery, the coulomb, and the bulb, you learned where energy goes when you use electricity.

Section 3 You explored two different types of electrical circuits and examined the similarities and differences. You also learned how to draw simple circuit diagrams for both types of circuit.

Section 4 You examined an electrical "black box" using tools to measure the voltage and current in a circuit. With this information, you learned about resistance in electrical circuits and how it affects the movement of coulombs, or electric currents. The relationship between resistance, voltage, and current in an electrical circuit is known as Ohm's law.

Section 5 You investigated load limits and electric power. Because the challenge requires that you stay within a 2400-W power limit at all times, this section provides critical information you will need.

Section 6 You explored the role of simple electrical switches. You also learned about the distribution of electricity and considered a wiring diagram to provide the best distribution in your electrical system design.

Section 7 You discovered how the law of conservation of energy applies to hot and cold objects. You also learned that every material, including water, has a specific heat, which dictates the amount of energy required to either heat or cool that material.

Students should be able to summarize the criteria and constraints of the *Goal*. Remind them that their electrical appliance package should satisfy the electrical needs of diverse families. In a class discussion, review the *Goal* and the requirements of the training manual. Discuss the students' *Inputs* based on the physics content they have learned from all the sections. Record their ideas on what *Inputs* they obtained from each section and review the inputs listed in the *Student Edition*. Emphasize the load limits of the electric power system of the HFE house, and the importance of specific heat that determines the amount of power needed to heat or cool materials. Consider discussing the *Investigate* that demonstrated how electrical energy was transformed into heat energy using a resistor. Students should realize that the total energy available for their appliance package will be far less than average consumption of most households in the United States. To assist in choosing an appropriate appliance package, they should be able to make accurate calculations of energy used by an appliance.

During the *Process* phase, while students decide on the information they should use to meet their *Goal*, divide them into groups or pair them up with another class member so that they can share essential information and carefully select appliances for their HFE design. Describe the criteria listed in the student text concerning the HFE package and training manual. Ask students how this might affect the process they choose for their group to follow. Emphasize that they should consider the power ratings of each appliance and calculate their monthly energy consumption. Encourage students to use a table or computer spreadsheet to list the appliances and the amount of time they may operate to satisfy the constraints

Section 8 You investigated the energy required to heat up a sample of water and investigated a method of converting electrical energy into heat by using a resistor. You also examined power ratings for various appliances.

Section 9 You calculated the energy used by an appliance based on the amount of time that it is operating. You also discovered that the energy available for your electrical system will be far below the average consumption of a typical household in the United States.

Process

In the *Process* phase, you need to decide what information you will use to meet the *Goal*. Defining your appliance package is a good way to start. Carefully select the appliances for your package that adequately provide for the needs of the family while operating within the constraints of the 2400-W wind-generator system. Remember to consider power ratings and total monthly energy consumption for each appliance. You will have to make difficult decisions about what services are absolutely essential for the family in your HFE dwelling. Your calculations will determine if you have the energy to run the appliances you've chosen and for how long. You may find that some appliances simply cannot operate on this electrical system and other appliances may be operated less frequently or for shorter periods of time.

It may be helpful to create a table to record your appliance list as well as the results of your time, power, and energy calculations. Each time you modify the appliance list, or the amount of time an appliance may operate, you have completed one iteration, and should create a new table. A computer spreadsheet could make this job easier to manage.

Once you have completed your appliance list and determined the range of operating times for each appliance, you will need to make sure that all of the necessary controls are on your circuit diagram. You may need to install switches or fuses that prevent too much power being used at one time. You will also need separate fuses or automatic switches to ensure that families don't run out of electricity or overload the system.

Develop an outline of the training manual for HFE volunteers. Your manual must explain the difference between 2400 W and 3 kWh. It should also give clear examples of how use of the appliances in the package can stay within the power and energy limits of the electrical system on both a daily and a long-term basis.

Outputs

Presenting your information to the class is your design-cycle *Output*. You should have a comprehensive appliance list, a complete circuit diagram, and the outline of your training manual. As you present each item to your class, you may be asked questions that will help you refine your design. Your presentation is also part of your design-cycle *Output*, so take the time to prepare your script and any posters, diagrams, or multimedia pieces you need to make your presentation effective and convincing.

Feedback

Your classmates will give you *Feedback* on the accuracy and the overall appeal of your presentation based on the criteria of the design challenge. This feedback will likely become part of your grade, but could also be useful for additional design iterations. From your experience with the *Mini-Challenge*, you should see how you could continuously rotate through the design process to refine almost any idea.

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of energy and power for their electrical system. Emphasize that switches and controls are equally necessary for the circuit diagrams in their HFE design to ensure that families do not run out of electricity or overload their electrical systems. The development of a training manual also entails a detailed explanation of how appliances should be used and how to stay within the energy limits daily or for a long term.

For the *Outputs* phase, just before students present their information to the class, review what students should include in their final HFE design and training manual. Encourage the use of posters, diagrams, and other multimedia resources for students to make effective presentations. During the *Feedback* phase, distribute a copy of the rubric to each student and ask them to grade their peers objectively based on how well each presentation meets the criteria of the *Chapter Challenge*. You could incorporate these individual assessments into the overall grade each student receives.

CHAPTER 6