

# Final Exam

Started: Dec 9 at 4pm

## Quiz Instructions

You will have until 6:50pm to complete the exam. Any work you want graded for partial credit should be uploaded through the submission system on webcourses. You must answer the first 8 questions, but you need to answer only 3 of the last 4 questions (9, 10, 11, and 12).

Any addendum will be given through webcourses announcements. You can ask for clarifications through zoom.

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### Question 1

10 pts

What is the problem with the following segment of MST code?  
Assume the Edge class is fine, and the function is called with parameters of number of nodes, number of edges, and the adjacency list, in that order. [Hint: there is more than one error]

```
int MST(int n, int m, ArrayList<Edge>[] adj) {  
    if (m < n - 1)  
        return IMPOSSIBLE;  
    boolean[] vis = new boolean[m];  
    vis[0] = true;  
    PriorityQueue<Edge> pq = new PriorityQueue<Edge>();  
    for (int i = 0; i < n; i++)  
        for (Edge e : adj[i])  
            pq.add(e);  
    int answer = 0;  
    int edgesUsed = 0;  
    while (!pq.isEmpty() && edgesUsed < m) {  
        Edge cur = pq.poll();  
        if (!used[cur.end]) {  
            used[cur.end] = true;
```


```

        answer += cur.weight;
        edgesUsed++;
    }
}
if (edgesUsed != m)
    return IMPOSSIBLE;
return answer;
}

```

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**Question 2**

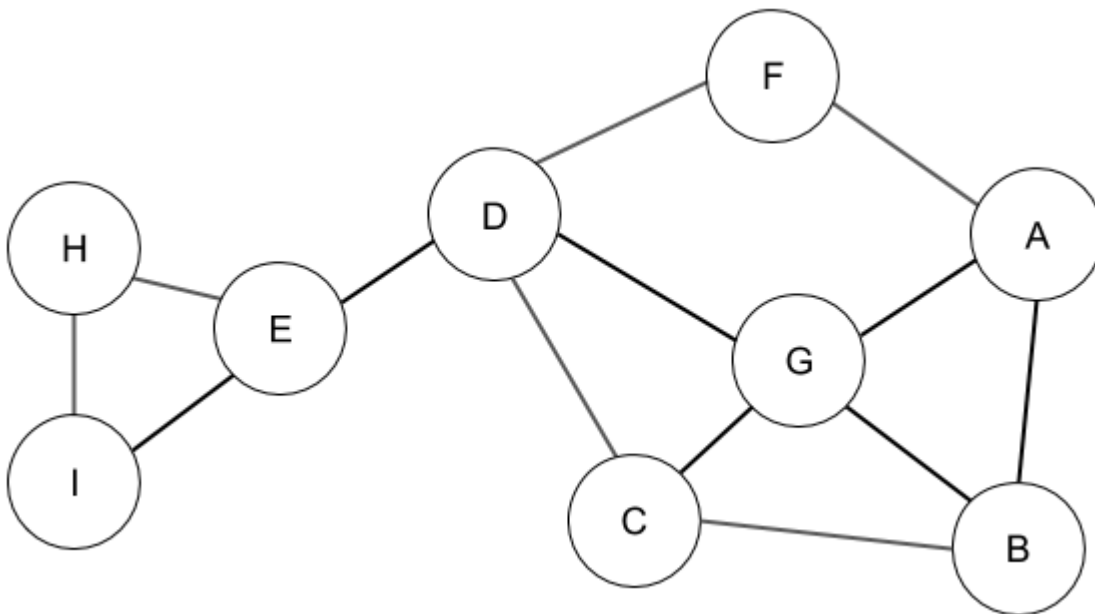
**5 pts**

What is the worst case Big-Oh memory usage for a R-B tree with N nodes?

### Question 3

5 pts

What order will the nodes be visited in the following graph when searching from node D with a BFS? Tie break by selecting the least alphabetical node first.

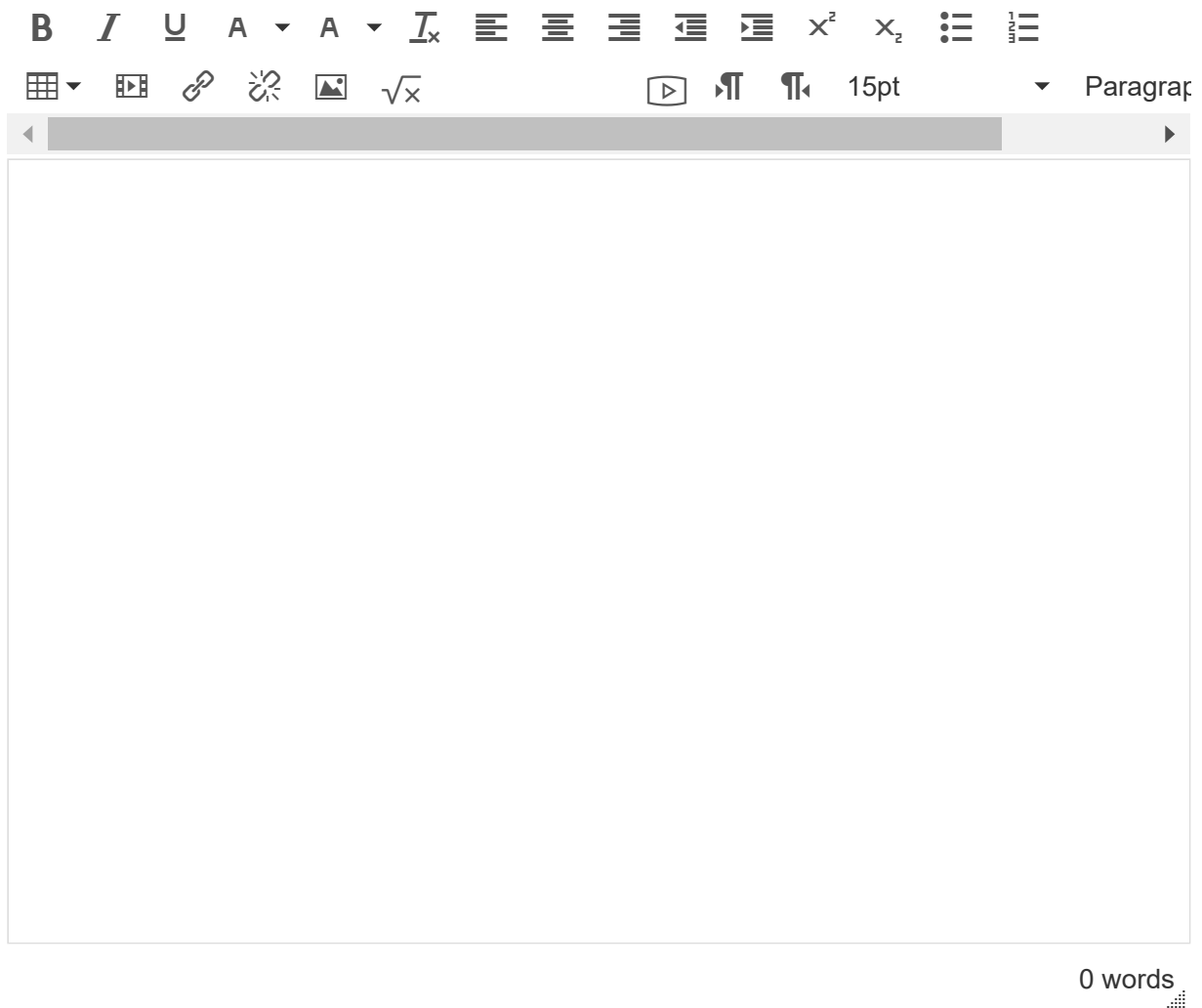


### Question 4

10 pts

Write a method **IN JAVA** that finds the maximum length (contiguous) strictly increasing subarray of a given array of N values. The method will need to have a runtime of  $O(N)$  for full credit.

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## Question 5

5 pts

What is the Big-Oh runtime of Tarjan's SCC algorithm on a Graph with  $|V|$  vertices and  $|E|$  edges?

## Question 6

5 pts

What is the Big-Oh runtime of the 0-infinity Knapsack with a capacity of C and N items?

## Question 7

10 pts

Below is some Floyd's code that did not work on an all pairs shortest path. The given graph had no negative edges, but the output was still wrong. What issues do you notice in the following code? [Hint: there is more than one error].

```
public static void main(String[] Args) {
    Scanner sc = new Scanner(System.in);
    int numNodes = sc.nextInt();
    int numEdges = sc.nextInt();
    int[][] graph = new int[numNodes][numNodes];
    for (int a = 0; a < numNodes; a++)
        for (int b = 0; b < numNodes; b++)
            graph[a][b] = 987654321;
    for (int i = 0; i < numEdges; i++) {
        int s = sc.nextInt() - 1;
        int e = sc.nextInt() - 1;
        int weight = sc.nextInt();
        graph[s][e] = weight;
    }
}
```

```

    }
    for (int i = 0; i < numNodes; i++)
        for (int j = 0; j < numNodes; j++)
            for (int k = 0; k < numEdges; k++)
                if (graph[j][i] > graph[j][k] + graph[k][i])
                    graph[j][i] = graph[j][k] + graph[k][i];
    for (int i = 0; i < numNodes; i++) {
        for (int j = 0; j < numNodes; j++)
            System.out.println(graph[i][j] + " ");
        System.out.println();
    }
}

```

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Question 8

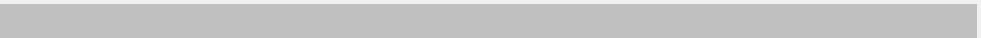
10 pts

In class we talked about point query/range update and range query/point update Fenwick Trees. What difficulties (if any) would be encountered when trying to use a BIT for range query/range update? If it is possible to use a Fenwick Tree efficiently for range query/range update, please explain your methodology.

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**Question 9**

**20 pts**

Mr. Frog lives on a log. The log is broken into N segments Mr. Frog wakes up on the first segment. Before Mr. Frog starts his day he likes to jump on to each other (NOT INCLUDING 1) log segment exactly once, after which he swims in the pond all day. Mr. Frog cannot jump to just any segment. Mr. Frog can only jump to a segment if it is separated by at most 2 segments (e.g. from 1, Mr. Frog can jump to 4, but not 5).

Mr. Frog is not good with math, but you are, and you can program. Write a method **IN JAVA** that counts the number of jump sequences that Mr. Frog can take to start his day right by landing on every segment (excluding 1) exactly once. Your method **can** be exponential in terms of runtime.

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**Question 10****20 pts**


Suppose we had graph with  $V$  vertices and  $E$  edges that have a weight. We want to know the set of edges that have the smallest weight sum such that after their removal the graph is disconnected. Describe at a high level an efficient manner to find this edge set. For full credit your method must at least as fast as  $O(V^4E)$ .


If you need to use an algorithm discussed in class, you don't need to describe how it works (e.g. SCC, Flow, MST, etc.), merely mention its use.

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## Question 11

20 pts

You have a sound board with many dials all in a line each one controlling a different sound. The dials go from 1 to 10. All the dials are set to 1 to begin with. You will over the course of a long period of time step a dial up by exactly 1 or play a sample across some range of dials. When you play a sample across the range you will notice the sounds from the dials that are set to the highest value. In other words if the dials are set to [1, 6, 5, 2, 5, 5, 1, 4] and you play the sample from 2 to 7 (1-indexed), you will hear 3 distinct sounds all set to the value of 5. You will repeat the process of turning up a dial and play a sound. You want to know with each sample playing how many sounds you should hear.

Explain how you would use a BIT(s) to quickly find the number of sounds heard at each sample. If another data structure is used to help describe it. Your explanation should be clear and have a single interpretation.

If you need to use an algorithm discussed in class, you don't need to describe how it works (e.g. SCC, Flow, MST, etc.), merely mention its use.

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**Question 12**

**20 pts**

For example consider the string "aba". There are 5 palindromic subsequences ("a", "b", "a", "aa", and "aba").

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Quiz saved at 4:00pm

Submit Quiz