CMPS 2200 Assignment 1

Name:__________________________________

In this assignment, you will learn more about asymptotic notation, parallelism, functional languages, and algorithmic cost models. As in the recitation, some of your answer will go here and some will go in `main.py`. You are welcome to edit this `assignment-01.md` file directly, or print and fill in by hand. If you do the latter, please scan to a file `assignment-01.pdf` and push to your github repository.

1. (2 pts ea) **Asymptotic notation**

- 1a. Is $2^{n+1} \in O(2^n)$? Why or why not? .

  Yes $2^{n+1} = 2 \cdot 2^n$, 2 is a constant

- 1b. Is $2^{2^n} \in O(2^n)$? Why or why not?

  No, 2^{2^n} grows exponentially faster than 2^n

- 1c. Is $n^{1.01} \in O(\log^2 n)$?

  no, as n grows larger grows much faster than $\log^2 n$

- 1d. Is $n^{1.01} \in \Omega(\log^2 n)$?

  Yes, no matter what constant we put in front of $n^{1.01}$, it is still much larger

- 1e. Is $\sqrt{n} \in O((\log n)^3)$?

  No, logarithmic functions still grow slower than sqrt fnctions as n gets large, even when cubed

- 1f. Is $\sqrt{n} \in \Omega((\log n)^3)$?

  Yes, $\sqrt{n}$ is still greater than $(\log n)^3$ for large values of n no matter what constant is put in front of $(\log n)^3$

2. **SPARC to Python**

Consider the following SPARC code of the Fibonacci sequence, which is the series of numbers where each number is the sum of the two preceding numbers. For example, 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610 . . .

```
foo x =
  if  x ≤ 1  then
    x
  else
    let  (ra, rb) = (foo (x − 1))  ,  (foo (x − 2))  in
      ra + rb
    end.
```

- 2a. (6 pts) Translate this to Python code – fill in the `def foo` method in `main.py`
- 2b. (6 pts) What does this function do, in your own words?

this function returns the x^{th} fibonacci number by recursively calling on itself until it reaches the base case of $X \leq 1$

3. **Parallelism and recursion**

Consider the following function:

```
def longest_run(myarray, key)
    """
    Input:
      `myarray`: a list of ints
      `key`: an int
    Return:
      the longest continuous sequence of `key` in `myarray`
    """
```

E.g., `longest_run([2,12,12,8,12,12,12,0,12,1], 12) == 3`

- 3a. (7 pts) First, implement an iterative, sequential version of `longest_run` in `main.py`.
- 3b. (4 pts) What is the Work and Span of this implementation?

Work $\in O(n)$

Span $\in O(n)$

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.
.
.
.

- 3c. (7 pts) Next, implement a `longest_run_recursive`, a recursive, divide and conquer implementation. This is analogous to our implementation of `sum_list_recursive`. To do so, you will need to think about how to combine partial solutions from each recursive call. Make use of the provided class `Result`.
- 3d. (4 pts) What is the Work and Span of this sequential algorithm?

Work = $O(n \log(n))$

Span = $O(n \log(n))$ assuming we don't parallelize?

- 3e. (4 pts) Assume that we parallelize in a similar way we did with `sum_list_recursive`. That is, each recursive call spawns a new thread. What is the Work and Span of this algorithm?

Work = $n \log(n)$

Span = n