Family Name:..... **Other Names:** .....

Student ID:..... **Signature**.....

COMP 261 : Test 2

6 April 2023,

Instructions

- Time allowed: **50 minutes**
- Attempt **all** the questions. There are 50 marks in total.
- **In-person**: Write your answers in this test paper and hand in all sheets.
  Remote: Type your answers in the template file and submit to "Test 1 Remote" on the COMP 261 submission system.
- If you think a question is unclear, ask for clarification.
- This test contributes 10% of your final grade.
- You may use dictionaries and calculators.
- You may write notes and working on this paper, but make sure your answers are clear.

Questions	**Marks**	
1. Regular Expressions	[10]	
2. Adjacency Matrix Data Structures	[6]	
3. Adjacency List Data Structures	[9]	
4. Shortest Paths.	[10]	
5. Connected Components.	[10]	
6. A$*$ Search	[5]	
	TOTAL:	

Question 1. Regular Expressions. **[10 marks]**

(See the reference table below)

(a) **[3 marks]** Carefully circle or underline all the sections of the following text that are matched by the regular expression:

```
t[a-z]*t
```

```
this is text with twenty words with lots of tee.
the pattern to the question is often totally different.
```

(b) **[3 marks]** Carefully circle or underline all the sections of the following text that are matched by the regular expression:

```
catch\s((this|that)\s(cat|dog)\s)*
```

```
don't catch this cat that dog this dog for me.
catch this that cat dog cat cat.
this cat catch that cat this dog; now catch thisthat catdog for you.
```

Reference table for Regular expression symbols:

|	or
*	0 or more times
+	1 or more times
?	optional (0 or 1 time)
[...]	set of characters (can use - for a range)
(...)	grouping (for | or for repetition)
\s	space
\d	any digit
\w	any word character (letter or digit)
\b	a word boundary

(Question 1 continued on next page)

(Question 1 continued)

(c) **[4 marks]**

Write a regular expression that would match simple variable declarations that have an initialisation in Java programs: a type, a variable, and an = sign.

For example, it should match the underlined sections in the following lines of code, but not any other parts.

```
int size = 15;
size = area * height;
Edge edge=fringe.poll();
Stop firstStop;
(int param1, int param2)
Stop  stop1 =stop.neighbours().get(0);
Cat6Cable cable = cables.pop();
Train lastTrain  = station.getLastTrain();
```

Note:

- The regexp does **not** have to match variables whose type is an array or a collection type with type parameters.
- Take note of spaces.
- Assume that identifiers (types and variables) may only contain letters and digits and must not start with a digit.

Question 2. Adjacency Matrix Data Structures for Graphs. **[6 marks]**

Consider the following adjacency matrix data structure to represent an **undirected** graph with a length associated with each edge.

The value in edges[j][k] represents the length of the edge from node j to node k, or -1 to indicate there is no edge from node j to node k.

```
public class Graph {
   private String[ ] nodeNames;        // names of the nodes
   private double[ ][ ] edges;          // adjacency matrix of edge lengths
```

(a) **[2 marks]** Assume there are N nodes in the graph and at most Δ edges out of each node. What is the Big-O cost of finding the closest neighbour of node j? (ie, the node with the shortest edge from node j.)

$O(\quad)$

(b) **[4 marks]** Complete the following method that would count and return the number of neighbours of node fromIndex.

Hint: the number of columns in the fromIndex row of edges is edges[fromIndex].length.

```
public int countOutEdges (int fromIndex){
    int count = 0;









    return count;
}
```

Question 3. Adjacency List Data Structures for Graphs. **[9 marks]**

Consider the following adjacency list data structure to represent a simple, **directed** graph with a length associated with each edge.

```
public class Graph{
   private String[ ] nodeNames;
   private List<Edge>[ ] outEdges;    // outEdges[indx] is a list of the edges from node indx
```

Edge objects have three methods:

```
   public int from();          // returns the index of the node at the start of the edge
   public int to();            // returns the index of the node at the end of the edge
   public double length();     // returns the length of the edge
```

(a) **[2 marks]** Assume there are N nodes in the graph and at most Δ edges out of each node. What is the Big-O cost of finding the shortest edge out of a given node?

O( )

(b) **[3 marks]** Complete countOutEdges(...) to return the number of out-edges from node fromIndex

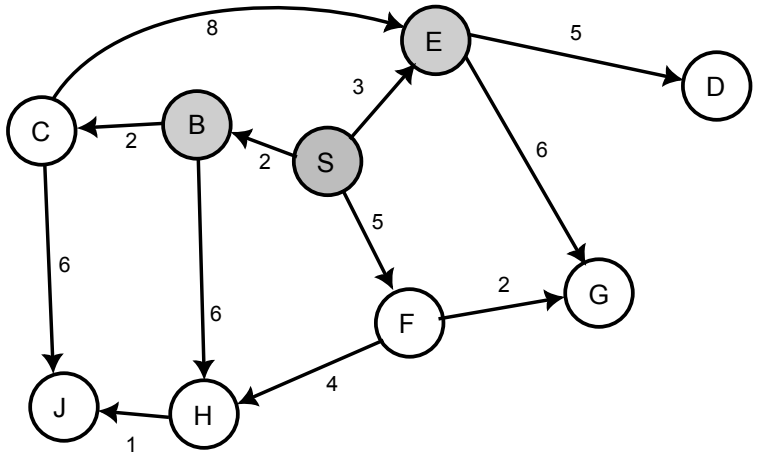
```
public int countOutEdges (int fromIndex){




}
```

(c) **[4 marks]** Complete countInEdges(...) to return the number of edges from other nodes to node toIndex.

```
public int countInEdges (int toIndex){
    int count = 0;









    return count;
}
```

Question 4. Shortest Paths. **[10 marks]**

Suppose we are using Djikstra's algorithm to search for the shortest path from node S to node G in the graph below. The fringe is a priority queue of $\langle node, edge, pathlength \rangle$ items, ordered by *pathlength*.



After three iterations of the **while** loop:

- The algorithm will have visited three nodes **S**, **B** and **E**;
- The fringe will contain five items:

  ⟨F, S-F, 5⟩, ⟨H, B-H, 8⟩, ⟨C, B-C, 4⟩, ⟨D, E-D, 8⟩, ⟨G, E-G, 9⟩
- The backpointers Map will contain two items

  ⟨B → S-B⟩, ⟨E → S-E⟩

```
DjikstrasShortestPath ( start , goal ):
    fringe ← PriorityQueue of ⟨node, edge, length−to−node⟩
    backpointers ← Map of nodes to edges
    put ⟨ start , null , 0⟩ on the fringe .
    while fringe is not empty:
        ⟨node, edge, length−to−node⟩ ← remove from fringe
        if node is not visited :
            visit node
            put ⟨node, edge⟩ into backpointers
            if node=goal:
                return ReconstructPath(start , goal , backpointers)
            for each edge out of node to a neighbour:
                if neighbour is not visited :
                    length−to−neighbour ← length−to−node + edge.length
                    add ⟨neighbour, edge, length−to−neighbour⟩ to fringe
```

(Question 4 continued on next page)

(Question 4 continued)

Show what the algorithm will do on each of the next three iterations:

- which node it will visit
- what will be added to the Backpointers
- what items will be added to the fringe

Show the shortest path that it finds.

Iteration 4:

Node visited:

Additions to Backpointers Map:

Additions to fringe:

Iteration 5:

Node visited:

Additions to Backpointers Map:

Additions to fringe:

Iteration 6:

Node visited:

Additions to Backpointers Map:

Additions to fringe:

Shortest Path:

Question 5. Connected Components. **[10 marks]**

The following findComponents() method finds all the connected components in an **undirected** graph, labeling each node with the number of its component. It uses the visitComponent(...) method to label all the nodes connected to a given node.

Complete visitComponent(...) to do a recursive depth first traversal from the given node, labeling the connected nodes with the given component number.

Note:

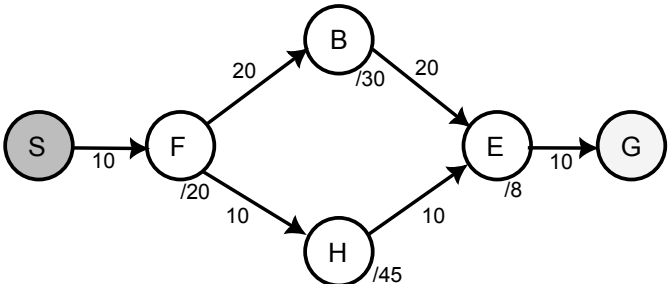
- You may assume that all nodes initially have a component number of -1;
- The relevant fields and methods of the Graph and Node classes are given at the bottom.
- You may (but do not have to) use the component number of the nodes to record whether a node has been visited.

```
public void findComponents(){
    int comptNum = 0;
    for (Node node : nodes){
        if (node.getCompt()== −1){
            visitComponent(node, comptNum);
            comptNum++;
        }
    }
}
public void visitComponent(Node node, int comptNum){









}
```

```
public class Graph {
    private Collection<Node> nodes;
    :
    public void findComponents(){...}
}

public class Node {
    private String name;
    private List<Node> neighbours;  // neighour nodes, connected to this node by an edge
    private int component = −1;     // the number of the component it belongs to

    public List<Node> getNeighbours(){ return Collections.unmodifiableList(neighbours); }
    public int getCompt(){ return component; }
    public void setCompt(int c){ component = c; }
}
```

Question 6. A∗ Search. **[5 marks]**

To be admissable, an estimate of the remaining path length must not be an overestimate. Explain why admissability is important for A* search using the following example graph. Note that an estimate of the remaining distance to the goal node is shown beside each node.



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SPARE PAGE FOR EXTRA ANSWERS

Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.