

Week 2: Lab

COLLABORATION LEVEL 0 (NO RESTRICTIONS). OPEN NOTES.

1. Consider the following code for BubbleSort that we discussed in class:

```
BUBBLE-SORT( $A$ )
1  For  $k = 1$  to  $n - 1$ 
2      // do a bubble pass
3      For  $i = 0$  to  $n - 2$ 
4          if  $A[i] > A[i + 1]$ : swap
```

Show how to change the code so that the algorithm does not do any redundant bubble-passes (i.e. if the input needs only 3 bubble passes to be sorted, the algorithm does only 3 passes).

2. Prove or disprove: $f = O(g)$ implies that $g = O(f)$.
3. Prove or disprove: $f = O(g)$ implies that $g = \Omega(f)$.
4. Find the order of growth of the following functions:
 - (a) $n \lg \lg n + n \lg n + \sqrt{n} \lg^2 n$
 - (b) $\sqrt{n} \lg n + n$
 - (c) $n^2 + \sqrt{n} \lg^3 n$
 - (d) $3^{\lg n} + n^2 + n \lg n$
 - (e) $\sqrt{3}^{\lg n} + n^2 + n \lg n$
 - (f) $2^n + 2^{2n}$
 - (g) $2^{\lg n} + \lg n^2$
 - (h) $(\lg n)^{\lg n} + n^3$
5. Arrange the following functions in ascending order of growth rate. For each pair of consecutive functions, give a brief justification on why they are in this order. For e.g., if you ordered A, B, C , you need to justify that 1. $A = O(B)$; and 2. $B = O(C)$.

$$2^{\sqrt{\log n}}, 2^n, n^{4/3}, n(\log n)^3, n^{\log n}, 2^{2^n}, 2^{n^2}$$

For additional practice I included a set of problems that were asked at tech interviews, as communicated by alums. These problems are optional, therefore you do not need to turn them in. However it is strongly encouraged that you engage with them and bring questions to the zoom meetings.

1. (interview question) You are given a set of n points on a circle in the plane. Come up with an algorithm that determines if there exists a pair of points that are antipodal (two points are antipodal if they are diametrically opposite). Analyze its running time.
2. (interview question) You are presented with 9 marbles. All of the marbles look identical i.e. same shape, color, and dimensions(except for weight). However, 8 of the 9 marbles have exactly the same weight; the last marble is heavier. The only tool you have to measure weights is an old fashioned balance scale. You are only allowed to use the scale 2 times. How do you find the one marble that is not the same weight as the others?

Generalize to n marbles: find it using the scale $\log_3 n$ times.

3. (interview question) Given an unsorted array and a number k . Find two elements in the array whose sum is k , or report if no such set exists. Analyze running time.

Generalize to 3-sum: Find if there exist 3 elements in the array whose sum is k , or report that no such subset exists. Analyze running time.

4. (interview question) Close all notes, pick a language of your choice, and implement: (a) bubble sort; (b) insertion sort; (c) binary search. Include tester functions (generate random arrays etc).

Do not open your notes! The goal is to be able to go on your own from the high level description of the algorithms (which you should know), to the low level details, which you need to figure out on the spot. To make it more fun (or not), imagine someone is looking at your screen.