Electricity and Circuits
Activity 3: Finding a MudWatt's Maximum Power

NGSS Alignment

CORE IDEAS

Core Idea PS1: Matter and Its Interactions

PS1.A: Structure and Properties of Matter

Core Idea PS3: Energy

PS3.A: Definitions of Energy

CROSS CUTTING CONCEPTS

- ☐ Patterns
- ☐ Cause and effect: Mechanism and explanation
- ☐ Scale, proportion, and quantity
- ☐ Systems and system models
- ☑ **Energy and matter: Flows, cycles, and conservation**
- ☐ Structure and function
- ☐ Stability and change

PRACTICES

- ☑ **Asking questions (for science) and defining problems (for engineering)**
- ☐ Developing and using models
- ☑ **Planning and carrying out investigations**
- ☑ **Analyzing and interpreting data**
- ☑ **Using mathematics, information and computer technology, and computational thinking**
- ☑ **Constructing explanations (for science) and designing solutions (for engineering)**
- ☑ **Engaging in argument from evidence**
- ☑ **Obtaining, evaluating, and communicating information**

Activity 3: Finding a MudWatt's Maximum Power

Microbial Fuel Cells have a "Maximum Power Point" that is achieved when you apply a certain external resistance (i.e. a resistor) to it.

In this lab, you will be building a microbial fuel cell using the MudWatt kit. Once constructed, you will be able to measure voltage of your MudWatt while it is being subjected to different resistors, and calculate current and power from these measurements.

Note: A MudWatt's max power will change over time as your microbe community develops, so track your MudWatt's growth by performing Sweeps throughout its lifetime.

Time: 45 minutes

Materials:

- MudWatt Science Kits
- Soil
- MudWatt MaxTracker (multimeter + resistors)

Preparation

Assemble your MudWatt(s) according to the instructions included in the kit. To compare different treatments to multiple MudWatts, add a special ingredient to the soil or change something about the configuration of each MudWatt. More instructions on this can be found in Module 4.

It may take up to 10 days before the red LED on the hacker board starts blinking, but you will start taking measurements before that.

Procedure

Each day examine the MudWatts to see if the red LED light is blinking. If the LED is blinking, measure the amount of power produced using the MudWatt Explorer App. This app converts the number of blinks per minute into microWatts of power. If the light is not blinking, record the value as 0.

Once the number of blinks per minute has stopped increasing or decreasing, measure the voltage by doing the following:

1. Remove all components from the Hacker Board, except the anode wire (green), and plug the cathode wire (orange) into Pin 3.

2. Switch the multimeter setting to "2000 m," and plug the red probe (+) into the "VΩmA" port and the black probe (-) into the "COM" port. Attach the alligator clips to the tips of the probes.

3. Plug a resistor into Pin 5 and Pin 6 (orientation does not matter). Identify and record its value using the color chart on the next page.

4. After 15 minutes, check the voltage by clipping the multimeter's red probe (+) to the resistor's wire in Pin 5, and the multimeter's black probe (-) to the resistor's wire in Pin 6 as shown below. Record the measured voltage.
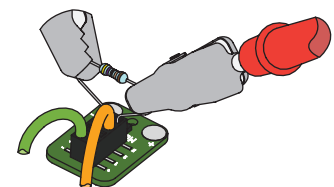
# Activity 3: Finding a MudWatt's Maximum Power

Procedure (cont.)

5. Repeat Steps 3 and 4 for all resistors provided, noting the measured voltage as it corresponds to each resistor. Don't forget to turn off the multimeter when you're done!

6. Calculate current and power (in microwatts, or µW)for each measurement, using the Ohm's Law equation and Power equation. Record values in a data table like the one shown in the Data Table below.

Use Ohm's Law to calculate the power:

$$P = \frac{V^2}{R}$$

P = Power (Watts)
V = Voltage (Volts)
R = Resistance (Ohms)

The Power Curve

Power vs. Resistance
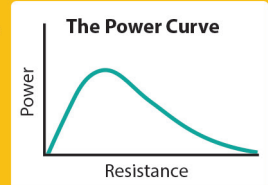
Resistor Data Chart

Resistors can be so small that you can't print numbers on them. Instead, resistors using a series of color bands to determine their resistance value. To make things easier, you can match the colors of your resistors below to identify their resistance value. (Ω = Ohms, k = x1000)

47Ω	100Ω	220Ω	470Ω	1kΩ	2.2kΩ	4.7kΩ
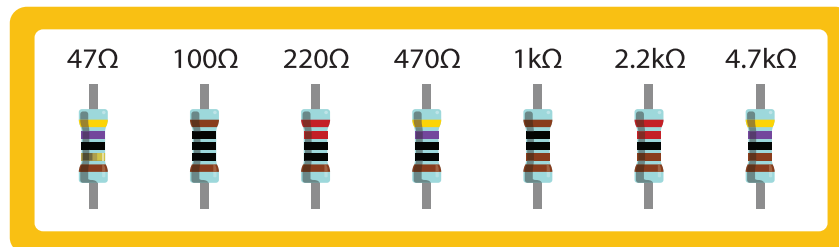
Resistance (Ohms)	Voltage (Volts)	Power (Watts)
4700		
2200		
1000		
470		
220		
100		
47		

Activity 3: Finding a MudWatt's Maximum Power

Questions:

1. **What was the maximum power output for your MudWatt?**

2. **At which resistance was the most power generated?**

3. **What was the highest and lowest amount of Power produced?**

4. **Why did the power change with the different resistors?**

5. **Which manipulated variable produced the highest maximum power in the MudWatt™?**

6. **Try to explain why this change caused the power output to increase.**