

Energy Harvesting Worksheet

Recall that $E = \frac{1}{2}C(V_2^2 - V_1^2)$. C given on the capacitor is in microfarads (μF). To convert to farads (F), divide by 1,000,000. When farads are multiplied by volt², the units come out as joules.

1. Calculate how much energy was used to power the LED.
 - Voltage before flipping the switch (V_2):
 - Voltage after flipping the switch (V_1):
 - Energy used by the LED:

2. Some piezoelectric generators are used to charge batteries so that the energy can be used later. Figure out how long it would take to charge your laptop using the piezoelectric generator built in class. **An average laptop battery can store 220,000 joules.**
 - a. How much energy does your generator store per tap.
 - Voltage measured before tap (V_1):
 - Voltage measured after a single tap (V_2):
 - Energy stored per tap:

 - b. How many taps will it take to charge the battery (to generate 220,000 joules)?

 - c. If you can tap your piezoelectric element 5 times per second, how long would it take to charge your laptop?
 - In seconds:

 - In hours:

Name: _____ Date: _____ Period: _____

- In days:

$$611,111 \text{ hours} / 24 \text{ hours per day} = 25,463 \text{ days}$$

- In years:

$$25463 \text{ days} / 365 \text{ days per year} = 69.8 \text{ years}$$

3. Repeat questions 2b and 2c for an **AA battery that stores 10,000 joules.**

- Number of taps:
- Seconds to charge:
- In hours:
- In days:
- In years:

4. Now that you have calculated how long it takes to generate enough energy to charge some common batteries, one way that engineers increase the rate of energy “production” in piezoelectric generators is by strategically placing the piezoelectric materials where they undergo a large quantity of deformations very rapidly. **Think about this as a way to improve your setup. List two places you could locate your piezoelectric generator in your everyday routine that would help it convert energy at a much higher rate. (Assume that any motion will work to deform the piezoelectric element; it does not necessarily need to be tapped directly.)**