Data Structures
CSCI C343, Fall 2017 **Pretest**

Name: _____

This test has 11 questions.

1. Fill in the implementation of the following `find_maximum` method in Java that finds the maximum element of the array `A` of integers. Recall that a maximum element is greater than or equal to every other element of the array. You may assume that the array has at least one element and that all the elements are greater or equal to zero.

```
static int find_maximum(int[] A) {
```

2. Fill in the implementation of the following `reverse` method in Java that reverses the characters in a contiguous subregion of an array. The first element of the subregion is at position `begin` and the last element of the region is at position `end - 1`. For example, given an array `A = 'a','b','c','d','e','f','g','h'` the call `reverse(A,2,6)` changes the array `A` to `'a','b','f','e','d','c','g','h'`. Your implemenation of `reverse` must be recursive, that is, it must call itself on a smaller part of the input.

```
static void reverse(char[] s, int begin, int end) {
```

3. What does the following method do when applied to the list of integers `1,2,3,4`?

```
static void f(List<Integer> list) {
    for (Integer i : list)
        if (i % 2 == 0)
            list.remove(i);
}
```

4. Design a class named `Bicycle` for computing the speed of a bicycle. The class should have a method named `speed` that has no arguments and returns a `double` that represents the current speed of the bicycle in miles per hour. You may assume that the speed of a bicycle is only dependent on the cadence (rotations per minute) and gear size (diameter in inches), so you may compute speed using the formula

$$speed = \frac{gearSize \times \pi}{12 \times 5,280} \times cadence \times 60$$

The gear size of a bicycle is fixed when it is created and cannot be changed, whereas the cadence can change. Add a method named `setCadence` that takes a `double` and changes the current cadence of the bicycle. Write code that creates a bicycle object, sets the cadence, and prints the current speed to standard output. Include in your Java code the appropriate access specifier (`public` or `private`) for the members of the `Bicycle` class.

5. Suppose you have just finished creating the following class. Write tests by creating a JUnit `TestCase` that achieves complete code coverage of the `Zombie` class.

```
class Zombie {
    public enum Direction { North, East, South, West };
    private int x, y;
    public Zombie() { x = 0; y = 0; }
    public void move(Direction d) {
        switch (d) {
            case North: x += 1; break;
            case East: y += 1; break;
            case South: x -= 1; break;
            case West: y -= 1; break;
        }
    }
    public int getX() { return x; }
    public int getY() { return y; }
}
```

6. Suppose the method `g` is defined as follows.

```
static void g(int x, Zombie z) {
   x = 5;
   z.move(Zombie.Direction.North);
}
```

What is the output of running the following code?

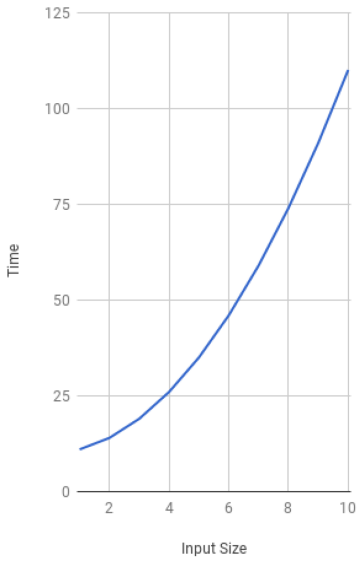
```
int a = 0;
Zombie z = new Zombie();
g(a, z);
System.out.println(a);
System.out.println(z.getX());
```

7. Given the following definition of a `Node` class, what is the output of the code below?

```
class Node {
    public Node(String name) { this.name = name; }
    public Node left;
    public Node right;
    public String name;
}

Node a = new Node("a");
Node b = new Node("b");
Node c = new Node("c");
a.left = b;
a.right = c;
b.left = c;
a.right.name = "d";
System.out.println(a.name);
System.out.println(a.left.name);
System.out.println(b.left.name);
```

8. What is the likely time complexity of an algorithm whose runtime with respect to input size is given by the following graph.



1. $O(\log n)$
2. $O(n)$
3. $O(n^2)$
4. $O(n^3)$
5. $O(2^n)$

9. Demonstrate that the function $f(n) = 3n^2 + n + 10$ is in $O(n^2)$.

10. What is the relationship between the number of nodes in a perfect binary tree and the height of the tree? Recall that the height of a tree is the length of the longest path from the root to a leaf. A perfect binary tree is a binary tree in which every non-leaf node has two children and all the leaves are at the same level. Prove by induction that the relationship you devise is correct for all perfect binary trees.

11. Suppose $A = \{1, 2, 3, 4\}$. Which of the following relations on A is reflexive? Which is symmetric? Which is transitive?

    1. $\{(1, 1), (2, 2), (3, 3), (4, 4)\}$
    2. $\{(1, 1), (1, 2), (2, 1)(2, 2), (2, 3), (3, 2)(3, 3), (3, 4)(4, 4), \}$
    3. $\{(1, 2), (1, 3), (1, 4)(2, 3), (2, 4), (3, 4)\}$