

**Indian Statistical Institute
Computer Science I (Programming in C)
11 November 2013**

**Total Marks: 50 Maximum time: Three hours
Answer Questions 1 & 2 AND any THREE from the rest**

Note: Please write neatly and legibly for a piece of a code to be readable.

Q 1. [Total Marks: 1+1+1+1+1+5+2=12]

For Q1a,b,c,d, and e, consider the swap function:

```
void swap(int *x, int *y) {  
    int temp = *x;  
    *x = *y;  
    *y = temp;  
}
```

Suppose we have an array of three integers int x[]={20,10,30}.

Are the following statements True (T) or False (F) as applied to the above array?

Q 1a.) swap(x[1], x[2]) swaps 10 and 30.

Q 1b.) swap (x, x+2) swaps 10 and 30

Q 1c.) swap(&x[2] , &x[0]) swaps 10 and 20.

Q 1d.) swap(x, &x[1]) swaps 20 and 10.

Q 1e.) Using the swap function given above fill in the missing line as indicated in the comment in the function definition given below that swaps a[i] with a[j].

```
void swap_i_j(int *a, int i, int j) //swaps a[i] with a[j]  
{  
    //FILL IN THIS MISSING STATEMENT:ONE LINE ONLY  
}
```

Q 1f.) Complete the definition of the following function sum by filling in the blanks

```
----- sum (----, ----, ----) // takes two int a and b and stores their sum in c  
{ ----- ;  
}
```

Q 1g.) Provide the missing statement in “while” in the function shown below

```
int factorial (int n) {  
int i = 1 , result = 1;  
while ( -----)  
result *= i ;  
return result ;  
}
```

Q 2. [Total Marks: 8] Complete the following C program by adding appropriate functions and statements as mentioned in the comment in the main program.

```
typedef struct{  
char name[30];  
int marks;  
} st_marks;  
  
main ( )  
{  
st_marks MarkSheet[5] =  
{"Samir",20},{"Jalal",40},{"John",30},{"Vidya",60},{"Ayesha",25} };  
  
// WRITE THE REST OF THE PROGRAM TO  
// print out the students' names in ascending order of marks  
}  
// You may want to use a modified version of the function given next.
```

```

void insertion_sort(int *arr, int length) //sorts an array of int of given length
{ int i,j,tmp;
  for(i = 0; i<length; i++)
  {
    for(j = i - 1 ; j >=0; j - -)
    {
      if( *(arr + j) > *(arr + j +1) )
      {
        tmp=*(arr + j);
        *(arr + j)=*(arr + j + 1);
        *(arr + j+ 1)=tmp;
      }
      else break;
    }
  }
}

```

Q 3. [Total Marks: 2+2+5+1=10]

Q 3a.) Define a structure that gives a linearly linked implementation of a stack of integers

Q 3b.) Write a C function that takes a pointer to a stack as input and checks if the stack is empty.

Q 3c.) Write a C function that pops out the integer on top of the stack.

Q 3d.) Which of the following represents the time complexity of popping a stack if it contains N elements? $O(\log_2 N)$, $O(1)$, $O(N)$.

Q 4. [Total Marks: 2+2+2+4=10]

Q 4a.) Define a structure that represents a node in a binary tree of integers.

Q 4b.) Define a C function that creates a single node of a binary tree of integers such that the node contains a given integer.

Q 4c.) Write a function that takes a pointer pointing to a node in a binary tree, and returns 1 if the node is a leaf and zero otherwise.

4d.) Use this function recursively to calculate the number of leaves in a binary tree.

Q 5. [Total Marks: 10]

Q 5a.) From the following traversals of the binary tree reconstruct the tree.

In-Order Traversal: F H E B C A G J N K

Pre-Order Traversal: C E F H B G A N J K .

Q 5b.) If a max heap is made from these nodes what will be the height of that heap?

Q 5c.) What is the maximum height of a max heap constructed out of n nodes?

Q 5d.) If a max heap is also a complete binary tree with n nodes. If a node at level ℓ is removed, show that it takes a maximum of $(\log_2(n+1) - \ell)$ steps to make it into a max heap again.

Q 6. [Total Marks: 2+2+6=10]

Q 6a.) Show that in the case of insertion sort the time complexity $T(n)$ can be written as $T(n) = T(n-1) + f(n)$.

What does the function $f(n)$ represent?

Q 6b.) What is $f(n)$ for the worst case and best case?

Q 6c.) Solve the above equation for the best case and the worst case, based on your answer for the above case and show that in the worst case $T(n) = O(n^2)$ and in the best case $T(n) = O(n)$.