PDPM INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, DESIGN AND MANUFACTURING JABALPUR

Mid-semester Examination, February 2014
ES103: Data Structures and Algorithms

Mobile Phones, Calculators or computing devices and other electronic gadgets are strictly prohibited inside the examination hall. Answer all the questions. Write precise answer. Do the details work neatly in the provided sheet and only write the answer in the appropriate place.No clarifications will be provided.

Max. Marks: 50 **Duration: 2Hours**

Name: _____ Roll No: _____ Signature: _____

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1. [4 marks] Calculate the asymptotic complexity of the following fragments of the code. Show the steps in the right side of the code:

   (a)
   ```
   sum1 = 0;
   for (k=1; k<=n; k*=2)
       for (j=1; j<=n; j++)
           sum1++;
   ```

   (b)
   ```
   sum2 = 0;
   for (k=1; k<=n; k*=2)
       for (j=1; j<=k; j++)
           sum2++;
   ```

2. [5 marks] Complete the following pseudocode to transpose an $n \times n$ matrix A[0:n-1,0:n-1], and compute the time complexity. Show the steps in the right side:

   ```
   for i = 0 to n - 2
       for j = ______ to n - 1
            t= A(i,j)
            --------------
            --------------
   ```

3. [10 marks] Fill in the blanks. Incase of multiple choice question write the correct choice(s).

   (a) Which of the following problems have solutions (algorithms) that run in $\Theta(n)$ time in the worst-case?_____
   A. Finding the median of n integers B. Finding the sum of n integers C. Finding the largest of n integers D. All of the above E. None of the above

   (b) An algorithm A is made up of two independent algorithms F and G written one after the other. The worst-case asymptotic time complexities of F and G on

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a set of n inputs are $f(n)$ and $g(n)$, respectively. Then the complexity of the algorithm A is:_____
A. $\max\{f(n),\ g(n)\}$ B. $\min\{f(n),\ g(n)\}$ C. f(n) $\times$ g(n)
D. Independent of f(n) and g(n) E. None of the above

(c) The asymptotic time-complexity of an algorithm in RAM model of computing is measured by:_____
A. Counting the number of basic operations, i.e., constant-time operations in RAM model
B. The actual time the algorithm takes to execute on a real computer
C. Counting the length (in bits) of a code written to implement the algorithm
D. All of the above E. None of the above

(d) Identify the correct statement(s):_____
A. $f(n) = O(g(n))$ implies $g(n) = O(f(n))$.
B. $f(n) = \Omega(g(n))$ implies $g(n) = \Omega(f(n))$.
C. $f(n) = \Theta(g(n))$ implies $g(n) = \Theta(f(n))$.
D. All of the above E. None of the above

(e) Identify the correct statement(s):_____
A. $f(n)+g(n) = \Theta(\min(f(n), g(n)))$. B. $f(n)+g(n) = \Theta(\max(f(n), g(n)))$.
C. $f(n) + g(n) = \Theta(f(n)g(n))$. D. All of the above E. None of the above

(f) Which is the best data structure to reverse a string _____ ?

(g) Which data structure is suitable to allocate resources (like CPU) by the operating system by first come first serve basis:_____ ?

(h) A tree with n nodes has _____ edges.

(i) A binary tree in which if all its levels except possibly the last, have the maximum number of nodes and all the nodes at the last level appears as far left as possible, is known as_____

(j) What is the maximum height of an n node binary tree_____ ?

4. 2 marks Propose a method to represent a polynomial in 2 variables via linked list representation? Define a structure of the node for this list in C. Then draw the list which stores polynomial $2x^2y^4 + 4x^3y^3 + 3xy + 5$ through such representation.

5. [4 marks] Consider the following recursive definition of fib:

```
fib(n): =  if n = 0 return 1
           else if n = 1 return 1
                else return fib(n-1) + fib(n-2)
```

The number of times fib is called (including the first call) for an evaluation of fib(7) is _____ ?

6. (a) [4 marks] Convert the following infix expression to postfix expression using stack. Illustrate the content of the stack in each step:

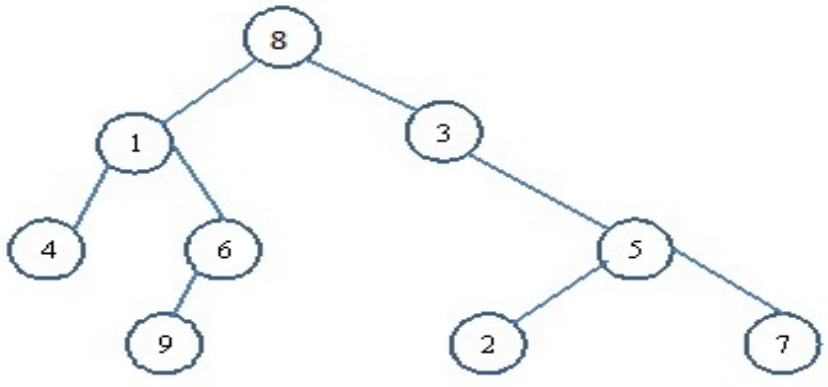
$$((A + B) * C - (D - E)) \uparrow (F + G)$$

Ans:

(b) [4 marks] Find the expression to calculate the number of elements **"NUM"** in a circular queue $Q(0 : N-1)$ maintained in an array with two variables FRONT and REAR. Maximum elements in the queue can not be greater than $N-1$. You are not supposed to traverse the queue to find **NUM** (You need not write an algorithm for it, just giving the formula will be sufficient).

(c) [2 marks] A circularly linked list is used to represent a Queue. A single pointer P is used to access the Queue. To which node should P point so that both the operations, "insert in queue" and "delete from queue" can be performed in constant time?

7. [5 marks] (a) Write the preorder, inorder, and postorder traversal of the following binary tree.



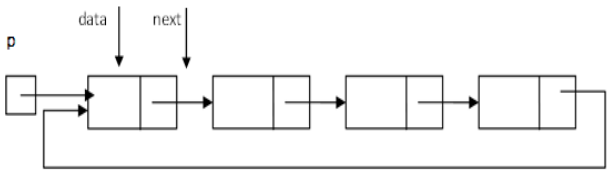
(i) Preorder:

(ii) Inorder:

(iii) Postorder:

(b) Inorder traversal and postorder traversal of a binary tree are D, J, E, G, B, A, I, C, F, H and J, D, B, G, E, I, C, H, F, A respectively. Construct the binary tree.

8. 5 marks Consider the following circular list, where p points to the FIRST node of the list. Each node contains two fields namelv "data" and "next":



Complete the following incomplete function to extend the circular linked list being pointed by p (the first node) by appending (adding) a singly linked list (pointed by q) to the end of the circular list. The resulting list will be one big circular list.

It is specified that the Circular list is NOT empty i.e. p cannot be NULL, but q may be NULL.

```
void extend(struct node **p, struct node **q)
{
  struct node *temp;   /* temp is used to traverse the lists */

  if (   _________________ )   /* if singly linked list is empty */

      return;

  temp = _______________;

  while (   _______________  )   /*traverse the circular list */

       temp =    _________________  ;

  _________________  ;  /* append the singly list */

  while (  _________________  )  /* traverse the singly list */
```

```
        temp =   _______________      ;

   _______________     ;
}
```

9. [5 marks] Complete the following function to reverse a given singly linked list of integers by making use of an integer stack. Use the interface function prototype given below for the stack and the linked list operations.

```
void reverse(struct node** head) {
struct node *stack;

_____________________ ;

if (   _________________ )   /* if singly linked list (SLL) is empty */

      return;

while (   _____________  ) { /*Here we will move all elements of SLL to stack*/

_____________________ ;

_____________________ ;

}
while (___________________) { /*Here we move all the elements of stack to SLL */

_____________________________________ ;

_____________________________________ ;

}
}
```

Stack:
*void push(struct node** top, struct node* p)*
*struct node * pop (struct node** top)*
The push(..) function takes address of the stack pointer, and a node pointer to push the node to stack. The pop(..) function returns the pointer to the node popped from the stack. You do not have to write the code of these functions.
LinkedList
*void insertAtLast(struct node ** head, struct node* p)*
*struct node * deleteFirst (struct node** head)*
The insertAtLast(..) function takes address of the head pointer of the linked list, and a node pointer to insert the node to the end of the linked list. The deleteFirst(..) function returns the pointer to the node removed from the linked list. You do not have to write the code of these functions.