PHY 101 Lab 6: Energy storage, especially electrical

Your name:

Other team members:

Goals:

Energy storage is necessary for any portable device. You will examine several forms of energy storage, and compare them to one another.

Materials:

Different materials for each activity. See below.

Activity:

1. *The zinc-copper vinegar battery*

<u>Materials</u>:

Zinc and copper strips

Vinegar

Digital multimeters

Assorted connectors and wires

Without using vinegar, hook up wires to a zinc strip and a copper strip. Hook up the other ends of the wires to the voltage inputs of the multimeter. What is the voltage that you read with the strips just sitting on the table?

Now fill a glass container with vinegar and insert the zinc strip. What is the voltage that you read?

Now insert also the copper strip. What is the voltage that you read?

Try changing the distance between the strips in the vinegar. Does the voltage depend on the separation of the electrodes?

Do you read the same voltage if you replace the copper strip with a second zinc strip? Or if you use two copper strips?

What happens to the voltage if you pull one or the other of the electrodes out?

Hook up a flashlight bulb across the terminals of the vinegar cell. What is the voltage that you read?

Reassemble the circuit to include a second multimeter set up to measure the current out of the vinegar solution. Draw the circuit diagram.

What current do you read?

What is the resistance of the flashlight bulb?

Did the voltage decline when you hooked up the flashlight battery? If so, it is helpful to try to understand this as coming from an *internal resistance* in the cell. The idea is to model a real cell as an ideal electrochemical cell (that always keeps a fixed resistance between its terminals) hooked up in series with an *internal resistance*. Draw a revised circuit diagram that includes an internal resistance in series with an ideal cell.

2. *Capacitive energy storage*

Materials:

Hand-cranked generator and cable
1 farad capacitor
Digital multimeters
Stopwatch
Assorted connectors and wires

Examine the circuit connecting the generator with the capacitor and the meters, and draw a complete circuit diagram.

Turn the crank on the generator **in the direction marked**, and keep turning until the voltage on the capacitor reaches about +5 volts. Describe how hard it is to turn the crank, as a function of the voltage on the capacitor.

When you stop cranking, what happens next? Describe what you see, and its cause.

After the capacitor is fully discharged, charge it again, but this time make more careful measurements while you do so. Have one team member run a stopwatch, and call out every 10 seconds. At each 10 second mark, the scribe should write down the voltage on the capacitor and the current through the capacitor, and enter the values in a table below. After reaching the 5 V charging limit, let the capacitor discharge again, and again write down voltage and current every 10 seconds until the capacitor is discharged.

Add a column to the table where you compute the power at each time, using the measured current and voltage values. Use those power measurements to estimate how much energy you stored in the capacitor by charging it, and how much energy came out during the discharge. Explain your method, and give your totals.

Do the values of "energy in" and "energy out" agree? How do they agree with the formula for Electrical Potential Energy in a capacitor, Electrical PE $= CV^2/2$?

Can you invent a way to turn the electrical energy into mechanical potential energy? Describe it, and implement it if possible.

Finally, Looking back on what you have learned in this lab:

Invent a "Rube Goldberg apparatus", one that makes a maximally complicated set of conversions of energy from one form to another. Try to use as many as possible of the components that you studied in this lab.

Make a sketch of your Rube Goldberg apparatus, labeling its parts, and explaining at each step what energy transformation process is taking place.

Comment on the efficiency you expect from your Rube Goldberg apparatus. Do you think it can be perfect? Very poor? Somewhere in between?