Computer Science and Information Management

School of Engineering and Technology

AT70.02 Data Structures and Algorithm

August 2020 Semester

MIDTERM EXAM

Instructor: CHAKLAM SILPASUWANCHAI
Time: 3 hours

STUDENT NAME: _________________________ STUDENT ID. NO. __________________

- This exam accounts for **30%** of the overall course assessment**.**
- This exam is **open-booked; open-internet.**
- **Don't write only the answer. Proof (and explanations) are required for ALL questions.**
- The completed exams shall be submitted at the Google Classroom

EXAMINATION RULES:
- For **offline students**, you may leave the room temporarily with the approval and supervision of the proctors. No extra time will be added to the exam in such cases.
- For **online students**, you are required to turn on your webcam during the entire period of the exam time.
- Students will be allowed to leave at the **earliest 45 minutes** after the exam has started.
- All work should belong to you. A student should NOT engage in the following activities which proctors reserve the right to interpret any of such act as **academic dishonesty without questioning**:
    - o Communicating with any human beings physically or via online methods
    - o Plagiarism of any sort, i.e., copying from internet sources or friends
- No make-up exams are allowed. Special considerations may be given upon a valid reason on unpredictable events such as accidents or serious sickness.

1.

1. Illustrate QUICKSORT on array *A* = <23, 211, 913, 46, 77, 342, 99, 54>. Use Median of Three (*1 or 0 pt.)*
2. Illustrate COUNTING SORT on array *A* = <3, 0, 5, 5, 3, 2, 6, 2, 7>. (*1 or 0 pt.)*
3. Find the MAXIMUM SUBARRAY of A = <-9, 3, -5, 11, -2, 7> (*1 or 0 pt.)*
4. List the functions below from the lowest to the highest order. (*1 or 0 pt.)*

$4n\log n + 2n$	2^{10}	$2^{\log n}$
$3n + 100\log n$	$4n$	2^n
$n^2 + 10n$	n^3	$n\log n$

5. Given a list of integers S, let's say

500	400	600	700	350	…

We want to calculate the daily average A. For example, the daily average of day 1 (A[0]) is $(500)\ /\ 1$, while daily average of day 3 (A[2]) is $(500\ +\ 400\ +\ 600)\ /\ 3$.

   a. Write an algorithm (in the form of pseudocode) that perform daily average of complexity of $O(n^2)$. Perform asymptotic analysis using Big Oh notations (*2 or 0 pt.)*
   b. Attempt to improve the algorithm to $O(n)$. Perform asymptotic analysis using Big Oh notations (*2 or 0 pt.)*

6. In HTML, one uses tag such as <body></body> or <li></li>.
   a. Write a simple program (in the form of pseudocode) using STACK that will return False, if the opening and closing tags DO NOT match (i.e., missing pair). (*2 or 0 pt.)*
   b. Perform asymptotic analysis using Big Oh notations (*1 or 0 pt.)*
7. Given a puzzle of the followings:
   - $a\ +\ a\ =\ b$
   - $aab\ +\ bc\ =\ ab$

Find all possible a and b that make this equation True, where a and b are unique and belong to an integer from 0 to 9. To solve this, we need to assign a unique digit (i.e., 0, 1, ….9) to each letter in the equation. Typically, this should be easy for humans to do, since we simply test all possible configurations. For example, for input $a\ +\ a\ =\ b$, we will know that

   - 0 + 0 = 0. Cannot! Because a and b are unique
   - 1 + 1 = 2
   - 2 + 2 = 4
   - 3 + 3 = 6
   - 4 + 4 = 8
   - 5 + 5 = 10, Cannot! Because 10 is not inside the range of 0 to 9

Thus, the output will be all possible configurations for (a, b) which is (1, 2), (2, 4), (3, 6), (4, 8)
What about $aab\ +\ bc\ =\ ab$? Try and see if you can find one configuration that works.

   a. Write a recursive algorithm (in the form of pseudocode) for solving such task. Hint: Idea is simple. We may first try a subset of integers, (e.g., 0, 1) where possible values of a and b are in this subset, then we find all their possible permutations. Once we finish trying. We remove 0 from this subset S and perhaps add 2 in this subset and recur. (*2 or 0 pt.)*
   b. Write the recurrence function of the algorithm (*1 or 0 pt.)*
   c. Draw the recursive tree of the algorithm, and attempt to get a rough estimate of the complexity (*1 or 0 pt.)*
   d. Perform substitution methods to confirm the rough estimate from c (*1 or 0 pt.)*
   e. Attempt to perform Master Theorem. Can we do it? Why? (*1 or 0 pt.)*

GOOD LUCK! ☺