In this lab, we explore the semantics of objects in the context of Java. That is, we try to integrate the object—this programming entity with state and behavior—into our mental model of computation. By doing so, we can answer some critical questions about how programs with objects execute in certain unintuitive settings as well as explain some bits of Java syntax that we have glossed over until this point.

Please answer the following questions below in the space provided as we discuss them during class. These are all questions that have “obvious” book answers, but they require a bit of effort on your part to internalize what they mean with respect to your programs. Try to (a) answer the question in your own words and (b) give an example illustrating your answer, e.g., example code snippets demonstrating the differences between two different situations.

**Problem 1: Value versus Reference Semantics**  What is the difference in calling the following three change methods and why is this the case?

```java
// in Cell.java
public class Cell {
    public int x;
    public Cell(int x) { this.x = x; }
}

// In Program.java
public class Program {
    public void change1(int x) { x = 5; }
    public void change2(Cell c) { c.x = 5; }
    public void change3(Cell c) {
        c.x = 5;
        c = new Cell(0);
    }
}
```

What’s the rule here? Does java pass parameters by value (i.e., copy) or reference? Is passing an object (with an arbitrary number of fields) to a function more costly than passing a primitive?
Problem 2: The this Variable  What is the this variable in a method and where does it come from? How do these two code classes differ with respect to their increment methods?

// In Counter1.java
public class Counter1 {
    public int value;
    public void increment() {
        value += 1;
    }
}

// In Counter2.java
public class Counter2 {
    public int value;
    public void increment(int value) {
        value += value;
    }
}

What’s the rule for variable look-up in Java? How does this differ from regular, old function calls in C?
Problem 3: static Versus Non-static Members  What is the distinction between a static and non-static member (i.e., field or method)? In particular, what does this code do and why?

// In TestObject.java
public class TestObject {
    public static int value;
    public TestObject() { value += 1; }
}

And why does this code not work? How do you fix it? In general, what is the rule for mixing static and non-static things?

// In Test.java
public class Test {
    public void printGreeting() { System.out.println("Hello World!"); }
    public static void main(String[] args) { printGreeting(); }
}
Problem 4: Reference Versus Structural Equality  Does the following code snippet behave as you expect? Why? How do you fix its behavior?

```java
// In Counter.java
public class Counter {
    public int value;
    public Counter() { this.value = 0; }
    public void increment() { this.value += 1; }
    public static void main(String[] args) {
        Counter c1 = new Counter();
        Counter c2 = new Counter();
        System.out.println("Are c1 and c2 equal? "+ c1 == c2);
    }
}
```

With this in mind, does this code behave as you expect?

```java
String s1 = "hello";
String s2 = "hello";
System.out.println(s1 == s2);
```

How about this snippet? What’s the difference between these two snippets and why?

```java
Scanner in = new Scanner(System.in);
String s1 = in.readLine();
String s2 = in.readLine();
System.out.println(s1 == s2);
```