VANCOUVER ISLAND UNIVERSITY
CSCI 260 — FINAL EXAMINATION
19 December 2018, 13:00 — 16:00

TO BE ANSWERED IN BOOKLETS DURATION: 180 Minutes

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Instructions

- Students must count the number of pages in this examination paper before beginning to write, and report any discrepancy immediately to the invigilator.
- This examination paper consists of 4 pages.
- This is a CLOSED BOOK examination. You are allowed to bring one piece of letter-sized double-sided note.
- Calculators are NOT permitted.
- Remember to state any assumptions and show rough work.
- Note carefully the weight of each question, and answer appropriately.
- Attempt all questions. All questions relate to material covered in the lectures, labs and assignments.

1. (28 Marks) Answer the following questions succinctly (briefly and clearly).

   (a) Describe how KMP failure function is defined. That is, explain the logical meaning of KMP failure function.

   (b) List the main operations of the abstract data type Dictionary, and 2 distinct concrete data structures that can be used to implement the ADT Dictionary.

   (c) List the main operations of the abstract data type Priority Queue, and 2 distinct data structures that can be used to implement the ADT Priority Queue.

   (d) What is the difference between the two statements "f(n) is in $O(n \log n)$)" and "f(n) is in $\Theta(n \log n)$"?

   (e) Is it possible to perform binary search on a sorted doubly linked list? If yes, how? If no, why?

   (f) Describe two distinct methods to resolve the conflict problem in a hash table.

   (g) Suppose a hash table is used to store data records whose key fields are character string type. Is it possible to traverse the hash table and display all data records stored in the hash table in ascending order of the keys? If yes, how? If no, why?

2. (12 Marks) Given the following struct used to implement the data records stored in a 2-4 tree:

```
struct Data {
    int key;
    string data;
};
```

   (a) Describe the concrete data structure that implements a 2-4 tree node.

   (b) Suppose the in-order traversal of the the 2-4 tree would display the data records in ascending order of the keys. Develop a C++ function that takes the 2-4 tree root node as its parameter and displays the data records in **descending** order of the keys.

3. (12 Marks) Using pseudo C/C++ code, describe an algorithm that finds the first occurrence of the pattern of 6 consecutive lower case letters in a given string.
   The algorithm should return the index of the first letter of the pattern in the given string, or -1 if such pattern doesn't exist in the given string. For example, if the given string is "abc6defg abcdefgh", then the underlined text is the pattern found and the returned index value should be 9.

4. (12 Marks)In the international telephone system, each country is assigned with a country calling code. The following table shows some examples of the codes and corresponding names:

Country Code	Country Name	Country Code	Country Name
1	USA and Canada	91	India
52	Mexico	355	Albania
44	UK	359	Bulgaria
86	China	855	Cambodia
..	...	..	...

   It is guaranteed that none of the country codes is the prefix of other country codes.

   (a) Define a concrete data structure for node used in a standard trie for the purpose of mapping the country codes to the corresponding country names.

   (b) Suppose that a standard trie has been constructed using the concrete data structure you defined in the previous question. Using pseudo C/C++ code, describe an algorithm that takes a string of country code as its parameter and returns the corresponding country name.
   If the country code provided is invalid, return an empty string.

5. (12 Marks) Consider the following recurrence equation, defining $T(n)$, as

$$T(n) = \begin{cases} 1 & \text{if } n = 1 \\ T(n-1) + n & \text{if } n > 1. \end{cases} \quad (1)$$

   Solve $T(n)$, and prove your solution by induction.

6. (12 Marks) Using Lempel-Ziv algorithm to encode (compress) the following message string:

   `around the house there are three green trees`

   with the following requirements:

   - The alphabet consists 12 characters (shown below):
     Σ = { ,a,d,e,g,h,n,o,r,s,t,u}
   - 5 bits should be used to code each entry in the dictionary.
   - When fully filled, the dictionary should simply stop accepting new entries.

   Show both the final dictionary entries and sequence of the codes.

7. (12 Marks) Given the following adjacency matrix of the graph G, where A to F are identities of the vertices in G, a positive number in row i and column j represents a directed edge from vertex i to vertex j with the given weight, and 0 means no such edge from vertex i to vertex j.

	A	B	C	D	E	F
A	0	0	15	12	0	0
B	5	0	0	0	6	0
C	0	0	0	0	0	25
D	0	19	0	0	0	0
E	0	0	0	0	0	8
F	0	0	0	0	0	0

   (a) Draw the graph G that is consistent with the above given adjacency matrix.

   (b) Order the vertices as they are visited in a DFS (depth first search) traversal starting at vertex A.

   (c) Draw the minimum spanning tree of the graph G. For the purpose of this question only, treat all the edges as undirected ones.

   (d) Using pseudo C/C++ code, describe an algorithm that determines whether there is a cyclic path in graph G that involves a given vertex (passed through a parameter).

   ====== END OF EXAM QUESTIONS ======