Spring Break: A Lesson in Circuits: Instructor Guide

Title:

Spring Break: A Lesson in Circuits

Author:

Barbara J. Duch
105 Pearson Hall
Newark, DE 19716
bduch@physics.udel.edu

This work by Barbara Duch is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

As an open educational resource, feel free to modify and distribute this work under the conditions stated by the Creative Commons license. Originally developed as a part of the PBL Clearinghouse at the University of Delaware.

Discipline:

Physics and Astronomy

Target Audience

Introductory, majors and nonmajors

Keywords

Circuits, electricity, power, wiring

Length of Time/Staging

Two weeks

Abstract

This case, taught in a problem-based learning format, introduces students to the topics of electricity and circuits within the context of house wiring. Students explore the properties of

series and parallel circuits, research local wiring codes, calculate the current used by appliances based on their power ratings, and, finally, design circuits in a typical kitchen.

Date Submitted

9/17/2001

Date Published

12/4/2001

Format of Delivery

This problem was taught in four 75 minute classes over two weeks, and interspersed with two hands-on labs on circuits.

Student Learning Objectives

1. To construct series, parallel, and combination circuits and predict which circuits will be best for a variety of needs.
2. To understand and be able to explain the transfer of energy in many different phenomena, including electrical circuits.
3. To explain how electricity is used to light appliances in a house or apartment.
4. To explain how circuit breakers work and how they are wired in the circuit.
5. To calculate the current through an appliance based on its power rating.

Student Resources

Energy Usage Chart from Delmarva Power

This Old House from PBS

Electric Codes from Code Check

Toasters: The Inside Story from The Toaster Museum Foundation

Supplemental Resources for Educators from FirstEnergy Corporation

Author's Teaching Notes

This case was written to introduce general education majors, non-science majors, or introductory physics students to the concepts of series and parallel circuits and power in a problem-based format. I chose to create the scenario of a student being put in the situation of needing to understand how houses are wired, what kind of power appliances use, and what kind of circuits need to be designed for kitchens (and why). In many cases, students have the opportunity to look at the main circuit box in their own homes and learn valuable practical information related to this topic.

I teach a general education science course to 140 nonscience majors in a fixed-seat auditorium. Students meet twice weekly for one hour and 15 minutes in the large class, then with their graduate teaching assistant for a one-hour discussion and a two-hour lab. The problem drives instruction in all three class modes, where students in their permanent groups are challenged to

do research, conduct experiments, and learn the concepts of Ohm's Law, parallel and series circuits, and power.

I introduce the first page of the problem after we have learned about static electricity, and then cycle in and out of the two-part problem for two weeks. Because students in this class generally have weak math skills and I want them to gain conceptual understanding about electricity and circuits, I have them design a variety of circuits in lab and guide them to recognize the characteristics of series and parallel circuits. Although this problem deals with house wiring, in the general education course students do wiring diagrams as if the current was direct rather than alternating. This problem could just as easily be used in a higher-level class with students calculating total resistance and current in circuits and dealing with AC rather than DC circuits.

Major Issues

Part one of the problem introduces students to circuits and asks them to research issues on this topic. In the large class, students are challenged to light a bulb with a single wire, battery, and bulb. Many initially are unable to do this and in fact create a short circuit (with the wire bypassing the bulb). Students who do this soon notice that the wire heats up. A general discussion in class usually leads students to design a simple circuit that will light a bulb. Most students are not aware of how houses are wired, so I provide some suggested web resources for their exploration.

In lab that week, students are asked to design a variety of circuits with a set of batteries, bulbs, and wires. In particular, they must add consecutive bulbs to a series circuit and new loops with a bulb to parallel circuits. They note the relative brightness of the bulbs and explore what happens to the other bulbs when one or more bulbs are removed from the circuit. After this experience, students in their groups discuss what they've already learned about house wiring and which type of circuit would most likely be used in houses.

Before moving onto part two of the problem, students need to learn the following:

- Housing circuits are wired in parallel with the circuit breaker (or fuse) wired in series (and be able to explain why).
- As resistors are added to a series circuit, the total resistance increases and the total current decreases (introductory physics students should be able to calculate total resistance and current using Ohm's Law).
- As resistors are added to a parallel circuit, total current increases and total resistance decreases.
- In series circuits, resistors share the total potential difference across the battery, while each resistor in a parallel circuit is wired directly across the battery.
- Most houses have 240 V and 120 V electrical lines. Items such as stoves, air conditioners, heating units need to be wired to 240 V lines (and explain why).

Students in their groups decide which questions need to be asked of the homeowner in order to decide the electrical needs in the kitchen. This leads into part two of the problem, in which Mr. Melvin lists the appliances that the family expects to use in the kitchen.

Students need to research into local wiring regulations, particularly as they pertain to kitchens. For example, some regulations control the maximum distance between outlets in a kitchen or the

minimum number per wall. In addition, students will learn about GFI circuits, why they are needed in kitchens and bathrooms, and how they work.

To design kitchen circuits, students will learn about the power used by appliances. For example, they will discover the amount of current that is drawn by a 1200 W electric frying pan that is plugged into a 120 V electrical outlet. Once the kitchen is sketched, students draw several circuits in the kitchen, ensuring that they are providing enough circuits to use all the appliances that the Melvins want to use. The internet or appliance stores are great sources for information on the number of watts used by various appliances.

Classroom Management

Each part of the problem sets the stage for students to research the concepts being addressed. In general, students in groups of four discuss the questions, list their own questions (or learning issues), and use data and results from the lab section to build an understanding of circuits and power.

Mini-lectures in class are driven by the students' learning issues. For example, students tend to have questions focusing on series and parallel circuits and the total resistance and current in the two types of circuits. Having the students look at circuit boxes, test appliances in their own homes, and design kitchen circuits helps them connect the concepts, which can be abstract, to realistic applications in their own lives.

Assessment Strategies

Students can be asked to submit their kitchen diagrams along with the circuit diagrams, or can be tested in a circuit lab exercise.