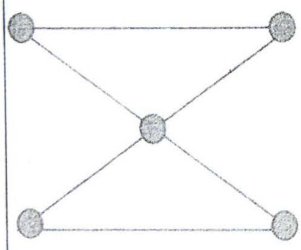
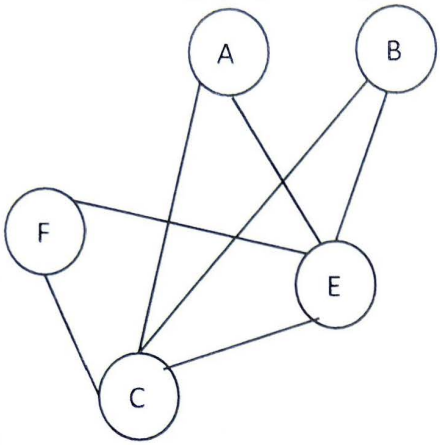
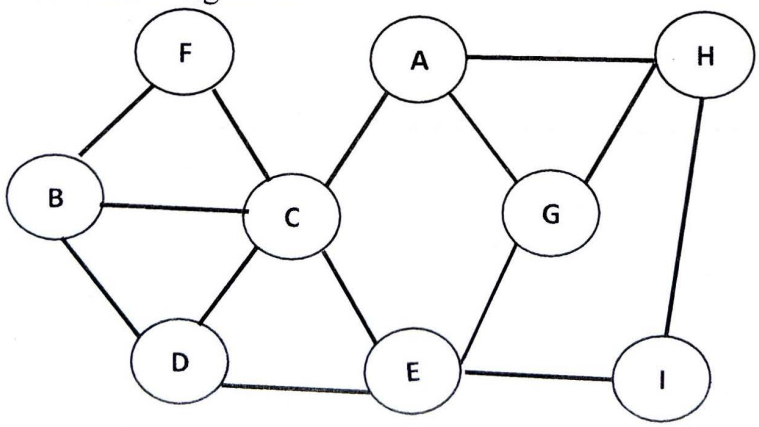
Q1. [12 points] General information question.
Multiple Choice Questions. Justify your answer.

| # | Question | Options [1point] | Justification [1point] |
|---|---|---|---|
| 1 | Pushing a value onto a stack containing n values, implemented as a linked list is O(1). | A. True<br>B. False | True, As we are inserting new elements at the head of the LinkedList. |
| 2 | Depth-First-Search graph algorithm requires F if it is implemented with adjacency list. Where F is | A. $O(\|V\|^2 + \|E\|)$<br>B. $O(\|V\| + \|E\|)$<br>C. $O(\|E\|)$<br>D. $O(\|V\|\|)$ | Answer B<br>According to the DFS algorithm, we need to track every vertex using each one of the edges, therefore if we add more vertex and paths the time will be affected Lineally.<br><br>So the order is O(IVI + IE!). |
| 3 | Which of the following belongs to NP class? | A. Hamiltonian Cycle<br>B. Vertex Cover<br>C. Traveling Salesman<br>D. A and B<br>E. A, B, and C<br>F. None of the above | Answer E.<br>For these 3 problems is easier to check a solution than to obtain a solution in the first place.<br>The solution can be verified (or that some solution exists) in polynomial time. |
| 4 | The following graph has a Hamiltonian cycle<br>  | A. True<br>B. False | False, because in a Hamiltonian cycle you can not visit a vertex more than one time. |

| | | | |
|---|---|---|---|
| 5 | The following graph is bipartite   | A. True<br>B. False | FALSE because of the path between C and E |
| 6 | Rehashing in linear probing process must be done when the load factor LF equals | A. 0.2<br>B. 0.5<br>C. 0.75<br>D. 0.9 | Answer C. In Java by default for Hashmap this is the recommended load factor or threshold to manage the collisions and decide when is appropriate to increase the array size and rehash the hashtable. |

Q2) [12 points] Graphs:

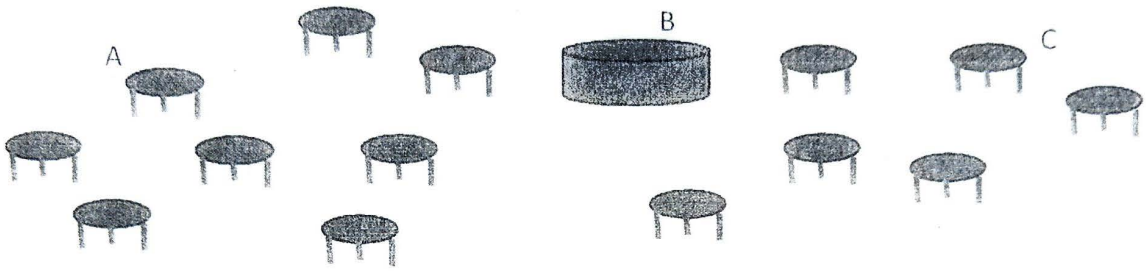
1. [2 point] In the following undirected graph, give a valid sequence of vertices that would be visited by the given algorithm starting from F. You should select the alphabetically least vertex, when there is a choice that is not determined by the algorithm.
   a. Breadth-First Search algorithm.



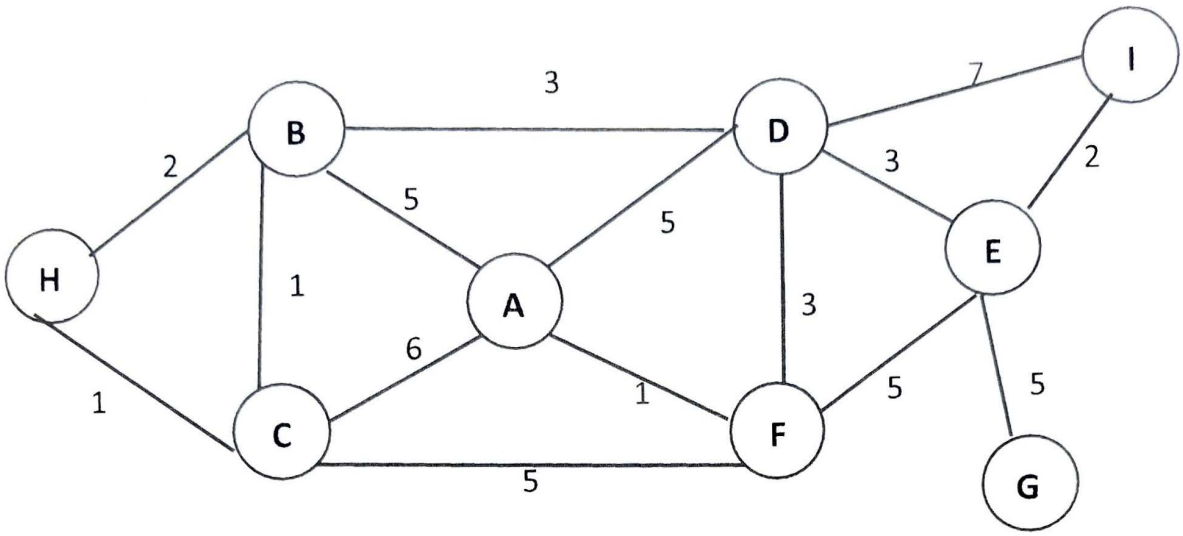

Answer: { F B C D A E G H I }

Step by Step: Queue F BC CD DAE AE EGH GHI HI I -

2. [4 points] Suppose that you want to get from table A to table C in a big restaurant. And you have to stop by the bar B to bring something to drink before you get to table C. If you mapped the tables to be vertices in an unweighted graph G = (V, E). Describe an efficient algorithm that would determine an optimal A-C path given your preference for stopping at B and having the shortest path.



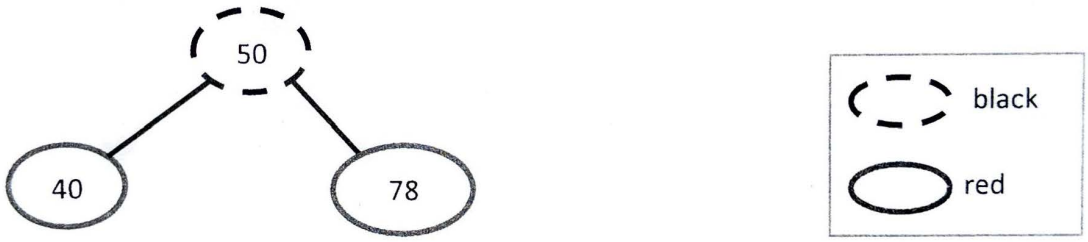
3. [4 points] Find the minimum spanning tree using Kruskal's algorithm



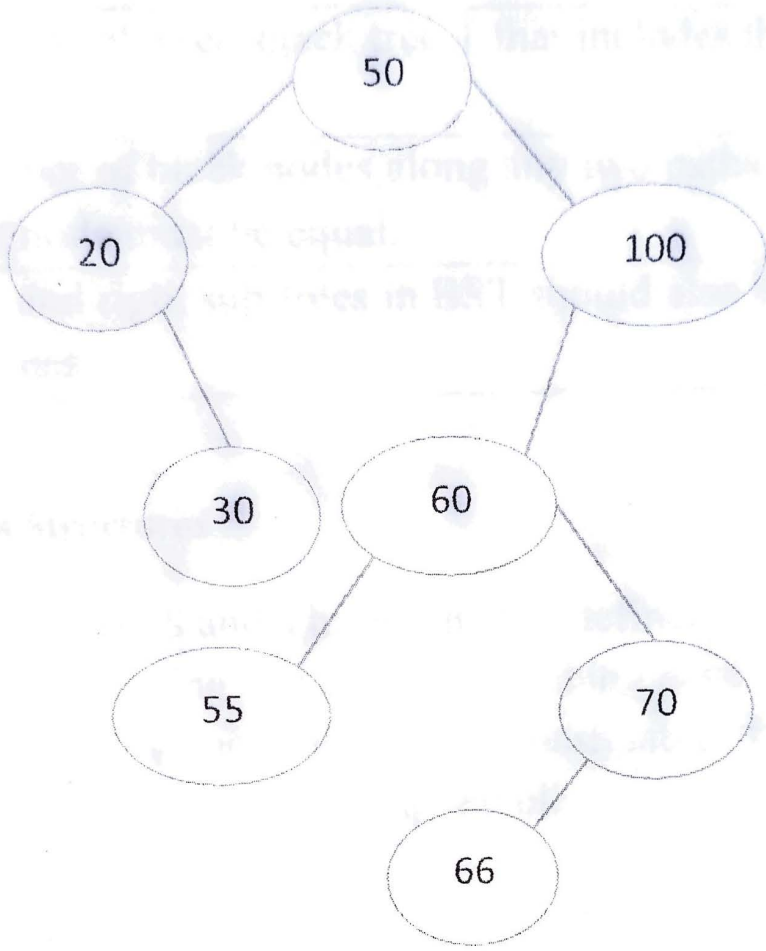
4. [2 point] A given undirected positive weighted graph G has minimum spanning tree T. If the weights of all edges in G are increased by a constant number, would T still be a minimum spanning tree. Justify your answer.

Q3) [9 points] Trees

1. [4 points] Given the following red black tree, insert 47 and 48 to the tree and show all steps.



2. [2 points] Given the following BST. Delete 50



3. [3 point] Answer with (True/ False)

| # | Statement | True/False |
|---|---|---|
| 1 | Any subtree of a red-black tree T that includes the root of T is red-black. | |
| 2 | The number of black nodes along any two paths from root to any null node must be equal. | |
| 3 | The left and right sub-trees in BST should also be binary search trees. | |

**Q4) [6 points] Data Structures**

Given a hashtable of size 8 and a hash function defined by H(x) = x mod tablesize. Assume that open addressing and quadratic probing have been used as a strategy to resolve collisions. What values will be in the hash table after the following sequence of insertions, starting from an initially empty table.

Hint: $H_i(x) = [H(x) + i^2]$ % tablesize

10, 26, 96, 12, 50

a. [2 points] Fill in the values the table below.
b. [3 points] Show your work for each value.
c. [1 points] Calculate the load factor for this table?

| | |
|---|---|
| 0 | |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |

**Q5) (6 points) SCI Question:**

Write a short essay that connects one of the studied topics to the Science of Creative Intelligence (SCI). You can pick any topic.