

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

November 2022

Instructions to Candidates:

- ◆ This paper has 4 questions.
- ◆ Answer all questions in the booklet given.
- ◆ The total marks for the paper is 100.
- ◆ This paper contains 8 pages, including the cover page.
- ◆ Electronic devices capable of storing and retrieving text, including calculators and mobile phones are not allowed.
- ◆ 10 minutes reading time is allowed

Question 1**(25 marks)**

Consider the StackX class shown below

int[] stackArray int maxSize int top
void push(double j) double pop() double peek() boolean isEmpty() boolean isFull()

- a) An object of StackX class is created as myStack with size 5. Start from the stack frame given in Figure 1 and draw the stack frame after each statement given below. (5 marks)

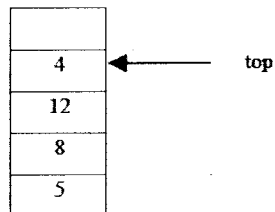


Figure 1

- myStack.push(6);
 - myStack.peek();
 - myStack.push(2);
 - myStack.pop();
 - myStack.pop();
- b) Assuming that the StackX class has been implemented using java, complete the following java program **StackApp** to do the following.

```

class StackApp {
    public static void main(String[] args) {
        -----
        -----
        -----
    }
  
```

- i) Create a stack object called **st** of size seven. (2 marks)
- ii) Store the integers given below. (2 marks)
20, 43, 12, 37
- iii) Read another integer from the keyboard. (1 mark)
- iv) Find out whether the number entered in iii) exists in the stack. (Hint : can use another stack object if necessary) (5 marks)
- c) Give your opinion about the following (4 marks)
- i) The array implementation of stack and queue has some limitations.
- ii) Circular queue allows to insert and remove items from the rear.
- d) Consider the following QueueX class

```
class QueueX {
    private int maxSize;
    private int [] queArray;
    private int front;
    private int rear;
    private int nItems;
    .....
    .....
}
```

Complete the following table with correct boolean expression used in the given method. (6 marks)

	Linear Queue	Circular Queue
boolean isEmpty()		
boolean isFull()		

Question 2**(25 marks)**

- a) Draw the link list created after executing the below code segment. insertFirst() method will insert the link as the first link and insertLast() method inserts the link as the last link. deleteFirst() method removes the first link from the link list. (3 marks)

```
linkList myList = new linkList();
myList.insertFirst(100);
myList.insertFirst(50);
myList.insertFirst(10);
myList.insertLast(200);
myList.deleteFirst();
```

- b) In a hospital management system, patient beds are stored in a link list. patientBed class and linkList classes are given below.
 'Vacant' attribute of patientBed class will be 0 when the patient is admitted to the hospital and assigned the bed. It will be 1 when the patient is discharged.

Assume the two classes have already been implemented.

patientBed

int bedNo int vacant patientBed next
patientBed (int bedNum) void displayDetails() void assignBed() void discharge()

linkList

patientBed first;
void linkList() boolean isEmpty() void addFirst(int bedNo) patientBed findVacant()

- i) You need to modify the linkList class by adding another method called countVacantBeds() in the linkList class. This method returns the number of vacant patient beds. Implement the method. (5 marks)
- ii) findVacant() method in the linkList class returns the first vacant patientBed. If there are no vacant beds, it will return NULL. Write code segment in your main application to find a vacant bed and assign the bed. Display the assigned bedNo. If there are no vacant beds in the hospital display the message "Patient beds are not available". (5 marks)

- c) i) Insert the following nodes to a binary search tree (3 marks)

88, 99, 77, 80, 90, 60

- ii) Find the height of the above tree (1 mark)
 iii) Display the nodes of the above tree using post order traverse method (3 marks)
 iv) Assume that the below methods are available in tree class to traverse the tree.

```
private void inOrder(Node localNode)
private void preOrder(Node localNode)
private void postOrder(Node localNode)
```

Implement a method of the tree class called displayGreaterThanOrEqualToRoot() to display all the nodes greater than the root in ascending order. (5 marks)

Question 3 (25 marks)

- a) Find the step count of the following pseudocode using RAM Model. (7 marks)

i)

```
int j = 0
for (i = 1 to 5)
  print i
  while (j < 5)
    j = j + 1
  print j
```

ii)

```
int i = 1
while (i <= 0)
  i = i + 2
  print i
```

- b) State the complexity using Big(O) notations of the following running time equations. (6 marks)

- i) $T(n) = n + n \log n + n^2 + 5$
 ii) $T(n) = 2n + 10$
 iii) $T(n) = 3^n + n! + 4n^2 + n^n - 8$

- c) i) What is the recurrence equation for the Merge Sort Algorithm? (2 marks)
 ii) State the reason of having only the best case in the Merge Sort Algorithm. (2 marks)

Pseudo code of the MERGESORT algorithm is given below

```

MERGESORT (A, p, r)
1.   if p < r
2.       q =  $\lfloor (p+r)/2 \rfloor$ 
3.       MERGESORT (A, p, q)
4.       MERGESORT (A, q+1, r)
5.       MERGE (A, p, q, r)

```

- d) Illustrate the operations of **PARTITION(A, p, r)** in Quicksort Algorithm for array $A=\{8,2,10,3,5\}$ (8 marks)

Pseudo code of the PARTITION algorithm is given below

```

PARTITION(A, p, r)
1   x = A[r]
2   i = p - 1
3   for j = p to r - 1
4       if A[j] ≤ x
5           i = i + 1
6           exchange A[i] with A[j]
7   exchange A[i + 1] with A[r]
8   return i + 1

```

Question 4

(25 marks)

a)

- i) Pseudo code of the BUILD_MAX_HEAP algorithm is given below. Complete line number 2 of the algorithm and explain the purpose of that line. (4 marks)

```

BUILD_MAX_HEAP (A)
1.   A.heap_size = A.length
2.   for i = ..... downto 1
3.       MAX_HEAPIFY (A, i)

```

- ii) Identify the violating node of the below max heap and illustrate the operations of the MAX_HEAPIFY (A,i) for the array A given below. (Use diagrammatic way to reach the answer) (6 marks)

Array A

10	90	60	50	20	35	40	15
----	----	----	----	----	----	----	----

Pseudocode of MAX_HEAPIFY is given below

```

MAX_HEAPIFY (A,i)
1.  l = LEFT_CHILD (i);
2.  r = RIGHT_CHILD (i);
3.  if l ≤ heap_size[A] and A[ l ] > A[ i ]
4.      largest = l;
5.  else largest = i;
6.  if r ≤ heap_size[A] and A[r] > A[largest]
7.      largest = r;
8.  if largest ≠ i
9.      exchange A[i] ↔ A[largest]
10.     MAX_HEAPIFY (A, largest)

```

- b) Answer the following question based on the Rabin – Karp algorithm
Taking modulo $q = 10$, how many spurious hits and valid hits would encounter in the text $T = 902883280088$ when looking for pattern $p = 28$? (5 marks)
- c) Draw the state transition diagram for a string-matching automation for the pattern $P = abb$ and take the input alphabet as $\{a,b\}$ (6 marks)
- d) 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.

```

Naïve-String-Matcher (T, P)
1. n = length[T]
2. m = length[P]
3. for s = 0 to n-m
4.     if P[1..m] = T[s+1..s+m]
5.         print "Pattern occurs with shift" s

```

Consider the below text

a	A	b	b	b	a	a	a	b	a
---	---	---	---	---	---	---	---	---	---

How many comparisons would occur in this algorithm for the pattern “abb”?

(4 marks)

End of Question Paper