# Rice-a-Roni: A San Francisco Treat: Instructor Guide

## Title:

Rice-a-Roni: A San Francisco Treat

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## Discipline:

Physics and Astronomy

## Target Audience

Introductory, non-majors

## Keywords

Appliances, circuits, electric power, electricity, household wiring, wiring

## Length of Time/Staging

Three half class periods

## Abstract

Students design the electric wiring portion of a home remodeling project. Appliance power ratings, distribution of electric power, voltage levels, circuit breakers, and wiring codes are encountered.

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## Format of Delivery

The 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 to each other, then begin design of floorplans. Outside of class they sketch floorplans; at the following class meeting, the full class discusses the range of answers and approaches used in preparing and evaluating the floorplan.

## Student Learning Objectives

Students have the opportunity to learn that:

1. There is an increasing need for electrical power in the typical U.S. home.
2. Household wiring is a distribution of circuits, with outlets wired in parallel.
3. Adding additional circuit elements in parallel (increasing the load), increases the current through the power source.
4. Household circuits are protected by circuit breakers, with specified current limits, and wire diameters (gauges) corresponding to safe current carrying ratings.
5. In the U.S., typical household voltages are 120 V; however, higher power appliances operate at higher voltages of 240 V, with correspondingly lower current. (Voltages are rms values.)
6. Design and installation of household wiring is controlled by codes that require, for example,
    a. safety considerations such as the installation of ground-fault circuit interrupters near water pipes and outlets at least two feet from a sink.
    b. convenience considerations such as outlets every four feet along a countertop multiple outlets installed on long walls.

In addition, students explore the variety of appliances used in daily living and identify power ratings associated with each appliance. They identify the typical electrical capacity required in today's homes. Students are also provided with an opportunity to design and sketch a wiring plan for a simple floorplan.

## Student Resources

### *House Wiring Resources*

Electric Codes from Code Check

http://www.codecheck.com/cc/CCE7th.html

Electrical Wiring FAQ

http://www.faqs.org/faqs/electrical-wiring/

Local Utility Companies

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

### *Appliance Resources*

Appliances Online

http://www.appliances.com/

See Appliances at Sears

http://www.sears.com/

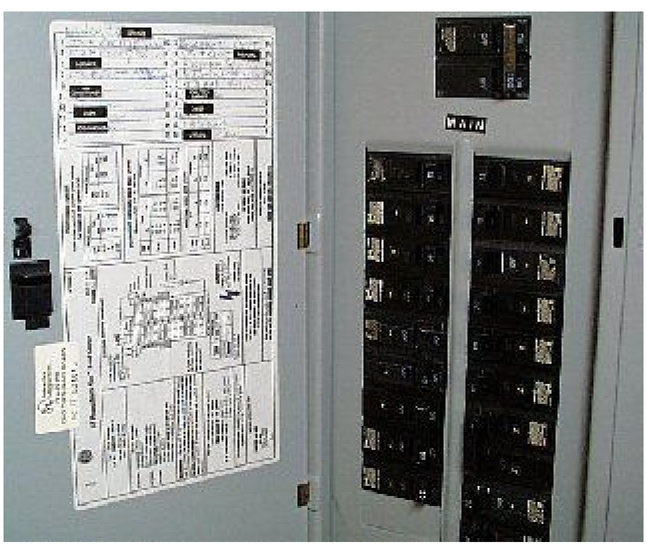
Local Electric Department, City of Newark

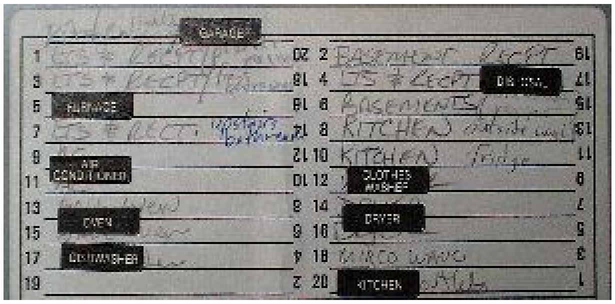
http://cityofnewarkde.us/index.aspx?nid=18

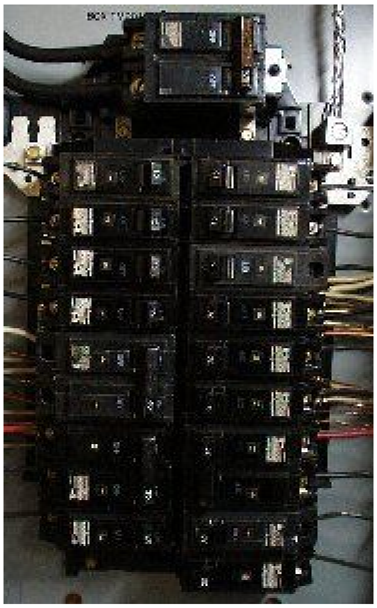
## Instructor Resources

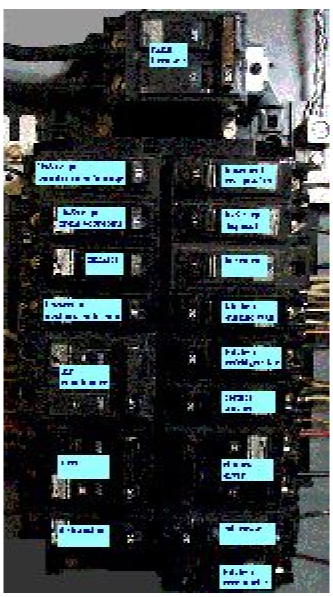
A slideshow of appliance-use leading to a "blown" circuit is available at http://www.physics.udel.edu/~watson/scen103/house/. This slideshow can be used to wrap up the full-class discussion of this problem. It reinforces that the outlets are wired in parallel with the source.

The following images are from a circuit breaker box in a typical U.S. home. Click on each image to obtain a larger, higher resolution image.







## Author's Teaching Notes

For some additional ideas on the topic, you may wish to refer to [Overload](), the problem by Barbara Duch that inspired this one.

Note that all voltages discussed are rms voltages.

This problem is part of a sequence of problems exploring electric circuits and electrical energy. "Rice-a-Roni" follows an introductory problem "Crossed Circuits," in which students learn that energy is the product of power and time, and an introductory lab exercise using a Power Line Analyzer and a variety of hairdryers to determine that power is the product of current and voltage. This problem is designed to engage the students in considering contemporary wiring requirements for a typical U.S. household as a context for the stated learning objectives.

Students start by creating a list of all the appliances that will be used. They then look up the power ratings for each appliance, and then convert to current requirements. Next, looking at the location of the appliances in action, circuits are distributed throughout the house from circuit breakers with appropriate ratings.

Students should be directed to consider electric codes, available online. While not part of a scientific content objective, familiarity with safety and convenience issues may serve them well as future homeowners. Learning about safe current carrying capabilities and circuit breaker actions may serve them immediately for their safe use of electrical power in their dorm rooms and apartments.

As a group problem, students tend to parse out and assign the various tasks associated with this problem: researching the appliance ratings, making the current calculations, designing the layout, and drawing the layout. If you prefer that students' not partition the work in this way, you will need to steer them appropriately.

Often, there is proportionately too much emphasis put on making a nicely drawn floor plan! In the first offering of this problem, I noticed that students often ignored describing the decision-making aspects of the project and focused instead on the floor plans. Encourage them to report fully on the process behind the drawing.

In the full class discussion following your examination of the student's submissions, you may need to elevate the fact that there are usually a number of high-power appliances running at 240 V. You may explain then that the 120 V service is derived.

In addition you may wish to follow up with their appreciation of the fact that appliances are operating in parallel connections to the circuit box. There is a URL for a slideshow depicting the overloading of a circuit breaker available in the Instructor Resource listing that can be shown to the class.

In follow up, it is also good to make sure that students appreciate what a ground fault circuit interrupter (GFCI) does and why it is important.

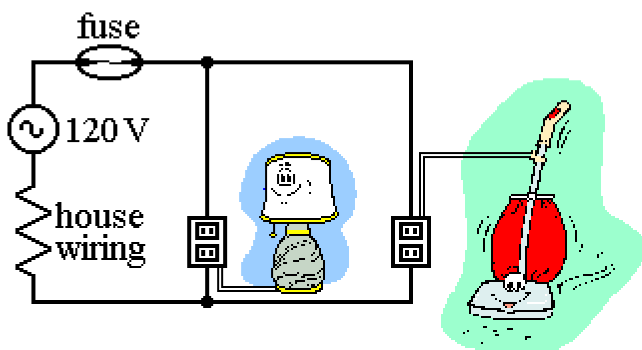
## Assessment Strategies

Here are some typical exam questions which relate to the learning objectives for this problem:

1. A circuit rated for 20 A is being used to operate a toaster (1000 W) and a lamp (100 W). When a 1500 W hairdryer is run on the same circuit with the other devices, the circuit breaker opens the circuit to avoid overheating of the household wiring. For quickest drying of hair, the maximum possible rating for the hairdryer is desired. Would you

recommend purchasing a 1200 W hairdryer, or should a lower power 1000 W unit be acquired?

2. A refrigerator (600 W) and a toaster oven (1400 W) are successfully operating from a standard kitchen circuit protected for 20 A. How much power remains available for lighting?
3. A 1000 W toaster oven is drawing 8.7 A of current as it heats a slice of frozen pizza. When a blender is turned on simultaneously at the same outlet, a 15 A circuit breaker opens the kitchen circuit to avoid overheating of the household wiring. The power rating of the blender must exceed what value?
4. Why is household wiring constructed so that appliances are connected in parallel to the source of voltage, as in the figure below?




5. The lamp dims in the circuit above when the vacuum cleaner is running. Explain this observation using circuit concepts. *HINT: the observation cannot be explained without explicitly considering the resistance of the house wiring.*

Note: this exam question also requires a working knowledge of Ohm's law, which is not covered in this particular problem, but comes in a later one.

## Solution Notes

Overall, 200 A service to the house should be adequate. If the students come up with a value closer to 300 A, then they most likely have forgotten that not all appliances will be running at the same time and designed a much larger current capacity for the breaker box than necessary as a result. You may use the images listed on the Instructor Resource page to show the students a typical box and the circuit breakers associated with particular circuits.

Permanent lighting fixtures; *e.g.* ceiling lights, in the rooms are often overlooked by the students.