MoDRN Molecular Design Research Network

Passive Energy Use

Summary

Difficulty	Easy-medium
Time Required	Preliminary work to establish key baseline data will take about an hour. Total data collection period is 7 days, but only about 5 minutes per day is required to collect the necessary data. The data analysis portion at the end of the experiment may take 2 to 4 hours.
Prerequisites	Having access to a cell phone, charger, and power outlet
Material Availability	Easy to obtain if you have a cell phone. You may also use another type of electronic device (e.g., iPad, iPod)
Cost	$0
Safety	Be careful plugging in and unplugging your cell phone charger!

Abstract

Our electronic devices are now ubiquitous since they entertain us, educate us, and keep us connected to our friends, family, and the world around us. We must charge our devices to keep them going, but often we end up charging the device well beyond the time it reaches 100% battery power – so what is the overall effect of this extra charging? In this experiment, we will develop a data set specific to our chosen electronic device so we can understand the true power draw of our electronic device, but when we are charging it to reach full battery capacity and when we charge it after we have reached a 100% charge. Following our data collection and analysis, we will examine "what it all means" through the lens of one of the 12 principles of green engineering – maximizing efficiency (including energy) – and how potentially improved charging design can allow us to more effectively utilize energy resources for our electronic devices.

Hypothesis/Research Question

Is the amount of electricity consumed by a portable electronic device (e.g., cell phone) after it is fully charged, but still plugged in, negligible?

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Materials Needed

- Your cell phone or portable electronic device of your choice
- Charger for your cell phone or selected portable electronic device
- Notebook
- Pen
- Computer with a spreadsheet program (Excel, Google Sheets, etc.)

Procedure

1. Up-Front Note: Use your cell phone as normal for the entire week of the experiments. It is critical to use "typical" usage and charging habits for this experiment to yield effective, unbiased data!
2. Begin your experiment at any time you wish, but be sure to record the exact time that your experiment "begins", because the duration must be exactly 7 days (you'll see why later on).
3. For simplicity, choose a convenient power outlet in your home where you can keep your notebook where you will record your data. Alternatively, if you typically charge your phone in different places, you need to keep your experiment log with you at all times so you can keep good data.
4. Data Collection
   a. First, we need to know the amount of time that it takes for your electronic device to charge fully from zero. So our first step is for us to drain the battery of our device down to zero.
      i. After the device reaches zero, plug your device into an outlet and record the time.
      ii. Periodically check on your device every 20 minutes and record the % charged at every 20-minute interval (you will need to turn your phone on and check settings to obtain a numerical value for the % charged at each time interval). You may want to record your data similar to this table below to facilitate calculations on the computer:

Time	Amount of Time since Last Checked Charge % (minutes)	% Charged
9:25	-	0
9:46	21	15
10:05	19	32
10:25	20	47

iii. When you have reached 100% charge, go into your computer spreadsheet program and record your data similar to that shown above.
iv. Double-check your entries to ensure you copied your data into the spreadsheet correctly.
v. Now, let's calculate the average charging rate of your phone. There are a few ways we can do this, but here is the way that we've selected here:

My Device's Charging Rate = ΔChargeinterval 1Δtimeinterval 1

So using the table above as an example, we would calculate the charging rate from the time between 9:25 and 9:46 as follows:
My Device's Charging Rate = 15%21 min=0.714% per minute

Repeat this calculation for all of your time intervals so that you have multiple device charging rates written down. Using your spreadsheet program, calculate the average of all of your calculated charging rates to come up with an overall average charging rate. *Remember, your average will be the sum of all of the calculated charging rates divided by the total number of computed charging rates.*

b. OK, now we have the necessary background data required to carry out our experiment.
c. Starting on the first day of your experiment, and just before plugging in your cell phone, record the following data in your data collection notebook:
i. Date
ii. Time
iii. % of battery available on the phone (this may be displayed by default in your phone, but there are free battery-tracking apps available, or you can simply look at the amount of power remaining by looking at Settings/Battery in most Android and iOS devices)
iv. Your action at the time of recording the data (Plug (P) or Unplug (U)).
d. Make sure that you record the time and charge % every time you plug or unplug your device!

Data Analysis and Observations

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We have two key data analysis steps once all of the data are collected for the full 7 days. Once we complete these two data analysis steps, we can really start to dive into the results and make some bigger picture observations about our use and extrapolate our individual behavior to larger populations!

Data Analysis Step 1

You have your data organized in your notebook, which should have entries that indicate the time, % charged, and whether or not you plugged or unplugged your phone at a given time. In this step, we want to calculate how long we actively charged our phone/device and how long we charged our phone/device after it had already reached 100% charge. We will use our previously-calculated % charging rate in this equation. The basic steps to carry out this calculation are provided below.

*insert some screenshots indicating how they would do calculations in Excel (one column for total charging time, one column figuring out how much time they'd need to charge to get 100%, then another column figuring out how much extra charging time there was

Supplementary questions:

1. What % of your total charging time was spent actually charging the device up? What % was spent on the charger when it was already charged?
2. Calculate the total power usage when it was on the charger but already fully charged ("wasted charge"). Use your previously-googled result to determine this quantity.
3. Let's assume that the retail cost of electricity is $0.07/kW-h. Based on that figure, calculate your energy cost for the quantity calculated in part (2) for an entire year (think about how long you collected data to determine your annual quantity).
4. Let's assume that your cell phone charging behavior is "typical" of the average American. Google around to find out the most recent US population estimate and write that number down in your computer spreadsheet. If 60% of the population has a cell phone, compute the "wasted charge" energy and the total cost for one year for the U.S.

Critical Thinking Questions:

1. From an engineering design perspective, are there any ideas you have so that we can reduce the amount of wasted energy from leaving our devices plugged in to charge? Try to think of two or three ideas WITHOUT LOOKING AT GOOGLE OR ANOTHER SEARCH ENGINE.
2. Now that you've thought of item (1), google around to see if there are any engineered solutions that are already out there. What are they? Try to find at least one example. If possible, see if you can find out what the additional cost would be for that engineered solution.

Variations

1. You can reduce the amount of time that you collect data from 7 days to 1, 2, or 3 days. This would capture a smaller window of your actual charging behavior, but you could still run the necessary calculations.
2. Try to involve your parents, guardians, or siblings in the experiment if you're in the same household. Be in charge of telling each participant what data they must record and ensure their methods are the same that you use. When you run through the calculations, an additional consideration would be to contrast how your charging habits differ from that of older or younger people. The U.S.-wide calculations can then be modified and simply split into two groups (e.g., adults and children).