United International University (UIU)

Dept. of Computer Science & Engineering (CSE)

Final Exam Total Marks: **40** Spring 2021

Course Code: CSI 227 Course Title: Data Structure and Algorithms II

Time: *1 hour 30 minutes* for answering. *Another 15 minutes* for download and upload.

Any examinee found adopting unfair means will be expelled from the trimester / program as per UIU disciplinary rules.

There are **FOUR questions**. **Answer all of them**. Figures in the right-hand margin indicate full marks.

1 Run **Algorithm 1** on the graph of **Figure 1** to find the MST where $r = v_s$. [The values of s, x, y, z are given in Figure 1] **[6+3]**

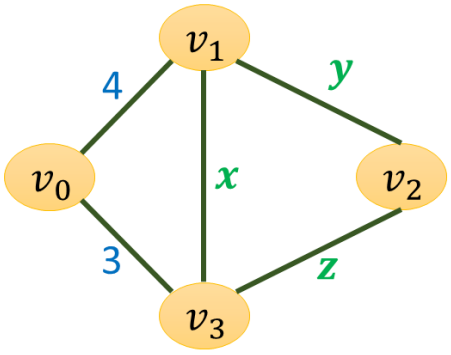
(a) Show the output of the algorithm (Notice the line 8 and 13 of **Algorithm 1**) and clearly write the edges of the MST found through this Algorithm.

(b) Analyze the runtime of Algorithm 1 assuming Q is a binary min heap.

```
MST-Prim(G, w, r)
1.    Q = V[G];
2.    for each u ∈ Q
3.        key[u] = ∞;
4.    key[r] = 0;
5.    p[r] = NULL;
6.    while (Q not empty)
7.        u = ExtractMin(Q);
8.        print(u, key[u], p[u])
9.        for each v ∈ Adj[u]
10.           if (v ∈ Q and w(u,v) < key[v])
11.               p[v] = u;
12.               key[v] = w(u,v);
13.               print(v, key[v], p[v])
```

Algorithm 1

s = your student id **mod** 4
x = (your student id **mod** 4) + 1
y = (your student id **mod** 3) + 1
z = (your student id **mod** 5) + 1



Graph $G(V, E)$

Figure 1

2 **(a)** *Problem X*: Find the average of n integers. Does the *Problem X* belong to the class NP? Explain your answer briefly. **[3]**

(b) Provide a pseudocode for function PRINT-SET(x), where for a given a node x, this function prints all the members of x's set. Assume that you have other Disjoint-Set operations (MAKE-SET, FIND-SET, UNION) at your disposal. **[3]**

(c) A disjoint set forest is given in **Figure 2**. Draw the resultant disjoint set after performing **UNION(7, 8)** following **Algorithm 2** on the given forest. **[5]**

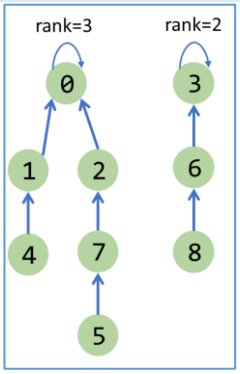


Figure 2

UNION(x, y)
1. **LINK**(FIND-SET(x), FIND-SET(y))

LINK(x, y)
1. **if** $rank[x] > rank[y]$
2. **then** $p[y] \leftarrow x$
3. **else** $p[x] \leftarrow y$
4. **if** $rank[x] = rank[y]$
5. **then** $rank[y]$++

FIND-SET(x)
1. **if** $x \neq p[x]$
2. **then** $p[x] \leftarrow$**FIND-SET**($p[x]$)
3. **return** $p[x]$

Algorithm 2

3 **(a)** Following is a directed weighted graph in adjacency matrix representation (**Figure 3**). Draw the graph. **[2]**

	A	B	C	D
A	0	4	5	0
B	0	0	x	0
C	0	0	0	y
D	0	-10	0	0

Where x = (your student id mod 6) +1
and y = (your student id mod 8) +1

Figure 3

(b) Which single source shortest path algorithm is suitable for the graph in 3(a) and why? Apply the algorithm to find the shortest path distance from A to all other vertices. Show each step of your shortest path distance calculation. **[5]**

(c) What is a negative cycle in a directed graph? Does the graph in 3(a) have one? How can you confirm it? **[3]**

4 **(a)** Draw the 11-item hash table that results from using the hash function $h(k,i) = (h'(k) + 2i^2)$ ***mod*** 11, where $h'(k) = k$ ***mod*** 11, to hash the keys **17**, **14**, **28**, **39**, and **6**. Assume that collisions are handled by open addressing. What kind of clustering did you encounter? **[5]**

(b) Consider the following text T = "237395" and pattern P = "739". Suppose that the alphabet consists of just the $d = 10$ digits {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}. Using ***modulo*** $q = 13$, find out with detail steps the valid matches and spurious hits using the **Rabin-Karp** algorithm. **[5]**