

HOMEWORK: COMPLEXITY AND ENERGY USAGE

The Python 3 *energyusage* package needed for this homework only runs on a Linux computer with the RAPL interface (an Intel CPU). The package can be installed by running: `pip install energyusage`.

- a) In Python, make functions that have the exact below complexity:
 - i) $50000000 \cdot n$
 - ii) $50000000 \cdot n^2$
 - iii) $50000000 \cdot 2^n$
- b) Suppose you have a computer that can perform 50,000,000 operations per second. For each of the functions, determine the largest input size n for which you can determine the result within 5 minutes.
- c) Run each of the functions above, varying n from 1 to the number you determined in part b. Run those functions using the *energyusage* package on a Linux computer with an Intel processor. The package will give you the information you'll need for the graphs in part d. An example run on a simple function f with input x and return value y is:
`secs, kwh, y = energyusage.evaluate(f, x, energyOutput=True)`
where `kwh` is the resulting energy usage in kilowatt hours, and the time used is also returned (in seconds). If you are running on a machine that performs *approximately* 50,000,000 operations per second, note that you can test your above calculations in this step, but they may not match exactly.
- d) Make two graphs for each of the functions above:
 - i) a graph showing n on the x-axis versus time (in seconds) on the y-axis, and
 - ii) a graph showing n on the x-axis versus energy usage (in kilowatt hours) on the y-axis.You may use whatever graphing software or package you prefer to create these graphs. Make sure you have properly labeled the axes and titled your graphs.
- e) The power plants supplying electricity to your computer emit between 2.4 and 1.1 pounds of carbon dioxide per kWh. Which function minimizes the amount of carbon dioxide emitted for $n = 5$? What about in total over 5 minutes?
- f) What do you notice about the graphs? Describe any conclusions you have reached about computational complexity and energy “complexity,” along with any caveats to these conclusions.

Your handed in solution to this homework should include:

- a) The functions you wrote.
- b) The values of n you determined.
- d) Two graphs for each function (a total of 6 graphs).
- e) A sentence or two.
- f) A short paragraph describing your conclusions.