Crossed Circuits: Instructor Guide

Title:

Crossed Circuits

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Discipline:

Physics and Astronomy

Target Audience

Introductory, nonmajors

Keywords

Circuits, electric energy, electric power, electricity

Length of Time/Staging

One class/all at once

Abstract

Two roommates argue about each others use of energy. Which roommate should pay a utility premium? How much extra?

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Format of Delivery

Problem is given to student groups mid-way through a class. They find and examine resources outside and return to the following class meeting to find their final answers. After students report their findings, full class discusses the range of answers and approaches used in finding information and evaluating the energy use.

Student Learning Objectives

Students learn that:

1. Appliances consume electrical power and that we pay for electrical energy.
2. Energy is the product of power consumed and the time over which it is consumed.
3. Electrical energy is commonly measured in kW-hr (kilowatt-hour) and energy charges are typically $0.05 to $0.08 per kW-hr.
4. Electrical heating typically consumes more power than lighting and other small appliances in the home.

Student Resources

Course Directory of Electric Utility Companies located on East Coast USA:

http://www.physics.udel.edu/~watson/scen103/utilities.html

Instructor Resources

A sample listing of appliance energy use may be found at:

http://cityofnewarkde.us/documentcenter/view/56

Author's Teaching Notes

This problem may serve as the introduction to PBL in an introduction to electricity for non-science majors. That is, it may serve as the first problem in a sequence leading them through a consideration of electrical circuits concepts. However, no circuit concepts are needed to solve this problem. Mainly students will be learning energy usage of various appliances and how utility companies charge for energy use.

Consideration of energy used in heating water for the shower tends to yield many interesting approaches from the students.

Assessment Strategies

The lessons learned in this problem are seldom assessed in isolation since this problem can be used before the students have encountered Ohm's law or even learned about current and voltage.

Ordinarily, understanding of concepts learned here are assessed in conjunction with later concepts.

Sample Exam Questions (individual):

Estimate the monthly cost for keeping a 100 W light burning overnight on my front porch.

Solution Notes

The night light and TV are of no consequence in the argument. The students' focus should be hairdryer vs. shower.

The hairdryer calculation is unambiguous: assume a power for the hairdryer: say 1200W. 20 minutes is 1/3 hr, so the energy used each time by the hairdryer is the product of 1200 W and 1/3 hr; that is, 0.4 kW-hr. 30 days would yield 12 kW-hr per month. Assuming $0.07 per kW-hr would net a charge of about $1 per month ($0.84).

The hot water charge is less definitive and the students must rise to the challenge of finding an approach. A number will incorrectly look at the power rating for a typical electric hot water heater and multiply by the time of the shower -- hopefully the group will realize that the "hot" shower ends when the hot water held in the storage tank of the hot water heater is emptied and that it takes longer to heat the new water than it did to empty the tank during the shower. One suitable approach is to find out the storage capacity of a typical hot water heater and use lessons learned in freshman chemistry to calculate the energy needed to raise that quantity of water from the temperature of tap water to the temperature suitable for showering.