CS213/293 Data Structure and Algorithms 2024 IITB India
Quiz 2

Duration : 45 minutes   **Total: 30 marks**

1. **(8 marks)** Give an example of
   - (a) a complete graph with 4 nodes.
   - (b) a cycle on a graph that is not simple.
   - (c) a graph with odd simple cycle.
   - (d) a graph that has no Eulerian cycle.
   - (e) a frequency distribution for four symbols that does not allow any compression via Huffman encoding.
   - (f) a sorting algorithm that has $O(n \log n)$ worst-case running time and does not require $O(n)$ extra space.
   - (g) an input to Quick sort that causes it to run for $\Theta(n^2)$ time.

2. **(6 marks)** Show a BFS run on the following graph starting from M. Show all intermediate states of the queue inside the BFS.
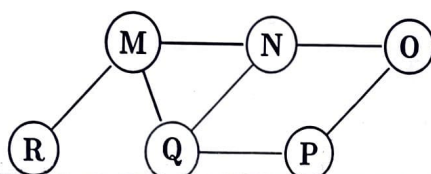
3. **(6 marks)** Show that if each node in a finite directed graph has non-zero incoming edges then there is a cycle.

4. **(10 marks)** Consider the following bubble sort algorithm, where A is the pointer to the input array and n is the length of the array. Let us suppose A contains distinct elements. The function call to swap(A, j, j+1) exchanges the values of $A[j]$ and $A[j+1]$.

Algorithm 3.1: BubbleSort(int* A, int n)

```
1 for i = 0; i < n − 1; i + + do
2     for j = 0; j < n − i − 1; j + + do
3         if A[j] > A[j + 1] then
4             swap(A, j, j+1);
```

Let us suppose $n = 3$. The if condition in the BubbleSort will execute three times as follows.

Algorithm 3.2: BubbleSortUnrolled(int* A, int $n = 3$)

```
1 if A[0] > A[1] then  swap(A, 0, 1) ;
2 if A[1] > A[2] then  swap(A, 1, 2) ;
3 if A[0] > A[1] then  swap(A, 0, 1) ;
```

In the above unrolled program, each if condition can either be true or false. Each combination is a path of the program. Therefore, there are 8 paths in the program. Not all paths are feasible, i.e., all ifconditions along the path is satisfied. For example, consider a path where the first two conditions are false and the last one is true. This path is infeasible because the first and the last conditions are the same and the content of A is not changed between the two conditions.

(a) (3 marks) Give one more path that is not feasible for $n = 3$.

(b) (3 marks) For $n = 4$, how many paths are there in the BubbleSort?

(c) (5 marks) For $n = 4$, how many infeasible paths are there in the BubbleSort?

$2^?$

3

2

1