<u>Assignment-3</u>

(Total Points: 70)

Instructions:

- Download the attached python file assignment_3.py (make sure to **NOT** change the name of this file).
- Follow the instructions and **<u>replace</u>** all TODO comments in the scaffolding code.
- Test your code as much as you can to make certain it is correct.
- Run flake8 in addition to testing your code; I expect professional and clear code with minimal flake8 warnings and having McCabe complexity (<10) from all of you.
- Create a write up with formatted code and screenshots of your output, running the McCabe complexity command and error free console.
- Save the write-up as a PDF and submit it along with your python code (file name assignment_3.py) as separate attachments before the due date on blackboard.

  <u>Note: Running flake 8</u>
  flake8 path/to/your/file (for warnings and errors)
  flake8 --max-complexity 10 path/to/your/file (for complexity)

Problem 1 (Max points 10):

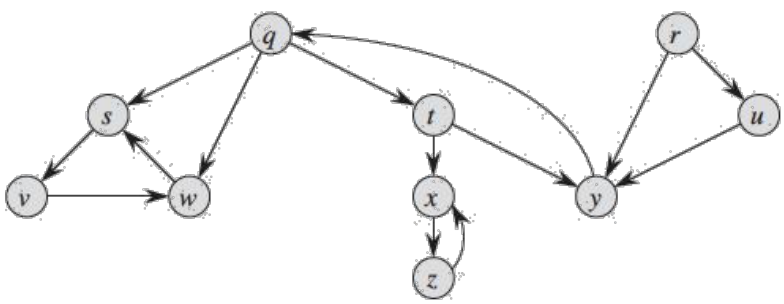
Part A In your program.
Given an adjacency-matrix representation of a directed graph, implement the '**in_degree**', and '**out_degree**' method in the scaffolding code. You must invoke the '**print_degree**' to output the degree in a certain format, so the grading script can judge the correctness of your answer.
Part B In your write-up.
How long does it take (in big-O notation) to compute the out-degree of every vertex? How long does it take (in big-O notation) to compute the in-degrees? Justify your answer with proper reasoning.

Problem 2 (Max points 10):

The transpose of a directed graph $G = (V, E)$ is the graph $G^T = (V, E^T)$, where $E^T = \{(v,u) \mid (u,v) \in E\}$. Thus, G^T is G with all its edges reversed. Implement an efficient algorithm for '**transpose**' method in the scaffolding code for computing G^T from G, for the adjacency-matrix representation of G. Provide the running time of your algorithms in big-O notation.

Problem 3 (Max points 10):

Part A In your code
Show how depth-first search works on the graph below by implementing the '**dfs_on_graph**' method in the scaffolding code. Assume that the vertices are explored in alphabetical order (at any point of time if it has to be chosen between q and r, then q will be explored before r), and that each vertex in the adjacency matrix is ordered alphabetically. Print the discovery and finishing times for each vertex using '**print_discover_and_finish_time**' method.
Part B In your write-up
Show the classification of each edge in your write-up (Tree/Forward/Back/Cross).



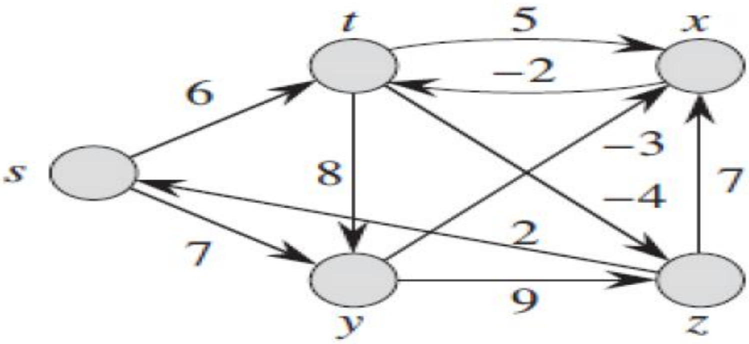
Problem 4 (Max points 10):

Suppose that we represent the graph G = (V, E) as an adjacency matrix. Give a simple (using linear search) implementation of Prim's algorithm ($O(V^2)$ time) by implementing the '**prim**' method in the scaffolding code.

Problem 5 (Max points 15):

Implement '**bellman_ford**' method in the scaffolding code and run the Bellman-Ford algorithm on the directed graph given below, using vertex z as the source. In each pass, relax edges in the order (t,x),(t,y),(t,z),(x,t),(y,x),(y,z),(z,x),(z,s),(s,t),(s,y) and invoke '**print_d_and_pi**' method to print out the d and π values after each pass. (For reference: if (u,v) is an edge which is relaxed in the pass , then v. = u)

Now, change the weight of edge (z,x) to 4 and run the algorithm again, using s as the source.



Problem 6 (Max points 15):

Dijkstra Algorithm

```
DIJKSTRA(G, w, s)
  INITIALIZE-SINGLE-SOURCE(G, s)
  S = ∅
  Q = G.V
  while Q ≠ ∅
      u = EXTRACT-MIN(Q)
      S = S ∪ {u}
      for each vertex v ∈ G.Adj[u]
          RELAX(u, v, w)
```

Implement the '**dijkstra**' method in the scaffolding code and run Dijkstra's algorithm on the directed graph given below, using vertex s as the source. Invoke '**print_d_and_pi**' method to print out the d and π values and the vertices in set S after each iteration of the while loop in the algorithm given above.