Massachusetts Institute of Technology

6.170 Laboratory in Software Engineering

Spring 2007

Quiz 1

Friday, March 2, 2007

Name: ____

Athena username: ________________________________

Section (circle one):

1: Lucy Mendel **2: Vikki Chou** **3: David Glasser**

4: Kah Seng Tay **5: Omair Malik** **6: Clayton Sims**

This quiz is closed book, closed notes. You have 50 minutes to complete it. It contains 24 questions in 15 pages (including this one), totaling 100 points. The last three pages contain duplicate material from multi-page questions. You may tear-off those pages for your reference. Before you start, please check your copy to make sure it is complete. Turn in pages 1-15, together, when you are finished. Separately turn-in pages 16-18.

Write your initials and section number on the top of *ALL* pages.

Please write neatly; we cannot give credit for what we cannot read.

Good luck!

Question(s)	Grading Scheme	Total	Max
1 to 7	☐ X 2 =		of 14
8 to 18	8,9 ☐ 10,11 ☐ 12,13 ☐ 14,15 ☐ 16 ☐ 17,18 ☐ X 5 =		of 55
19			of 7
20			of 6
21	☐ X 4 =		of 12
22			of 6
			of 100

True/False Questions

Question 1.

T/F Unlike interfaces, abstract classes are partially implemented and can be `instantiated`.

Question 2.

T/F Unlike interfaces, abstract classes may implement constructors.

Question 3.

T/F In Java, both implements and extends indicate the "is-a" relationship between the class and what that class implements or extends.

Question 4.

T/F Abstract Data Types are immutable.

Question 5.

T/F In Java, Abstract Data Types are expressed as interfaces.

Question 6.

T/F According to the specification for Object.equals(Object), y.equals(x) implies x==y

Question 7.

T/F According to the specification for Object.equals(Object), x.equals(y) implies y.equals(x)

Multiple Choice Questions:

Question 8. (circle all that apply)

The specifications for an Abstract Data Type can refer to which of the following:

(A) Specification fields

(B) Java fields

(C) The Abstraction Function

(D) Observers

(E) Creators

Question 9. (circle all that apply)

Which of the following statements are true?

(A) A factory method can act as a substitute for a constructor.

(B) Using interfaces eliminates the need to rewrite fields and methods that were already implemented in the interface.

(C) A Java class can have multiple superclasses.

(D) An interface can extend multiple interfaces.

(E) Java supports multiple inheritance

Question 10. (circle all that apply)

Which of the following statements are true?

(A) The abstraction function can refer to the concrete (Java) fields of a class.

(B) The representation invariant specifies the valid outputs of the abstraction function.

(C) The representation invariant should be part of a class's public Javadocs.

(D) An abstraction function for a class can be written by someone with no knowledge of or access to the implementation of that class.

(E) Checking the validity of rep invariant at the end of a public method is good defensive programming

Question 11. (circle all that apply)

The tests that run every night during the project development or before a programmer checks in any changes to the global repository are normally characterized as ________.

(A) Regression tests

(B) Integration tests

(C) Validation tests

(D) System tests

(E) None of the above

Question 12. (circle all that apply)

Glass box tests ________.

(A) should always be written before you write the code for a class.

(B) have their quality measured by what percentage of the code they cover

(C) may require their writer to think about control-flow details

(D) ensure that clients fulfill the preconditions of a method

(E) can be reused even if the implementation of a class changes, as long as the specification does not change

Question 13. (circle the most relevant)

A a = new B()

(A) Will compiles in Java only if A is a java subtype of, or equal to, B

(B) Will compiles in Java only if B is a java subtype of, or equal to, A

(C) Will always compiles in Java

(D) Will not compile in Java if A and B are not the same type.

(E) None of the above

```
/** represents a mutable solid ball **/
public class SolidBall {
    // radius : integer
    // RI – radius >= 0
    // AF – this.radius represents the actual radius of the physical Ball
    private int radius; // ball radius
    SolidBall(int radius) {
        this.radius = radius;
    }
    /** @returns weight */
    public int getWeight() {
        return (int)(4.0/3.0*Math.PI*Math.pow(radius, 3));
    }
    /** @returns volume */
    public double getVolume() {
        return getWeight();
    }
}

/** represents a SolidBall filled with low-density filler with air bubbles making the ball bouncy */
public class BouncySolidBall extends SolidBall {
    BouncySolidBall(int radius) {
        super(radius);
    }
    /** @returns weight */
    public int getWeight() {
        return (int)(getVolume()/2);
    }
}

SolidBall ball = new BouncySolidBall(6); // note: 6^3 = 216
System.out.print(ball.getWeight());
```

Question 14. (circle the most relevant)

In the class SolidBall, the method getWeight() is invoked in the code for getVolume(). What is the compile-time type of the receiver of getWeight()?

- **(A)** The answer varies depending on how getVolume() is invoked
- **(B)** BouncySolidBall
- **(C)** SolidBall
- **(D)** Object
- **(E)** None of the above

Question 15. (circle the most relevant)

The method call ball.getWeight()

- **(A)** prints the integer 216*PI
- **(B)** prints the integer 288*PI
- **(C)** prints the integer 144*PI
- **(D)** prints an arbitrary integer due to ambiguous dispatch.
- **(E)** throws an exception due to infinite recursion.

Ben Bitdiddle joins a local software company in Kendall Square that deals in telecommunications. Ben's first assignment is to investigate problems that have arisen from merging code in the software's code base. Ben finds 2 different implementations for a function, checkHashes. Abstractly, checkHashes checks whether a numerical hash of each string in entries is equal to its predetermined value in correctHashes.

public boolean checkHashes(List<String> entries, List<Integer> correctHashes)

Fortunately for Ben, all the implementations have specifications written in 6.170 style.

Specification A
@requires: entries.length = correctHashes.length
@modifies: nothing
@throws: nothing
@effects: nothing
@returns: true iff for all i s.t. 0 <= i < entries.length, hash(entries [i]) = correctHashes[i]

Specification B
@requires: nothing
@modifies: entries
@throws: ArrayOutOfBoundsException if entries.length < correctHashes.length
@effects: for all i where hash($entries_{PRE}$[i]) != correctHashes [i], $entries_{POST}$[i] = ""
@returns: true iff for all i s.t. 0 <= i < entries.length, hash($entries_{POST}$[i]) = correctHashes[i]

Question 16. (circle the most relevant)

What following statement(s) represent the relationship between the above two specifications

(A) Specification A and specification B are equivalent

(B) Specification A is stronger than the specification B

(C) Specification B is stronger than the specification A

(D) Neither specification is stronger than the other

(E) Without analyzing the implementation, it is impossible to say

After more investigation, Ben discovers another implementation with this specification:

Specification C
@requires: entries.length >= correctHashes.length
@modifies: nothing
@throws: nothing
@effects: nothing
@returns: true iff for all i s.t. 0 <= i < correctHashes.length, hash(entries[i]) = correctHashes[i]

Question 17. (circle all that apply)

We would like to reduce the code bloat by eliminating redundant methods.

(A) Method A can be replaced by the implementation of method B.

(B) Method A can be replaced by the implementation of method C.

(C) Method B can be replaced by the implementation of method A.

(D) Method C can be replaced by the implementation of method A.

(E) No methods can be replaced.

Question 18. (circle all that apply)

We know class A is a Java subtype of Class B if

(A) Every situation that requires a class of type B will work correctly when given a class of type A

(B) Every situation that requires a class of type A will work correctly when given a class of type B

(C) There exists a declared relationship A extends B or A implements B

(D) There exists a declared relationship B extends A or B implements A

(E) B’s specification is stronger than A’s specification

Consider another implementation of the RatNum class which you saw in Problem Set 1 that keeps to the same specifications:

```
/** RatNum represents an immutable rational number.
   It includes all of the elements in the set of rationals, as well as the special "NaN" (not-a-number)
   element that results from division by zero.
   The "NaN" element is special in many ways.  Any arithmetic operation (such as addition) involving
   "NaN" will return "NaN". With respect to comparison operations, such as less-than, "NaN" is
   considered equal to itself, and larger than all other rationals.
   Examples of RatNums include "-1/13", "53/7", "4", "NaN", and "0".   */
public class RatNum extends Number implements Comparable<RatNum> {
        int whole;
        int numer;
        int denom;

        /** A constant holding a Not-a-Number (NaN) value of type RatNum */
        public static final RatNum NaN = new RatNum(1, 0);

        /** A constant holding a zero value of type RatNum */
        public static final RatNum ZERO = new RatNum(0);

        /** @effects   Constructs a new RatNum = n. */
        public RatNum(int n) {
                whole = n;      // ADDED IN THIS IMPLEMENTATION
                numer = 0;      // CHANGED IN THIS IMPLEMENTATION
                denom = 1;
        }


        /** @effects   If d = 0, constructs a new RatNum = NaN.  Else constructs a new
                       RatNum = (n / d)  */
        public RatNum(int n, int d) {
                if (d == 0) {    // special case for zero denominator; gcd(n,d) requires d != 0
                        whole = 0;   // ADDED IN THIS IMPLEMENTATION
                        numer = n;
                        denom = 0;
                } else {
                        // reduce ratio to lowest terms
                        int g = gcd(n,d);
                        n = n / g;
                        d = d / g;
                        if (d < 0) {
                                numer =  – n;
                                denom =  – d;
                        } else {
                                numer = n;
                                denom = d;
                        }
                        whole = (int) (numer / denom);          // ADDED IN THIS IMPLEMENTATION
```

```
                        numer = numer – whole * denom;      // ADDED IN THIS IMPLEMENTATION
                        if (whole < 0) {                    // ADDED IN THIS IMPLEMENTATION
                                numer =  – numer;           // ADDED IN THIS IMPLEMENTATION
                        }                                   // ADDED IN THIS IMPLEMENTATION
                }
        }
        /** Makes a RatNum from a string describing it.
        @requires       'ratStr' is an instance of a string, with no spaces, of the form:
                        "NaN"
                        "N/M", where N and M are both integers in decimal notation, and M != 0, or
                        "N",    where N is an integer in decimal notation.
        @returns        NaN if ratStr = "NaN".  Else returns RatNum r = ( N / M ), letting M be 1 in
                        the case where only "N" is passed in.   */
        public static RatNum valueOf(String ratStr) {
                int slashLoc = ratStr.indexOf('/');
                if (ratStr.equals("NaN")) {
                        return NaN;
                } else if (slashLoc == -1) {    // not NaN, and no slash, must be an Integer
                        return new RatNum( Integer.parseInt( ratStr ) );
                } else {        // slash, need to parse the two parts seperately
                        int n = Integer.parseInt(ratStr.substring(0, slashLoc));
                        int d = Integer.parseInt (ratStr.substring(slashLoc+1, ratStr.length()));
                        return new RatNum(n, d);
                }
        }
    ...
}
```

Here are some examples, both good and bad;

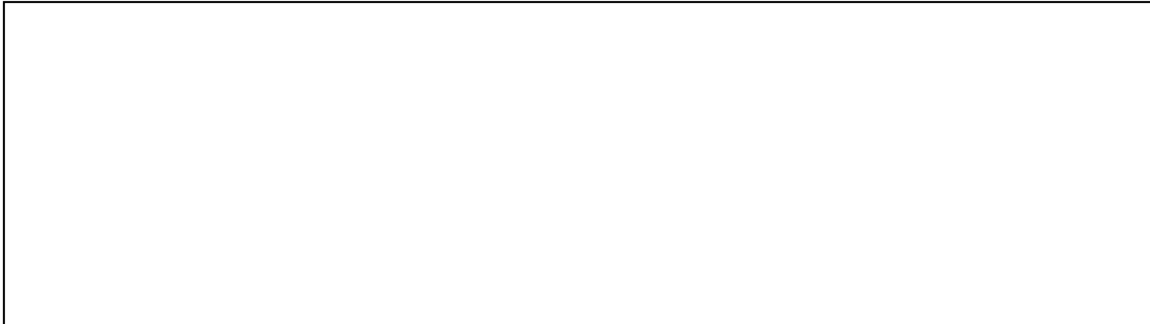
Representation			Abstract Value
whole=1,	numer=1,	denom=4	1 1/4 = 5/4
whole=0,	numer=1,	denom=0	NaN
whole=-5,	numer=0,	denom=1	-5
whole=-2,	numer=2,	denom=3	-2 2/3 = -8/3
whole=0,	numer=-1,	demon=4	-1/4
whole=1,	numer=3,	denom=2	Illegal
whole=0,	numer=5,	denom=0	Illegal
whole=0,	numer=0,	denom=0	Illegal
whole=2,	numer=1,	denom=-2	Illegal
whole=-2,	numer=-1,	denom=2	Illegal

Question 19.

Write a representation invariant based on this description. You may use math, clear English, Java code or any mixture.

Question 20.

Write an abstraction function for RatNum.



You realize that there are very large rational numbers that cannot be represented using RatNum. For example the whole part of RatNum can only handle numbers between Integer.MIN_VALUE and Integer.MAX_VALUE, thus a number such as 17179869184 1/3 (i.e. 2^{34} 1/3) cannot be represented. You need to create a new class BigRatNum that is able to represent very large rational numbers. Thus, you decided to use a long to represent whole. You figure you can be smart about it by reusing the code of RatNum and just change whole from int to long. Clients of BigRatNum do not need to know how you implemented this class.

```
/** Immutable arbitrary-precision rational numbers.  **/
public class BigRatNum extends RatNum implements Comparable<RatNum>
{
        ...
        long whole;
        ...

        public BigRatNum(long n, int d) {

                if((n <= Integer.MAX_VALUE) && (n >= Integer.MIN_VALUE)) {
                        numer = (int)n;
                        denom = d;
                        this.whole = super.whole;
                } else {
                        long excess = n / d;
                        numer = (int)(n – excess*d);
                        denom = d;
                        this.whole = super.whole + excess;
                }
        }
        …

}
```

Question 21.

Write one sentence on 3 things that are wrong with this implementation.

Question 22.

Briefly describe (in less than 2 sentences) a better way to implement BigRatNum.

```
/** represents a mutable solid ball **/
public class SolidBall {
	// radius : integer
	// RI – radius >= 0
	// AF – this.radius represents the actual radius of the physical Ball
	private int radius; // ball radius
	SolidBall(int radius) {
		this.radius = radius;
	}
	/** @returns weight */
	public int getWeight() {
		return (int)(4.0/3.0*Math.PI*Math.pow(radius, 3));
	}
	/** @returns volume */
	public double getVolume() {
		return getWeight();
	}
}

/** represents a SolidBall filled with low-density filler with air bubbles making the ball bouncy */
public class BouncySolidBall extends SolidBall {
	BouncySolidBall(int radius) {
		super(radius);
	}
	/** @returns weight */
	public int getWeight() {
		return (int)(getVolume()/2);
	}
}

SolidBall ball = new BouncySolidBall(6); // note: 6^3 = 216
System.out.print(ball.getWeight());
```

```
/** RatNum represents an immutable rational number. It includes all of the elements in the set of rationals, as well as the special "NaN"
    (not-a-number) element that results from division by zero. The "NaN" element is special in many ways.  Any arithmetic operation (such
    as addition) involving  "NaN" will return "NaN". With respect to comparison operations, such as less-than, "NaN" is  considered equal to
    itself, and larger than all other rationals.  Examples of RatNums include "-1/13", "53/7", "4", "NaN", and "0".   */
public class RatNum extends Number implements Comparable<RatNum> {
        int whole;
        int numer;
        int denom;
        /** A constant holding a Not-a-Number (NaN) value of type RatNum */
        public static final RatNum NaN = new RatNum(1, 0);

        /** A constant holding a zero value of type RatNum */
        public static final RatNum ZERO = new RatNum(0);

        /** @effects  Constructs a new RatNum = n. */
        public RatNum(int n) {
                whole = n;      // ADDED IN THIS IMPLEMENTATION
                numer = 0;      // CHANGED IN THIS IMPLEMENTATION
                denom = 1;
        }
        /** @effects  If d = 0, constructs a new RatNum = NaN.  Else constructs a new RatNum = (n / d)  */
        public RatNum(int n, int d) {
                if (d == 0) {     // special case for zero denominator; gcd(n,d) requires d != 0
                        whole = 0;   // ADDED IN THIS IMPLEMENTATION
                        numer = n;
                        denom = 0;
                } else {
                        // reduce ratio to lowest terms
                        int g = gcd(n,d);
                        n = n / g;
                        d = d / g;
                        if (d < 0) {
                                numer = – n;
                                denom = – d;
                        } else {
                                numer = n;
                                denom = d;
                        }
                        whole = (int) (numer / denom);             // ADDED IN THIS IMPLEMENTATION
                        numer = numer – whole * denom;           // ADDED IN THIS IMPLEMENTATION
                        if (whole < 0) {                           // ADDED IN THIS IMPLEMENTATION
                                numer = – numer;                   // ADDED IN THIS IMPLEMENTATION
                        }                                          // ADDED IN THIS IMPLEMENTATION
                }
        }
        /** Makes a RatNum from a string describing it.
        @requires     'ratStr' is an instance of a string, with no spaces, of the form:
                        "NaN"
                        "N/M", where N and M are both integers in decimal notation, and M != 0, or
                        "N",     where N is an integer in decimal notation.
        @returns      NaN if ratStr = "NaN".  Else returns RatNum r = ( N / M ), letting M be 1 in the case where only "N" is passed in.   */
        public static RatNum valueOf(String ratStr) {
                int slashLoc = ratStr.indexOf('/');
                if (ratStr.equals("NaN")) {
                        return NaN;
                } else if (slashLoc == -1) {              // not NaN, and no slash, must be an Integer
                        return new RatNum( Integer.parseInt( ratStr ) );
                } else {          // slash, need to parse the two parts seperately
                        int n = Integer.parseInt(ratStr.substring(0, slashLoc));
                        int d = Integer.parseInt (ratStr.substring(slashLoc+1, ratStr.length()));
                        return new RatNum(n, d);
                }
        }
   ...
}
```

*/** Immutable arbitrary-precision rational numbers. **/*

```
public class BigRatNum extends RatNum implements Comparable<RatNum>
{
        ...
        long whole;
        ...

        public BigRatNum(long n, int d) {

                if((n <= Integer.MAX_VALUE) && (n >= Integer.MIN_VALUE)) {
                        numer = (int)n;
                        denom = d;
                        this.whole = super.whole;
                } else {
                        long excess = n / d;
                        numer = (int)(n – excess*d);
                        denom = d;
                        this.whole = super.whole + excess;
                }
        }
        …

}
```