

# Cake By Conduction

## Just Like Ohm

Cook a cake using the heat produced when the cake batter conducts an electric current.



### **DANGER! READ THESE ITEMS CAREFULLY!**

- **BE SURE THE DEVICE IS UNPLUGGED BEFORE TOUCHING ANY PART OF IT AT ANY TIME. THIS DEVICE USES 120 VOLTS AC. WHEN ASSEMBLED AS SHOWN , THERE ARE SEVERAL BARE CONTACTS -- THESE MAY BE LETHAL IF TOUCHED WHILE THE DEVICE IS PLUGGED IN.**
- **USE WITH GFCI OUTLET ONLY!\*\* (SEE BELOW)**
- **DO NOT PLUG THE DEVICE IN UNTIL ALL PREPARATION IS FINISHED. BE ACUTELY AWARE OF THE LOCATION OF YOUR HANDS AT ALL TIMES!**
- **DO THIS AS A DEMONSTRATION ONLY. KEEP STUDENTS AT A SAFE DISTANCE.**

The setup shown in the photo consists of the following items connected together in a simple series circuit:

- 2-cup (500 mL) Pyrex measuring cup (or other suitable heat-resistant container) with two large stainless steel serving spoons or soup spoons clipped to opposite sides with wooden spring-loaded clothespins
- AC ammeter (optional) -- meter needs at least a 5 amp scale -- though you likely won't get over 5 amps, a 10 amp scale is an even more comfortable choice -- NOTE: many of the very inexpensive multimeters measure only DC amps, not AC amps

**\*\* The circuit is plugged into a GFCI (Ground Fault Circuit Interrupter) outlet. The GFCI outlet is a safety feature that reduces (but does not entirely eliminate!) the danger of death or serious injury from electric shock.**

The cake mix used in this activity was Betty Crocker Super Moist Milk Chocolate Cake Mix (but other brands and flavors have also been used successfully).

The total amount of dry mix in the box was almost 4 cups. Directions on the box called for the addition of 1 1/4 cups of water, 1/3 cup of vegetable oil, and 3 eggs.

I cooked the cake in the 2 cup (500 mL) Pyrex measuring container, and used about a third of the recommended ingredients. Here are the ingredients used:

- 1 1/4 cup (about 310 mL) dry mix
- 1/2 cup (about 125 mL) water
- 2 Tbsp (about 30 mL) canola oil
- 1 egg

**NOTE: Containers and utensils used for any food activity should be new (or only used previously for food), thoroughly washed (preferably in a dishwasher) before and after each use, and never used for anything else if they are going to be used for food again.**

Mix these ingredients **thoroughly**, either in a separate bowl, or in the 2 cup Pyrex measuring container. The cake produced from the ingredients shown will just about fill the 500 ml measuring container after the cake rises.

When the batter is in the Pyrex container with the electrodes in place, and the circuit is set up as shown, plug into the GFCI outlet. **USE WITH GFCI OUTLET ONLY! DO NOT TOUCH ANY EXPOSED CONTACTS WHEN THE CIRCUIT IS PLUGGED IN!**

If you want to measure the current as the cake cooks, connect the AC ammeter in SERIES as shown. This is optional. You can then take current readings at regular intervals, e.g. every 30 seconds. With the spoons shown, the current rose to almost 3 amps in one minute, and then steadily decreased to 0.23 amps after 10 minutes and 0.17 after 12 1/2 minutes. The larger the surface area of the electrode used, the larger the current that should be expected, so spoon size is a variable that can be tested.

Depending on the current obtained, a cooking time of 10-15 minutes should be OK. The cooking time used for the array shown was 12 1/2 minutes, since current had leveled off at around 0.2 amps and was very slowly decreasing. It's an arbitrary decision as to when the cake is "done;" pretty much you just judge when nothing much seems to be happening any more. If you aren't using an ammeter, you should probably just cook the cake for 15 minutes. It's better to cook the cake a little too long than not enough.

If you do measure the current at different times as cooking progresses, you can also calculate the corresponding resistances. This can lead to a discussion of the relation of the changes in resistance and current to the cooking process.

## **DON'T FORGET TO UNPLUG THE SETUP BEFORE TOUCHING THE ELECTRODES OR EXAMINING THE CAKE!**

When the cake is "done," **unplug the setup**. Then use the two spoons to remove the cake from the container and place it on a separate plate. Cut it open, and notice where it is done and not done. The portion of the cake between the electrodes should be very much like normal cake in appearance and texture -- and taste! Other parts of the cake may vary from gooey to runny. Don't expect a completely "normal" cake -- but do expect an enjoyable and educational experience!

There are many variables in this activity which may affect current flow, cooking time and quality of the cake. Some have already been noted, but here is a summary:

- brand of cake mix
- water/mix ratio
- size and shape of container, and amount of batter used
- spacing, surface area and configuration of electrodes (e.g., flat spatulas, large or small spoons, concave or convex surfaces facing each other, etc.)

These are variables to consider for further experimentation -- a lot of food for thought, so speak! Bon appetit!

Thanks to my friend and colleague Raleigh Ellisen, who first introduced me to the idea of this activity many years ago.