00284

Sri Lanka Institute of Information Technology

B.Sc. Honours Degree in Information Technology

Specialized in Information Technology

Final Examination

Year 2, Semester 2 (2022)

IT2070 – Data Structures and Algorithms

Duration: 2 Hours

June 2022

Instructions to Candidates:

- This paper has 4 questions.
- Answer all questions.
- The total marks for the paper is 80.
- Electronic devices capable of storing and retrieving text, including calculators and mobile phones are not allowed.

Question 1 **(20 marks)**

1) Taking modulo $q = 100$, how many spurious hits and valid hits do the Rabin -Karp matcher encounter in the text T = 900800600300900 when looking for pattern $P = 600$? (2 marks)

2) Draw the state transition diagram for a string-matching automation for the pattern P = ***abab*** and take the input alphabet Σ as $\{a,b\}$. (6 marks)

3) Following is the **Naïve-String-Matcher** Algorithm, which is used to find the occurrence(s) of a pattern string within another string or body of text. (4 marks)

Naïve-String-Matcher (T, P)

1. n ← length[T]
2. m ← length[P]
3. for s ← 0 to n-m
4. do if P[1..m] = T[s+1..s+m]

Given the text and pattern as follows; (2 marks)

Text ***T***

1	0	0	0	1	0	0	0	1

Pattern ***P***

0	0	0

a) How many comparisons would occur in this algorithm?

b) Show that best-case time complexity of the above algorithm is $O((n-m+1))$ where n is the number of characters in the text and m is the number of characters in the pattern.

4) Given a chain $(A_1, A_2, ..., A_{n-1}, A_n)$ of n matrices, where for i = 1,2, …, n matrix A_i has dimension $p_{i-1} \times p_i$. Assume that $m[i,j]$ is the minimum number of scalar multiplications needed to compute the matrix $A_{i...j} = A_i \times A_{i+1} \times ..... \times A_{j-1} \times A_j$ and it is defined below

$$m[i,j] = \begin{cases} 0 & \text{if } i = j \\ \min\limits_{i \le k < j} \{m[i,k] + m[k+1,j]\} + p_{i-1} p_k p_j & \text{otherwise} \end{cases}$$

Consider the following set of metrics A_1, A_2, A_3 and A_4 with their dimensions of 2×5, 5×5, 5×10 and 10×20 respectively. (8 marks)

a) Draw the m and s table to find the optimal parenthesizing of the matrices for the above sequence of matrices using the dynamic programming algorithm.

b) Hence find the optimal parenthesizing and optimal number of scalar multiplications of the above matrices

Question 2 **(20 marks)**

1) The power function can be defined as $pow(x, n) = x^n$. This can be evaluated using the multiplication as $x^n = x \times x^{n-1}$ where x is any real number and n is a non-negative integer. [Hint: $pow(x, n-1) = x^{n-1}$] (8 marks)

   a) Write a recursive relation for $pow(x, n)$ where x is any real number and n is a non-negative
   b) Write a recursive algorithm in pseudo code for the above recursive relation.
   c) Write a recurrence equation that describe the running time T (n) for the above part b) recursive algorithm.

2) Analyze the running time of the following program fragment assuming a **RAM model** of computation. (4 marks)

```
sum ← 0
for i ← n down to 0
    sum = sum + 1
```

3) Given below is an algorithm for *QUICKSORT* (*A, p, r*)

```
Procedure QUICKSORT (A, p, r)
1  if p < r
2    then q ← PARTITION(A, p, r)
3         QUICKSORT (A, p, q-1)
4         QUICKSORT (A, q+1, r)
```

```
Procedure PARTITION(A, p, r)
1  x ← A[r]
2  i ← p - 1
3    for j ← p to r - 1
4      do if A[j] ≤ x
5           then i ← i + 1
6                exchange A[i] ↔ A[j]
7    exchange A[i + 1] ↔ A[r]
8  return i + 1
```

Illustrate the operations of the *QUICKSORT (A, p, r)* for the array with the given set of elements. (For the illustration process assign the values only once to the given algorithm codes and then use diagrammatic way to reach the answer.) (4 marks)

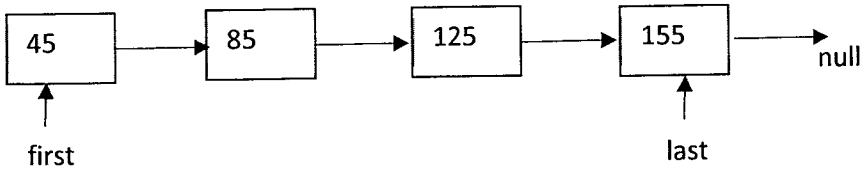
1	2	3	4	5	6
28	15	1	30	0	8

4) Is the sequence representing <40, 25, 19, 6, 13, 18, 20, 5, 7, 12> a max heap? Justify your answer. (4 marks)

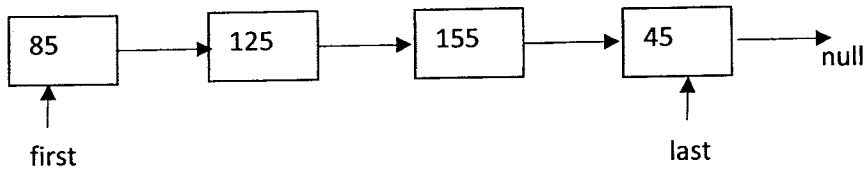
Question 3 **(20 marks)**

1) Consider the following two link lists. Write the code segment to convert link list A to link list B. (4 marks)

Link list A



Link list B



2) Consider the below link class and implement the method deleteLast() in the link list class to remove the last link from the linklist. (4 marks)

Link class

int iData; Link next;
Link(int id) void displayLink()

3) Following numbers are inserted to a binary search tree.

45, 67, 12, 6, 20, 80, 50

i. Draw the binary search tree after inserting all the numbers (3 marks)

ii. What type of a binary tree do you get in i) above? (1 mark)

iii. What is the height of the tree in i) above? (1 mark)

iv. Assume you have N nodes in a binary search tree of the type given in i) above. Find the running time in Big O notation when searching a value from this tree. Give reasons for your answer. (3 marks)

v. What is the running time in Big O notation when searching a value from a link list with N no of links? Give reasons for your answer. (2 marks)

vi. Comment on the speed of the two data structures (with large N values) when searching a value. (Hint: use the answers given in iv) and v) above) (2 marks)

Question 4 **(20 marks)**

1) State one similarity and one difference between Stack and Queue data structure. (2 marks)

2) You are expected to develop a function to delete the middle element of a given stack. Note that the stack class is already implemented. You may assume that the stack is implemented to store integers. (9 marks)

Hint: Use two stacks (stack objects are '"s" and "s1")

Sample input and output is given below.

Input: `Stack[] = [1, 2, 3, 4, 5]`

Output: `Stack[] = [1, 2, 4, 5]`

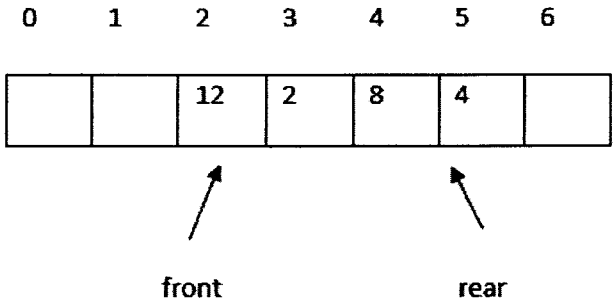
Input: `Stack[] = [1, 2, 3, 4, 5, 6]`

Output: `Stack[] = [1, 2, 3, 5, 6]`

The function signature is as follows.

```
public void deleteMiddle()
{   }
```

3) (c) Consider the following circular queue which is implemented to store integers. Draw the queue frames after executing each of the statements. (5 marks)



(i) insert (10)
(ii) peekFront()
(iii) insert (22)
(iv) remove ()
(v) insert (18)

5) Consider a linear queue to store double values. Implement a method to calculate the mean value of the currently available values in the queue and insert it to the same queue. Note that the queue class is already implemented and assume the queue object is "q". (4 marks)