Solution for Assignment 3:

COMP-352

by

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Question 1:

a) Content of the array of 13 elements (each index represents a linked list):
`[[65], [105], [28, 223], [185, 120], [225, 69], [70, 122, 18, 44], null, [85, 111, 59], [177], [256], [10, 49, 140], [245, 180], [12]]`

b) 11 collisions

Question 2:

a) `[19, 58, null, null, 62, 24, null, null, null, 28, null, 36, null, 47, null, null, null, 17, 37]`

b) 3

c) 6 total collisions

d) $\frac{9\ entries}{19\ size} = 0.47$ is the load factor

Question 3:

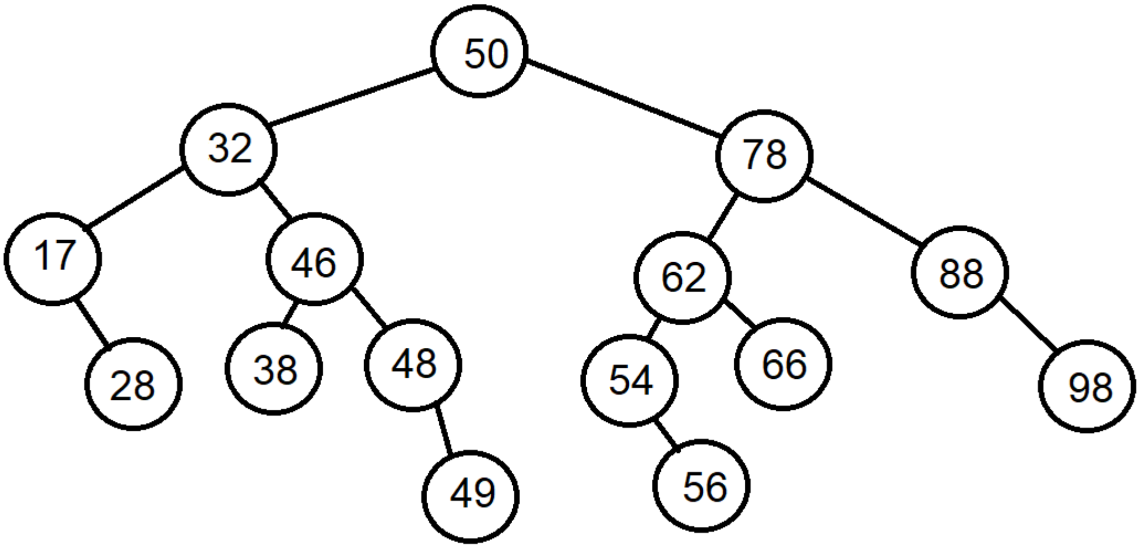
a) [null, 36, 58, null, null, null, null, null, null, 47, null, null, null, null, null, null, null, 17, 37]

b) 2. $O(n)$

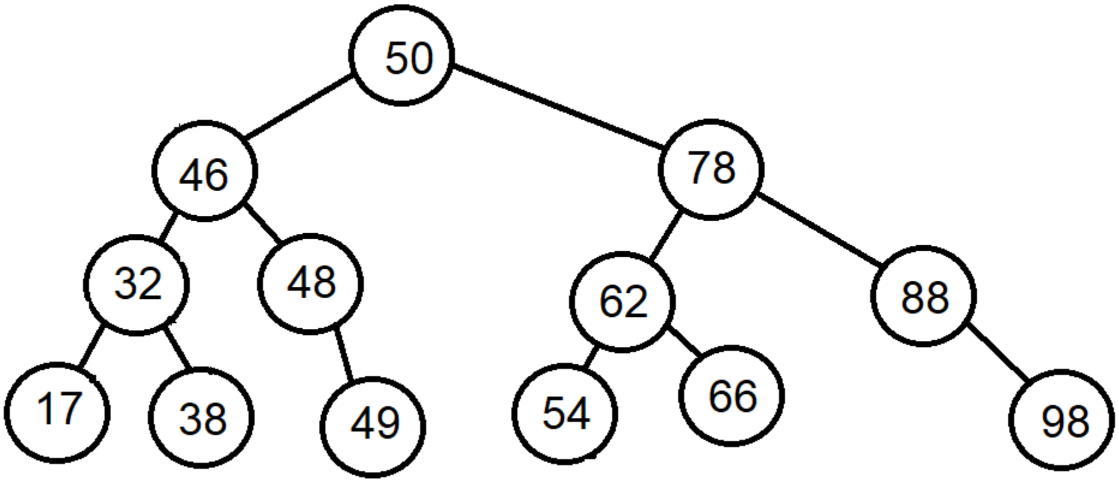
c) 3 collisions

Question 4:

a) After inserting 56



b) After removing 28 to the initial tree



Question 5:

a) Merge sort

First the array is divided as follows:

```
[4, 12, 19, 26, 47, 53, 63, 74, 89]   [8, 15, 17, 50, 71, 82, 87,
93]
[12, 19, 47, 74, 89]  [4, 26, 53, 63]
[8, 15, 71, 93] [17, 50, 82, 87]
[12, 47, 74]    [19, 89]
[50, 87]   [17, 82]   [4, 63]    [26, 53]   [8, 93]    [15, 71]
[12, 47]   [74]
[12]  [47] [19]  [89] [26]  [53] [71]  [15] [87]  [50] [17]  [82]
[4]   [63] [8]   [93]
```

Now the array is merged and sorted.

```
[4, 63]
[8, 93]
[12, 47]
[19, 89]
[26, 53]
[15, 71]
[50, 87]
[17, 82]
[12, 47, 74]
[4, 26, 53, 63]
[8, 15, 71, 93]
[17, 50, 82, 87]
[12, 19, 47, 74, 89]
[8, 15, 17, 50, 71, 82, 87, 93]
```

```
[4, 12, 19, 26, 47, 53, 63, 74, 89]
[4, 8, 12, 15, 17, 19, 26, 47, 50, 53, 63, 71, 74, 82, 87, 89, 93]
```

b) Quick sort:

```
Pivot: 82. Start: 0. End: 16
[12, 47, 74, 19, 4, 63, 26, 53, 8, 71, 15, 50, 17, 82, 89, 93, 87]

Pivot: 93. Start: 0. End: 15
[12, 47, 74, 19, 4, 63, 26, 53, 8, 71, 15, 50, 17, 82, 89, 93, 87]

Pivot: 89. Start: 0. End: 14
[12, 47, 74, 19, 4, 63, 26, 53, 8, 71, 15, 50, 17, 82, 89, 93, 87]

Pivot: 82. Start: 0. End: 13
[12, 47, 74, 19, 4, 63, 26, 53, 8, 71, 15, 50, 17, 82, 89, 93, 87]

Pivot: 17. Start: 0. End: 12
[12, 4, 8, 15, 17, 63, 26, 53, 74, 71, 19, 50, 47, 82, 89, 93, 87]

Pivot: 50. Start: 0. End: 11
[12, 4, 8, 15, 17, 26, 19, 50, 74, 71, 63, 53, 47, 82, 89, 93, 87]

Pivot: 63. Start: 0. End: 10
[12, 4, 8, 15, 17, 26, 19, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 71. Start: 0. End: 9
[12, 4, 8, 15, 17, 26, 19, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 63. Start: 0. End: 8
[12, 4, 8, 15, 17, 26, 19, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 50. Start: 0. End: 7
[12, 4, 8, 15, 17, 26, 19, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 19. Start: 0. End: 6
[12, 4, 8, 15, 17, 19, 26, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 19. Start: 0. End: 5
[12, 4, 8, 15, 17, 19, 26, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 17. Start: 0. End: 4
[12, 4, 8, 15, 17, 19, 26, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 15. Start: 0. End: 3
[12, 4, 8, 15, 17, 19, 26, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]
```

```
Pivot: 8. Start: 0. End: 2
[4, 8, 12, 15, 17, 19, 26, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Pivot: 8. Start: 0. End: 1
[4, 8, 12, 15, 17, 19, 26, 50, 63, 71, 74, 53, 47, 82, 89, 93, 87]

Final:
[4, 8, 12, 15, 17, 19, 26, 47, 50, 53, 63, 71, 74, 82, 87, 89, 93]
```

c) Bucket sort

We put data in 10 buckets. Because we know the range, we can use the following “hash” function to distribute the values: $\frac{\text{Number}}{\text{bucketSize}}$

```
[4, 8]
[12, 19, 15, 17]
[26]
[]
[47]
[53, 50]
[63]
[74, 71]
[89, 87, 82]
[93]
```

Now we merge the buckets after sorting each one individually and we get the sorted array.

d) Radix sort

Original array:

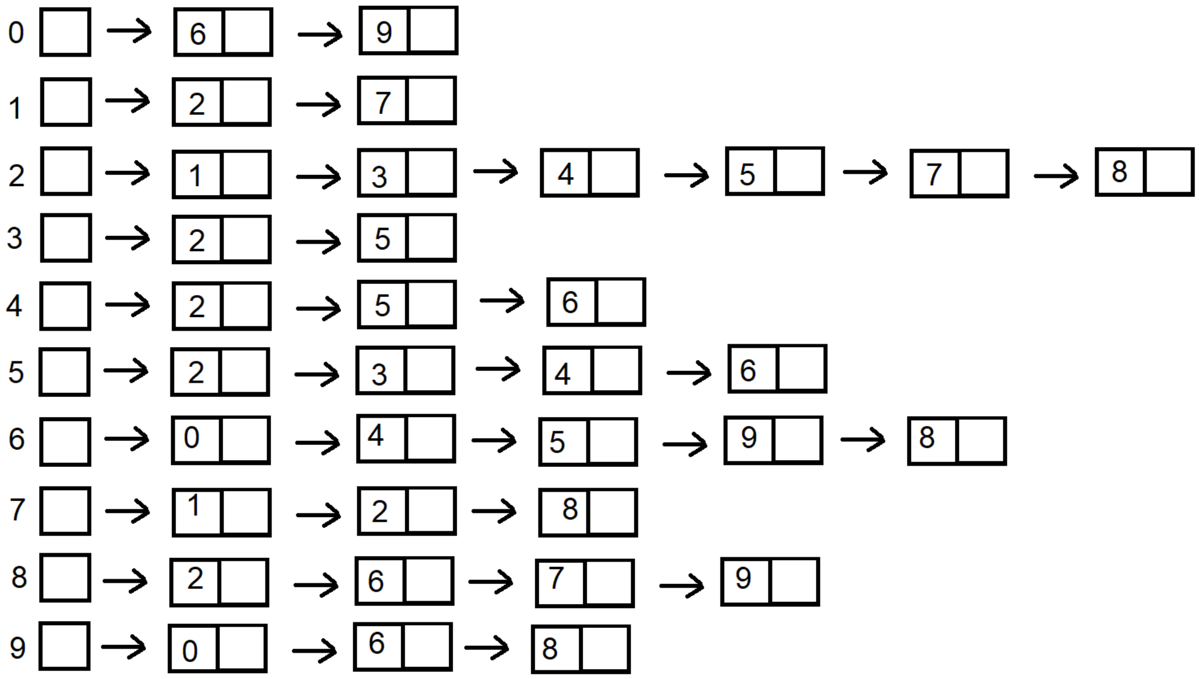
```
[12, 47, 74, 19, 89, 4, 63, 26, 53, 8, 93, 71, 15, 87, 50, 17, 82]

Using the first digit
[50, 71, 12, 82, 63, 53, 93, 74, 4, 15, 26, 47, 87, 17, 8, 19, 89]

Using the second digit
[4, 8, 12, 15, 17, 19, 26, 47, 50, 53, 63, 71, 74, 82, 87, 89, 93]
```

Question 6:

1. Matrix representation (empty squares are 0):

	0	1	2	3	4	5	6	7	8	9
0							1			1
1			1					1		
2		1		1	1	1		1	1	
3			1			1				
4			1			1	1			
5			1	1	1		1			
6	1				1	1			1	1
7		1	1						1	
8			1				1	1		1
9	1						1		1	

2. List representation (with linkedlist):



3. Using breadth-first tree starting at 0:

   Trace (This is the content of the queue):

   ```
   [0]
   [6, 9]
   [9, 4, 5, 8]
   [4, 5, 8]
   [5, 8, 2]
   [8, 2, 3]
   [2, 3, 7]
   [3, 7, 1]
   [7, 1]
   [1]
   ```

   ```
   Output: 0 6 9 4 5 8 2 3 7 1
   ```

4. Using depth-first search tree (also starting at 0):
   The number to the left is the head of the stack **that is not visited** (the element that will be popped in the current iteration). The elements inside [] are the reset of the stack.

   ```
   []
   0 [6]
   9 [6, 0, 6]
   8 [6, 0, 6, 2, 6]
   7 [6, 0, 6, 2, 6, 1]
   2 [6, 0, 6, 2, 6, 1, 1, 3, 4]
   5 [6, 0, 6, 2, 6, 1, 1, 3, 4, 2, 3, 4]
   6 [6, 0, 6, 2, 6, 1, 1, 3, 4, 2, 3, 4, 0]
   4 [6, 0, 6, 2, 6, 1, 1, 3, 4, 2]
   3 [6, 0, 6, 2, 6, 1]
   1
   ```

   ```
   Output: 0 9 8 7 2 5 6 4 3 1
   ```

Question 7:

In order to get these answers, I have implemented the Dijkstra’s Algorithm’s pseudo code in java and ran it on the provided graph.

Source	Destination	Distance
H	A	2
H	G	2
H	I	1
H	B	8
H	F	3
H	E	6
H	J	3
H	D	6
H	C	11

Here is the code I used:

```java
public static Map<WUGraph.Vertex, Integer> dijkstraAlgorithm(WUGraph
graph, WUGraph.Vertex vertex) {

   Map<WUGraph.Vertex, Integer> D = new HashMap<>();
   for (var v : graph.getVertices()) {
      D.put(v, Integer.MAX_VALUE);
   }
   D.put(vertex, 0);

   PriorityQueue<WUGraph.Vertex> Q = new PriorityQueue<>(((o1, o2) ->
o1.getLabel().compareTo(o2.getLabel())));

   while (!Q.isEmpty()) {
      var u = Q.poll();
      for (var v : u.getAdjVertecies(Q)) {
         if (D.get(u) + u.getWeightTo(v) < D.get(v)) {
            D.put(v, D.get(u) + u.getWeightTo(v));
         }
      }
   }

   return D;
}
```