Sri Lanka Institute of Information Technology

B.Sc. Honours Degree in Information Technology

Specialized in Information Technology

Final Examination
Year 2, Semester 2 (2023)

IT2070 – Data Structures and Algorithms

Duration: 2 Hours

November 2023

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.
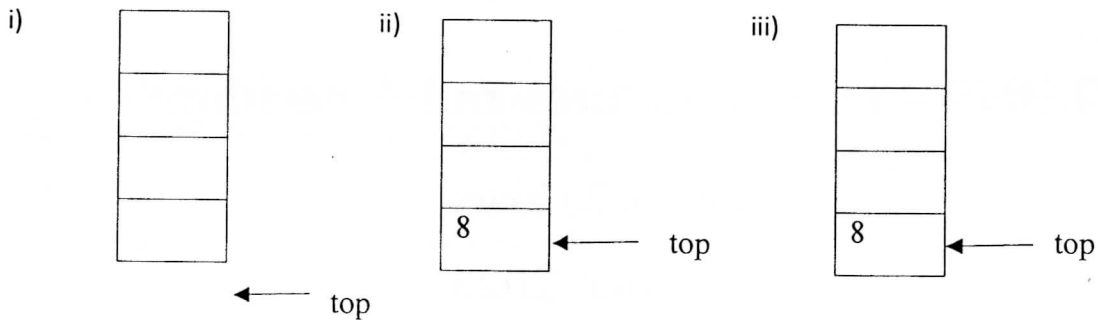- 10 minutes reading time is allowed

Question 1

a) Write one practical example for each of the following   (2 marks)
     i)   stack
     ii) queue

b) Consider the initial stack frame of a stack given below.
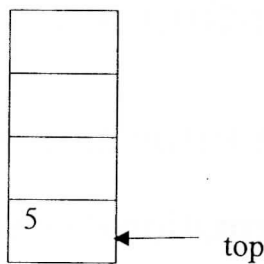
Below stack frames are obtained after executing three operations one after another to the above stack frame. Write down the operations.   (3 marks)

c) Fill in the following blanks.   (6 marks)

     i)   The "top" is _____ when the stack is empty.
     ii)   The no of items in a stack can be obtained from (top + _____) .
     iii) A stack can be implemented using _____ or _____.
     iv) "PeekFront" operation of a linear queue and circular queue are _____ (same/different)
     v)   The time complexity of the "insert" operation on a queue implementation is _____ .

d) Consider the below circular queue. A value is removed from the queue using the "remove" method given below. Write down the values of front after executing line 4, line 5, line 6 and line 8.   (4 marks)

2
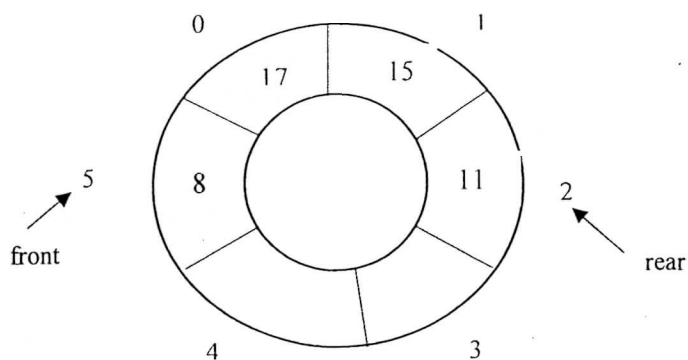
```
      public int remove() {
1.        if ( nItems == 0)
2.            system.out.println("Queue is empty");
3.      else  {
4.          int temp = queArray[front++];
5.          if (front == maxSize)
6.              front  = 0;
7.          nItems--;
8.          return temp;
9.      }
      }
```

e) "front - rear + 1 can be used to find the no of items in a linear queue"

Do you agree with the above statement? If you agree, justify your answer using a diagram. If you do not agree, write the correct answer. **(3 marks)**

f) Write a code segment in your main program using java to sort the values in a stack in ascending order. Assume the stack object **myStack** is available with values and another empty stack object called **sortedStack** is already created. The sorted values should be stored in sortedStack. **(7 marks)**

Ex:

myStack
11
45
8
56

sortedStack
56
45
11
8

Consider the StackX class is given below.

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

Question 2   (25 marks)

a) Consider the link list given in Figure (a)

first → 8 → 10 → 32 → 88 → null

Figure (a)

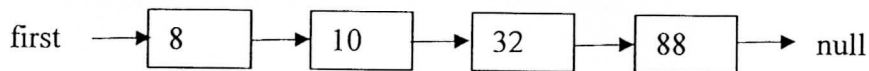Execute below code segments on the link list given in Figure (a). Display the output after executing the code segment   (6 marks)

```
i)    Link temp = first;
      while (temp != NULL)
      {
          System.out.print(temp.ID);
          temp = temp.next;
      }
```

```
ii)   Link temp = first;
      while (temp.next != NULL)
      {
          System.out.print(temp.ID);
          temp = temp.next;
      }
```

```
iii)  first = first.next;
      System.out.print(first.next.ID);
```

4

b) Modify the code segment given in a) i) above to display the last link in a link list   (4 marks)

c) Consider the following Link class of a **doubly link list**. Implement the insertFirst() method of the doubly link list class   (4 marks)

```
Link
---------------------
+int ID
+Link next
+Link previous
---------------------
+ Link (int IDNo)
```

d) Key values of a binary search tree is given below.

        50   65   25   30   10   58   70

   i)   Insert the above values in a binary search tree.   (2 marks)
   ii) What type of a binary tree did you get in d) i)?   (1 mark)
   iii) Assume the values given above are sorted in ascending order first and then inserted to a binary search tree. Compare the tree you get with d) i) and discuss the performance.   (3 marks)

e) Complete the method displayLeafNodes() of the tree class given below. This method will print all the leaf nodes in the tree.
   Assume the Node class given below has been implemented.   (5 marks)

```
Node
---------------------
+int ID
+Node leftChild
+Node rightChild
---------------------
+Node(int ID)
+displayNode()
```

```
private void  displayLeafNodes(Node localNode)
{


}
```

Question 3

(25 marks)

a) Find the step count of the following pseudocodes using RAM model. (6 marks)

i)   ii)

```
a = 5
while (a < 10)
    a = a + 2
print a
```

```
i = 10
for ( j = 1 to 5 )
    while ( i >= 0 )
        i = i - 1
print i
```

b) State the asymptotic notations in Big(O) notations for the above pseudocodes a) i) and a) ii).
(4 marks)

c) PARTITION() algorithm which is used in Quick Sort algorithm is given below. It returns the partition index.

i) Consider the following array A and illustrate the steps of applying PARTITION() algorithm to array A
(7 marks)

Array A

1	2	3	4	5
8	5	7	6	2

```
Procedure PARTITION(A,p,r)
1   x ← A[p]
2   i ← p -1
3   j ← r +1
4   while TRUE
5       do repeat j ← j - 1
6           until A[j] ≤ x
7           repeat i ← i + 1
8           until A[i] ≥ x
9           if i < j
10              then exchange A[i] ↔ A[j]
11              else return j
```

ii) If the values are in ascending order, comment on the performance of Quick Sort algorithm using the above Partition() algorithm. (3 marks)

iii) For the situation derived from ii), obtain the recurrence equation that describes the running time T(n). (2 marks)

6

iv) Solve the recurrence equation obtained in iii) using Repeated Substitution method and express the time complexity using Big(O) notation. (3 marks)

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

Question 4   (25 marks)

a) State one difference between a queue and a priority queue. (1 mark)

b) If the following pseudocode is applied to the max heap A, what will be returned as the output? (1 mark)

A

1	2	3	4	5
70	60	30	20	10

```
HEAP_EXTRACT_MAX (A[1 .. n])
1. if A.heap_size >= 1
2.      max = A[1]
3.      A[1] = A[A.heap_size]

4.      A.heap_size = A.heap_size -1
5.      MAX_HEAPIFY(A,1)
6.      return max
```

c) Based on the pseudocode given in b) above, answer the following.

i) What is the purpose of executing line (4)? (2 marks)
ii) What is the purpose of executing line (5)? (2 marks)

d) Illustrate the steps to be followed in heap_insert() given below to the max heap A. Assume that a node with the value of 145 to be inserted as a new node.   (7 marks)

A

1	2	3	4	5	6	7
200	185	100	50	40	80	90

```
HEAP_INSERT(A, key)
1. A.heap_size = A.heap_size + 1
2. i = A.heap_size
3. while i > 1 and A[PARENT(i)] < key
4.     A[i] = A[PARENT(i)]
5.     i = PARENT(i)
6. A[i] = key
```

e) i) Compute the number of valid shifts and invalid shifts occurred with Naïve String-Matching algorithm for following Text(T) and the Pattern(P).   (2 marks)

   T = abacbadab
   P = cab

ii) Briefly explain the time complexity using Big (O) notation for the situation occurred in e) i) above.   (2 marks)

f) i) Draw the state transition diagram for the Pattern 'baa' given the input alphabet = {b, a}   (6 marks)

ii) Consider the below text

b	b	b	a	b	a	a	a	b	a

Illustrate how you would find the pattern "baa" in the above text using your answer in part f) i) above.   (2 marks)

End of Question Paper