

Indian Institute of Information Technology Guwahati

Data Structures (CS103)

Mid-Semester Exam

Time: 2 Hours

Answer all questions

Full Marks: 30

Please write to-the-point and concise answers. Unnecessary lengthy answers may result into deduction of marks.

Please answer all questions of a part together.

Part A

1. Suppose a stack implementation supports, in addition to PUSH and POP, an operation REVERSE, which reverses the order of the elements of the stack. To implement a queue using the above stack implementation, show how to implement ENQUEUE using a single operation and DEQUEUE using a sequence of 3 operations. [4]
2. Prove by the principal of mathematical induction that maximum number of nodes in a binary tree of depth d is $2^{d+1} - 1$. Assume that depth of the root node is 0. [3]
3. Consider the following infix expression: [5]

$$A+B*(C+D)/F+D*E$$

While converting it into postfix expression workout the following:

- (a) Show the contents of the stack when "(" is encountered.
 - (b) Show the contents of the stack when last "*" is encountered.
 - (c) Show the contents of the stack at the end of expression.
 - (d) Final postfix expression.
4. How many distinct binary trees can be created out of 4 distinct keys? Draw all the possible trees. [3]

~~CD*F/~~
 $A + BCD + *F/$

Part B

5. Answer the following questions:

[2+1]

- (a) Determine and explain the functionality of the following function. Compute the best case and worst case complexity of function1. Explain your answers.

```
int function1 (int a[], int n, int x)
{
    int i;
    for (i = 0; i < n && a[i] != x; i++);
    if (i == n) return -1;
    else return i;
}
```

$abc/d + *$

$a+b/c*d$

$a+bc/*d$
 $a+bc/d*$

- (b) Find the time complexity of the following code snippet. Assume that complexity of `rand()` function is constant.

```
int b = 0, i, j, k = 0;
for (i = N / 2; i <= N; i++) {
    for (j = 2; j <= N; j = j * 2) {
        k = k + N / 2;
    }
}
for (j = 0; j < M; j++) {
    b = b + rand();
}
```

6. There is a double ended queue which supports `insertFront()`, `deleteFront()`, `insertRear()`, and `deleteRear()` operations.

- Write the pseudocode of two functions to implement `insertFront()` and `deleteRear()` operations on a double ended queue implemented using a doubly linked list. [2]
- Assume that the implementation of the double ended queue with all four operations is available. Propose an algorithm to evaluate a postfix expression using double ended queue which supports four operations mentioned above. [2]
- Consider the following postfix expression with single digit positive integers:

2536+**5/2-

Evaluate the value of this expression. Show all the contents in the double ended queue at each step of the evaluation of this particular postfix expression. [0.5+1.5]

- Draw a binary tree of minimum height with 15 nodes such that the binary tree is a strictly binary tree and it is not a full/complete binary tree. What is the height of the binary tree. Assume that height of tree with a single node is 0. The definition of full/complete binary tree, strictly binary tree follows the class discussion. [0.5]
 - Write a pseudocode of a function to evaluate an arithmetic expression represented using a binary tree. [1]
 - Consider the following arithmetic expression: [0.5+1]

$((5*(8-6))/2)+(9*(4+3))$

Draw a binary tree to represent this arithmetic expression. Write the execution sequence of the function proposed in the answer of question 7(b) on this binary tree.

- Write the binary search algorithm and analyse its time complexity. Clearly write the input(s) and output(s) of the algorithm. Let $A[]$ be a sorted array of integers of infinite size. Propose an efficient algorithm to find the location of a given integer x in $A[]$. Assume that x is present in the array. [1.5+1.5]

Handwritten notes for Binary Search:

$n = 7$ $mid = 3$

AB 1 2 3 ... n ... $n+1$

$n/2$ $n/4$ $n/8$... $n/2^n$ break

$n/2 + n/4 + \dots + n/2^n$

$kx = n/2^n$

$2^n = kx$

$n \log_2 = \log$