**Synthesis Assignment #1  
CS 5800, Fall 2024  
Dr. Alan Jamieson**

**DUE: October 4th, 11:59pm eastern via Canvas**

**Tl;dr version - create a textbook collecting your explanations of 9 different topics including problems and solutions for each. Put it in a single pdf/docx file and submit on Canvas.**

Your task is to demonstrate your understanding of the material by writing a mini-textbook. For each topic we’ve discussed in class (up to the week before this assignment is due) you will write an explanation of the topic based on the way that you understand the concept. These writeups need to be a thorough explanation, enough to convince the reader that you understand the concept. This explanation should be in your own words, but use of external sources is allowed as references if you include appropriate citations. A complete topic list is provided at the end of the document, divided into “chapters” based on the modules as we presented them in class.

Each topic will be complemented by at least one problem and solution of your own creation (no taking problems from other sources) unless otherwise noted. This means that you will (in addition to the write up) be also responsible for creating 8 original problems and their **detailed, step-by-step** solutions (with some noted exceptions). **NOTE:** these are problems like homework problems NOT problems that you are using to explain the concept. Yes, this means that there are 9 sections that you will be creating as part of this assignment. **ANOTHER NOTE:** implementation exercises (i.e. “Implement this algorithm in Python”) are not acceptable for the synthesis.

Please clearly number and space out your sections so that I know exactly where one section ends and the other begins, and what exercises belong to what topic. If helpful, a format I would suggest is:

1 **Chapter Name** (like Asymptotic Analysis)

1.1 **Section Name** (like Big O)

<your write up goes here>

**Exercise:** <problem write up>   
**Solution:** <solution write up>

1.2 **Section Name** ...

Regardless of what format you use, **you must** make clear when one section starts and one section begins AND what is considered an example in your write up, and what is an exercise.

Note: these sections don’t have to be terribly long or involved, **but they have to demonstrate that you do understand the concepts enough to explain them and come up with exercises**. There is no page limit, or page minimum, so use your best judgment (you should expect 1-2 pages per topic). An example of the kind of thing that I’m looking for will be provided in the assignment area on Canvas.

**Special topic note:** The topics labeled “XXXX design” are topics that are meant to distill your knowledge about the topic, and as such do not have a particular linkage to a specific thing talked about in class. These are designed to explain to the reader how you, personally, would design an algorithm for a problem using that technique. The original exercise for these sections should show your steps and thought process behind designing a solution for a particular problem, utilizing this technique. **DO NOT GIVE ME JUST CODE**. You must explain every part of your solution.

**Teamwork note:** this is an assignment where it is important that you are the sole author of your work. You are allowed to discuss concepts with your classmates, but at no time are you allowed to discuss or share problems, writeups, or your overall plan for this assignment with anyone other than the professor or the TAs.

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**Format:** a single pdf or docx file. Note that you can create this in Google docs, just please export to pdf or docx before submitting. **All text and formula must be typed.** Graphs may be neatly created on paper and then digitized and embedded into your document.

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**Topics to be covered (organizational section in bold, actual topics listed under each “chapter”):**

**Chapter 1: Asymptotic Analysis -**

* Big O
  + Problem should be to take a sorting algorithm of your choice, provide the Big-O analysis of that algorithm with justification. This problem does not need to be original, but your solution and explanation should be.
* Big Omega
  + Problem should be to take a sorting algorithm of your choice, provide the Big-Omega analysis of that algorithm with justification. This problem does not need to be original, but your solution and explanation should be.
* Big Theta
  + Problem should be to take a sorting algorithm of your choice, provide the Big-Theta analysis of that algorithm with justification. This problem does not need to be original, but your solution and explanation should be.

**Chapter 2: Divide and Conquer -**

* technique definition (no problem/solution required)
* divide and conquer multiplication
  + Original problem should be to take two distinct binary strings of length 16 or more and utilize Karatsuba’s Algorithm to calculate the multiplication of those two strings, showing all steps.
* divide and conquer algorithmic design
  + Problem should be to pose a problem and solve that problem with a divide and conquer algorithm, discussing your thought process and explaining correctness and time complexity. This problem does not need to be original, but your solution and explanation should be.

**Chapter 3: Recurrences and Master Theorem -**

* Recurrences, including definitions and the iterative/expansion method for solving
  + Original problem should be to solve a recurrence using the expansion method
* Master Theorem
  + Original problem should be to solve 3 distinct recurrences utilizing the Master Theorem, demonstrating each of the three options present in the Master Theorem.
* using Master Theorem to analyze a recursive algorithm
  + Problem should be to take a recursive sorting algorithm and give the Big O for that algorithm utilizing the Master Theorem, including justification. This problem does not need to be original, but your solution and explanation should be.