

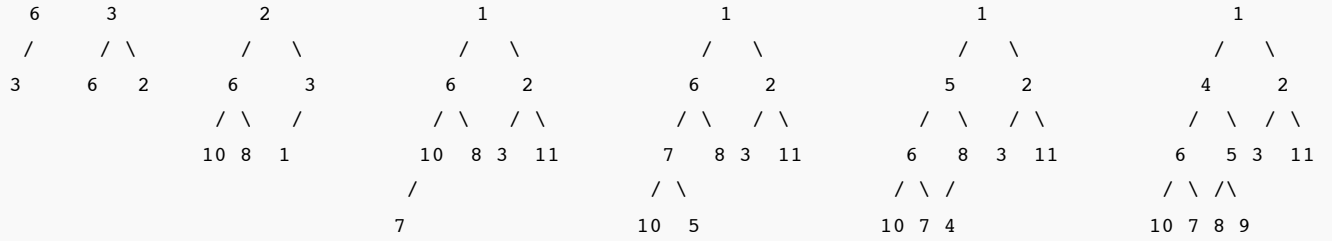
## CSE 373, Winter 2011 Final Key

### 1. Sorting (15 Points)

Part	Answer
a	<pre> {6, 7, 4, 8, 11, 1, 10, 3, 5, 9} 0 {1, 7, 4, 8, 11, 6, 10, 3, 5, 9} 1 {1, 3, 4, 8, 11, 6, 10, 7, 5, 9} 2 {1, 3, 4, 8, 11, 6, 10, 7, 5, 9} 3 {1, 3, 4, 5, 11, 6, 10, 7, 8, 9} 4 {1, 3, 4, 5, 6, 11, 10, 7, 8, 9} 5 </pre>
b	<pre> {6, 7, 4, 8, 11, 1, 10, 3, 5, 9}  initial {9, 7, 4, 8, 11, 1, 10, 3, 5, 6}  swap pivot to end {9, 7, 4, 8, 11, 1, 10, 3, 5, 6}   ^                               ^ {5, 7, 4, 8, 11, 1, 10, 3, 9, 6}   ^                               ^ {5, 3, 4, 8, 11, 1, 10, 7, 9, 6}   ^           ^ {5, 3, 4, 1, 11, 8, 10, 7, 9, 6}   ^^ {5, 3, 4, 1, 6, 8, 10, 7, 9, 11}  swap pivot back; end of initial partition {5, 3, 4, 1}    {8, 10, 7, 9, 11} {1, 3, 4, 5}    {11, 10, 7, 9, 8}  swap pivots to end   ^^           ^           ^                 {7, 10, 11, 9, 8}                   ^^ {1, 3, 4, 5}    {7, 8, 11, 9, 10} {1, 3, 4, 5, 6, 7, 8, 11, 9, 10}  overall </pre>

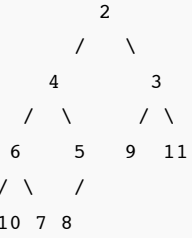
## 2. AVL Trees and Heaps (15 Points)

Part	Answer
a	<pre>       6      3          3          6      /      / \      / \      / \     3      2  6     2  8     3   8    /          \    /  / \    / \ / \   2            10  1  6  10  2  5  7 10                 / \  \    /  /  / \                 8   5  7  11 1  4  9 11                     /                     4 </pre> <p>                     imbalance at 6 (case 1): Right rotation                      imbalance at 6 (case (3): Right-Left rotation                      imbalance at 3 (case 3): Right-left rotation                 </p>



bubble up 3 to 6; bubble up 2 to 3; bubble up 1 to 2; bubble up 7 to 10; bubble up 5 to 6;  
 bubble up 4 to 5

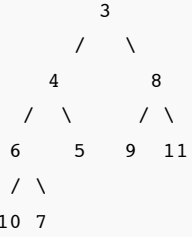
remove 1:



bubble down 9 with 2; bubble down 9 with 3

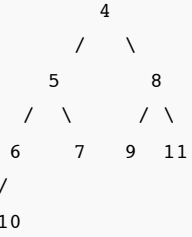
b

remove 2:



bubble down 8 with 3

remove 3:



bubble down 7 with 4; bubble down 7 with 5

### 3. Hashing (12 Points)

Initial hash table just before rehashing occurs:

	key		value	
	+-----+-----+			
0				
	+-----+-----+			
1				
	+-----+-----+			
2		7	Jessica	
	+-----+-----+			
3		17	Ryan	
	+-----+-----+			
4		34	Tyler	
	+-----+-----+			

Final state of the hash table:

	key		value	
	+-----+-----+			
0				
	+-----+-----+			
1				
	+-----+-----+			
2				
	+-----+-----+			
3		33	Kona	
	+-----+-----+			
4		R	R	
	+-----+-----+			
5		15	Daisy	
	+-----+-----+			
6		R	R	
	+-----+-----+			
7		7	Meghan	
	+-----+-----+			
8		6	Tina	
	+-----+-----+			
9				
	+-----+-----+			

size: 4

capacity: 10

load factor: .4

```
map.put(7, "Jessica")    --- AFTER: loadFactor = 1/5
map.put(34, "Tyler")    --- AFTER: loadFactor = 2/5
map.put(17, "Ryan")     --- DURING: collision with 7; AFTER: loadFactor = 3/5
map.put(15, "Tina")     --- BEFORE: loadFactor > 0.5; DURING: REHASH! (collision on 17); AFTER loadFactor
= 4/10
map.put(84, "Saptarshi") --- DURING: collision with 4 and 5; AFTER: loadFactor = 5/10
remove(34)              --- AFTER: loadFactor = 4/10
map.put(7, "Meghan")    --- DURING: the key 7 is already in the table, so value "Jessica" gets
overwritten; AFTER: loadFactor = 4/10
map.put(33, "Kona")     --- AFTER: loadFactor = 5/10
map.remove(17)          --- AFTER loadFactor = 4/10
map.put(6, "Tina")      --- DURING: collision with 84, 6; AFTER: loadFactor = 5/10
map.remove(84)          --- AFTER: loadFactor = 4/10
map.put(15, Daisy)     --- DURING: the key 15 is already in the table, so value "Tina" gets overwritten;
AFTER: loadFactor = 5/10
```

#### 4. HashSet Implementation (12 Points)

(a)

```
public void addAll(StringHashSet otherSet) {
    for (int i = 0; i < otherSet.table.length; i++) {
        StringHashSetEntry temp = otherSet.table[i];
        while (temp != null) {
            if (!this.contains(temp.data)) {
                this.add(temp.data);
            }
            temp = temp.next;
        }
    }
}
```

(b)  $O(N)$  based on the size of the "other" hash table

## 5. Graphs (12 points)

Part	Answer
a	directed
b	unweighted
c	unconnected (counterexample: Jennifer can't reach anybody) (Technically, the right way to describe a graph like this is "weakly connected" because the vertices are all touching, but not necessarily by edges in the right direction.)
d	cyclic (example cycle: Carmelita, Marty, Steve, Carmelita)
e	in-degree of Louann: 2 (from Donald, Carmelita); out-degree of Louann: 4 (to Isabelle, Kris, Marty, Moshe)

## 6. Minimum Spanning Trees (12 points)

Part	Answer
a	a, c, b, d, g, h, f, j, i, e - edges: AC = 1 AB = 6 BD = 3 BG = 10 GH = 8 HF = 4 GJ = 9 JI = 5 IE = 2
b	AC = 1 EI = 2 BD = 3 HF = 4 JI = 5 AB = 6 GH = 8 GJ = 9 BG = 10



## 7. Graph Implementation (12 points)

The first four solutions shown are correct solutions. The final two solutions shown were also graded as "correct" but do not always produce a correct answer.

```
// Solution 1: inexplicit base case
public int numReachable(V v, int steps) {
    this.clearVertexInfo();
    return this.numReachableHelper(v, steps);
}

private int numReachableHelper(V v, int steps) {
    int count = 0;
    if (!this.vertexInfo.get(v).visited) {
        this.vertexInfo.get(v).visited = true;
        count = 1;    // the vertex V itself
    }

    if (steps > 0) {    // recursive case
        for (V n : this.neighbors(v)) {
            count += this.numReachableHelper(n, steps - 1);
        }
    }

    return count;
}

// Solution 2: explicit base case
public int numReachable(V v, int steps) {
    this.clearVertexInfo();
    return this.numReachableHelper(v, steps);
}

private int numReachableHelper(V v, int steps) {
    if (steps == 0) {
        if (!this.vertexInfo.get(v).visited) {
            this.vertexInfo.get(v).visited = true;
            return 1;
        } else {
            return 0;
        }
    } else {
        int count;

        if (!this.vertexInfo.get(v).visited) {
            this.vertexInfo.get(v).visited = true;
            count = 1;
        } else {
            count = 0;
        }

        for (V n : this.neighbors(v)) {
            count += this.numReachableHelper(n, steps - 1);
        }

        return count;
    }
}
```

```

// Solution 3: using Set as a supporting data structure
public int numReachable(V v, int steps) {
    Set<V> visited = new HashSet<V>();
    visited.add(v);
    numReachable(v, steps, visited);
    return visited.size();
}

private void numReachable(V v, int steps, Set<V> visited) {
    if (steps > 0) {
        for (V n : neighbors(v)) {
            visited.add(n);
            numReachable(n, steps - 1, visited);
        }
    }
}

// Solution 4: counting visited solution
public int numReachable(V v, int steps) {
    this.clearVertexInfo();
    numReachableHelper(v, steps);
    int n = 0;
    for (VertexInfo<V> i : vertexInfo.values()) {
        if (i.visited) {
            n++;
        }
    }
    return n;
}

private void numReachableHelper(V v, int steps) {
    vertexInfo.get(v).visited = true;
    if (steps > 0) {
        for (V n : neighbors(v)) {
            numReachableHelper(n, steps - 1);
        }
    }
}

// Solution 5: Nearly correct solution, but stops short on neighbors of a
// visited vertex with that can be reached through multiple
// paths and a longer path is examined before a shorter one
public int numReachable(V v, int steps) {
    this.clearVertexInfo();
    return this.numReachableHelper(v, steps);
}

private int numReachableHelper(V v, int steps) {
    this.vertexInfo.get(v).visited = true;
    int count = 1;    // the vertex V itself

    if (steps > 0) { // recursive case
        for (V n : this.neighbors(v)) {
            if (!this.vertexInfo.get(n).visited) {
                count += this.numReachableHelper(n, steps - 1);
            }
        }
    }

    return count;
}

```

```

// Solution 6: Nearly correct solution, but stops short on neighbors of a
//           visited vertex with that can be reached through multiple
//           paths and a longer path is examined before a shorter one
public int numReachable(V v, int steps) {
    this.clearVertexInfo();
    return this.numReachableHelper(v, steps);
}

private int numReachableHelper(V v, int steps) {
    if (steps == 0 || this.vertexInfo.get(v).visited) {
        return 0; // base case
    } else {
        int count = 1; // the vertex V itself
        this.vertexInfo.get(v).visited = true;

        for (V n : this.neighbors(v)) {
            count += this.numReachableHelper(n, steps - 1);
        }

        return count;
    }
}

```

## 8. Disjoint Sets (10 points)

Part	Answer
a	<pre> initial disjoint set 0   1   2   3   4   5   6   7   8   9   10  11  12  after first for loop (i.e. union(0, 1), union(2, 3), union(4, 5), union(6, 7), union(8, 9), union(10, 11)): 0   2   4   6   8   10  12                       1   3   5   7   9   11  after second for loop (i.e. union(0, 2), union(4, 6), union(8, 10)):   0       4       8       12  / \     / \     / \ 1  2     5  6     9  10                      3       7       11  after union(9, 1):   0       4       12  /   \   /   \ 1  2  8  5  6    / \       3 9 10  7             11  after union(12, 6):   0       4  /   \   /   \ 1  2  8  5  6 12    / \       3 9 10  7             11 </pre>
b	<pre>       0       4  / /   \ \   /   \ 1  2  8 10 11  5  6 12                3  9       7 </pre>