WRITTEN TEST 2F

This is a 60 minute test. The test is closed book (no aids are allowed).

Written question instructions

- There are 8 short answer questions, each worth 2 marks.
- There are 3 questions that require students to explain their answers, each worth 8 marks.
- Answer the written questions in a text file named `answers.txt`—a suitable file should open in a text editor when the test starts. Feel free to use a different text editor if you wish.
- Make sure to save your work before submitting it! Every year a small number of students end up submitting an empty file because they forgot to save their work.
- You may submit your work as many times as you wish.
- A few minutes before the end of the test you will receive a warning that the test is ending soon. The message will repeat every minute until the end of the test. Use this time to submit your work; it is difficult to work effectively with the message popping up every minute.

Submission instructions

- Open a terminal (if one is not already open)
- Find the directory where you have saved your `answers.txt` file; the file should be in your home directory.
- Type the following command:

  ```
  submit 2030 test2F answers.txt
  ```

  and press enter.

1. [2 marks] What does the modifier `final` mean when applied to a field of a class?

Solution: The field can be assigned a value only once.

2. [2 marks] Consider the following class that represents a line segment connecting two points (its start point and its end point):

```
public final class LineSegment {
       private final Point2 start;
       private final Point2 end;

       public LineSegment(Point2 p1, Point2 p2) {
              this.start = new Point2(p1);
              this.end = new Point2(p2);
       }

       public Point2 getStart() {
              return new Point2(this.start);
       }

       public Point2 getStop() {
              return new Point2(this.stop);
       }
}
```

Which statement best describes the class `LineSegment`? Give your answer as A, B, C, or D.

A. `LineSegment` is an aggregation of two points

B. `LineSegment` is a composition of two points

C. `LineSegment` is mutable

D. `LineSegment` has a privacy leak

Solution: B

3. [2 marks] How could you use a Java `Map` to emulate the functionality of a Java `List<String>`? (In other words, what would the keys of the map represent and what would the values of the map represent?) Hopefully, you would never actually do this.

Solution: The keys would be the indices and the values would be strings.

4. [2 marks] What is a Java interface?

Solution: A set of method declarations (and their contracts).

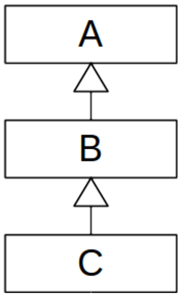
5. [2 marks] When a class has fields that are not of primitive type, we often need to consider using composition instead of aggregation. Why is composition often required instead of aggregation?

Solution: To maintain class invariants, or to prevent changes in state from outside of the class, or to prevent privacy leaks.

6. [2 marks] Is an overridden method also an overloaded method? Explain your answer using one sentence.

Solution: No, an overridden method has the same signature as the superclass method whereas overloaded methods have different signatures.

7. [2 marks] Consider the following inheritance hierarchy:



Which class or classes are substitutable for the class named `B`?

Solution: `B` and `C`

8. [2 marks] What should the first line of a subclass constructor do?

Solution: Call another constructor (often in the superclass).

9. Suppose that you have the following class:

```
public class Question {

        public static int a = 1;
        private static int b = 2;

        public double f;
        private double g;

        // constructors not shown

        public static void someMethod() {
                // implementation not shown
        }

        public static void someMethod(Question q) {
                // implementation not shown
        }

        public void anotherMethod(Question q) {
                // implementation not shown
        }
}
```

(a) [2 marks] What fields of `Question` can `someMethod()` use?

Solution: `someMethod` can only use the static fields (`a` and `b`).

(b) [4 marks] What fields of `Question` can `someMethod(Question q)` use? If your answer is different than your answer to part (a), explain why.

Solution: `someMethod(Question)` can use the static fields (`a` and `b`) and it can use the non-static fields as long as it uses the reference `q` to do so. The answer is different from (a) because there is a parameter of type `Question` in this method.

(4 marks if the answer says that all of the fields are usable and that the non-static fields are usable via the parameter.

2 marks if the answer says that only the static fields are usable)

(c) [2 marks] What fields of `Question` can `anotherMethod(Question q)` use? If your answer is different than your answer to part (b), explain why.

Solution: `anotherMethod` can use any field of the class because it is a non-static method.

10. Consider the following class that represents a transcript of grades:

```
/**
 * A transcript of grades. The transcript owns all of the grades
 * in the transcript.
 */
public class Transcript {
    private List<CourseGrade> grades;

    public Transcript(List<CourseGrade> grades) {
        /* IMPLEMENTATION NOT SHOWN */
    }

    public int numCourses() {
        /* IMPLEMENTATION NOT SHOWN */
        /* RETURNS THE NUMBER OF COURSES IN THIS TRANSCRIPT */
    }

    public double getGPA() {
        /* IMPLEMENTATION NOT SHOWN */
        /* RETURNS THE GPA OVER ALL COURSES IN THIS TRANSCRIPT */
    }

    public CourseGrade getGrade(String course) {
        /* IMPLEMENTATION NOT SHOWN */
        /* RETURNS THE COURSEGRADE FOR THE SPECIFIED COURSE */
    }
}
```

Now consider the following fragment of code:

```
// course completion date
LocalDate completed = LocalDate.of(2018, Month.APRIL, 30);

// grade for EECS2030 with gpa of 7 completed Apr 30, 2018
CourseGrade c = new CourseGrade("EECS2030", 7, completed);

// a list with one CourseGrade
List<CourseGrade> grades = new ArrayList<>();
grades.add(c);

// a transcript
Transcript t = new Transcript(grades);

// remove all elements from grades
grades.clear();

// change the grade of c
c.setGrade(9);

// get the grade for EECS2030
CourseGrade g = t.getGrade("EECS2030");
```

(a) [2 marks] After running the code fragment above, what values should `t.numCourses()` and `t.getGPA()` return if the constructor of `Transcript` is implemented correctly?

Solution: There is only one course with a grade of 7 in the transcript so:
`t.numCourses()` should return `1`
`t.getGPA()` should return `7`

(b) [2 marks] Suppose that after running the code fragment above, the statement `t.numCourses()` returns the value `0`. Did the constructor make an alias, shallow copy, or deep copy of the argument `grades`? Briefly explain your answer.

Solution: The constructor made an alias because clearing the list `t` also causes the transcript to clear its list of grades.

(c) [2 marks] Suppose that after running the code fragment above, the statement `t.getGPA()` returns the value `9`. Did the constructor make an alias, shallow copy, or deep copy of the argument `grades`? Briefly explain your answer.

Solution: The constructor must have made a copy of some kind because clearing the list `t` did not cause the transcript to clear its list of grades. It must have made a shallow copy because modifying the grade of the course in the list `t` causes the transcript to have a modified grade for the same course.

(d) [2 marks] Suppose that after running the code fragment above, the statement `c == g` returns `true`. Did the constructor make an alias, shallow copy, or deep copy of the argument `grades`? Briefly explain your answer.

Solution: The constructor must have made a copy of some kind because clearing the list `t` did not cause the transcript to clear its list of grades. It must have made a shallow copy because the `CourseGrade c` is the same object as the `CourseGrade g` from the transcript.

11. Consider the following two classes related by inheritance:

```
public class Lock {

       private static int numLocks = 0;
       private long id;
       private boolean isLocked;

       public Lock(boolean isLocked) {
              this.id = Lock.numLocks;
              if (isLocked) {
                     this.lock();
              } else {
                     this.unlock();
              }
              Lock.numLocks = Lock.numLocks + 1;
       }

       protected void lock() {
              this.isLocked = true;
       }

       protected void unlock() {
              this.isLocked = false;
       }
}

public class CombinationLock extends Lock {

       private Combination combo;

       public CombinationLock(Combination combo) {
              [PART (a)]
              this.combo = new Combination(combo);
       }

       @Override
       protected void lock() {
              [PART (b)]
              this.combo.shuffle(); // randomly shuffles the dials on the lock
       }

       @Override
       public boolean equals(Object obj) {
              if (!super.equals(obj)) {
                     return false;
              }
              CombinationLock other = (CombinationLock) obj;
              if (!this.combo.equals(other.combo)) {
                     return false;
              }
              return true;
       }

}
```

(a) [2 marks] What would you write on the line labelled `[PART (a)]` to complete the `CombinationLock` constructor? Why is the line required?

Solution: Either `super(true);` or `super(false);` (both answers are acceptable). One of the two is required because a `Lock` constructor must be called and there is no other constructor in `Lock`.

(b) [2 marks] What would you write on the line labelled `[PART (b)]` to complete the overridden version of the method `lock()`?

Solution: `super.lock();` is required to actually lock the lock. The field `isLocked` is private in `Lock` so `CombinationLock` has no other way to access the field.

(c) [2 marks] What sequence of events occurs when a user of the two classes makes a new `CombinationLock`? Is the `CombinationLock` always successfully initialized?

Solution: The `Lock` constructor is called which might call the method `lock` which is overridden by `CombinationLock`. If this happens then the overridden version of `lock` runs which will cause a `NullPointerException` because `this.combo` is `null` when `lock` is running. Therefore, the `CombinationLock` might not be successfully initialized.

(d) [2 marks] `CombinationLock` overrides the `equals` method; is this override required to check if two `CombinationLock` instances are equal? Justify your answer.

Solution: The override is *not* required because `Lock` does not override `equals`. This means that `super.equals(obj)` is `true` if and only if `this CombinationLock` and `obj` have the same memory address, which means that `this.combo.equals(other.combo)` will always be `true`.

(The explanation must be partly correct to receive part marks; answering yes with an incorrect answer should not receive any marks).