Name ____________________________________________________________

Do not start this quiz until you are told to do so!

Instructions

• You have 20 minutes for this quiz.
• This is a closed book exam. No notes or other aids are allowed.
• Answer essay questions concisely in 2-3 sentences. Longer answers are not needed.
• For partial credit, show all of your work and clearly indicate your answers.
• Write neatly. Credit cannot be given for illegible answers

1. (Multithreading, 10pts)
List all possible outputs from the following program. Indicate next to each possible output whether all threads complete at the end, or, if they do not, which threads remain blocked.

```java
l = new ReentrantLock();
c = l.newCondition()

Thread 1
l.lock();
System.out.print("a");
c.signalAll();
System.out.print("b");
c.await();
System.out.print("c");
l.unlock();

Thread 2
l.lock();
System.out.print("d");
c.await();
System.out.print("e");
c.signalAll();
System.out.print("f");
l.unlock();
```

2. **(Garbage Collection, 6pts)**
Consider the following Java code:

```java
class A {
    static Integer a, b, c, d;
    private void foo() {
        a = new Integer(1); // object 1
        b = new Integer(2); // object 2
        c = new Integer(3); // object 3
        c = a;
    }
}
```

What objects are garbage after `foo` returns? Explain your answer.

3. **(Function arguments, 4pts)**
What are upward and downward funargs? What is the main difference in their implementation?