Student ID: .....

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

**EXAMINATIONS – 2015**

**TRIMESTER 1**

**SWEN221**

**Software Development**

**Time Allowed:** TWO HOURS

**CLOSED BOOK**

**Permitted materials:** No calculators permitted.
Non-electronic Foreign language to English dictionaries are allowed.

**Instructions:** Answer all questions
All questions are of equal value

Answer all questions in the boxes provided.
Every box requires an answer.
If additional space is required you may use a separate answer booklet.

| Question | Topic | Marks |
|---|---|---|
| 1. | Code Comprehension | 30 |
| 2. | Testing | 30 |
| 3. | Java Masterclass | 30 |
| 4. | Exceptions and Assertions | 30 |
| | **Total** | 120 |

## Question 1. Code Comprehension [30 marks]

Consider the following classes and interfaces, which compile without error:

```
1  // A variable holding a logic (i.e.  boolean) value
2  class LogicVar {
3    private boolean value;
4
5    public LogicVar(boolean value) { this.value = value; }
6
7    public boolean get() { return value; }
8
9    public void set(boolean value) { this.value = value; }
10 }
11
12 // A logic gate reads two inputs and writes one output
13 abstract class LogicGate {
14   private LogicVar[] variables = new LogicVar[3];
15
16   public LogicGate(LogicVar in1, LogicVar in2, LogicVar out) {
17     variables[0] = in1;
18     variables[1] = in2;
19     variables[2] = out;
20   }
21   public void evaluate() {
22     boolean in1 = variables[0].get();
23     boolean in2 = variables[1].get();
24     variables[2].set(evaluate(in1,in2));
25   }
26   public abstract boolean evaluate(boolean in1, boolean in2);
27 }
28
29 // If both inputs true, out is true; othewise, out is false.
30 class AndGate extends LogicGate {
31   public AndGate(LogicVar v1, LogicVar v2, LogicVar v3) {
32       super(v1,v2,v3);
33   }
34   public boolean evaluate(boolean in1, boolean in2) {
35       return in1 && in2;
36 } }
37
38 // If either input is true, out is true; othewise, out is false.
39 class OrGate extends LogicGate {
40   public OrGate(LogicVar v1, LogicVar v2, LogicVar v3) {
41       super(v1,v2,v3);
42   }
43   public boolean evaluate(boolean in1, boolean in2) {
44       return in1 || in2;
45 } }
```

**(a)** Based on the code given on page 2, state the output you would expect for each of the following code snippets:

**(i)** [2 marks]

```
1      LogicVar v1 = new LogicVar(true);
2      System.out.println(v1.get());
```

**true**

**(ii)** [2 marks]

```
1  LogicVar v1 = new LogicVar(false);
2  LogicVar v2 = new LogicVar(true);
3  LogicVar v3 = new LogicVar(true);
4  LogicGate gate = new AndGate(v1,v2,v3);
5  gate.evaluate();
6  System.out.println(v1.get() + "␣" + v2.get() + "␣" + v3.get());
```

**false true false**

**(iii)** [2 marks]

```
1  LogicVar v1 = new LogicVar(true);
2  LogicVar v2 = new LogicVar(false);
3  LogicGate gate = new OrGate(v1,v2,v2);
4  gate.evaluate();
5  System.out.println(v1.get() + "␣" + v2.get());
```

**true true**

**(iv)** [2 marks]

```
1  LogicVar v1 = new LogicVar(true);
2  LogicVar v2 = new LogicVar(false);
3  LogicVar v3 = new LogicVar(false);
4  LogicGate gate1 = new OrGate(v1,v2,v3);
5  LogicGate gate2 = new AndGate(v3,v2,v1);
6  gate1.evaluate();
7  gate2.evaluate();
8  System.out.println(v1.get() + "␣" + v2.get() + "␣" + v3.get());
```

**false false true**

**(b)** [5 marks] Provide an implementation for a class `XorGate`. This sets the `out` field to **`true`** if exactly one input is **`true`** (i.e. not both); otherwise, it sets it to **`false`**.

```
1 class XorGate Extends LogicGate {
2   public XorGate(LogicVar in1, LogicVar in2, LogicVar in3) {
3     super(in1,in2,in3);
4   }
5
6   public void evaluate(boolean in1, boolean in2) {
7     return in1 != in2;
8   }
9 }
```

**(c)** [3 marks] Consider the method `LogicGate.evaluate()`. Does it *overload* or *override* the method `LogicGate.evaluate(boolean,boolean)`? Justify your answer.

`LogicGate.evaluate()` overloads `LogicGate.evaluate(boolean,boolean)`. This is because they have the same name, but different parameter types. For a method to override another, they must have the same signature (i.e. name and parameter types).

**(d)** Suppose the following method were added to class `LogicGate`:

```
1  public boolean equals(Object o) {
2     if(o instanceof LogicGate) {
3        LogicGate lg = (LogicGate) o;
4        for(int i=0;i!=variables.length;++i) {
5           if(variables[i] != lg.variables[i]) { return false; }
6        }
7        return true;
8     }
9     return false;
10 }
```

**(i)** [6 marks] This method means an `AndGate` can equal an `OrGate`. Briefly, illustrate how you would fix this problem.

```
1  public boolean equals(Object o) {
2    if(o != null && this.getClass().equals(o.getClass())){
3      LogicGate lg = (LogicGate) o;
4      for(int i=0;i!=variables.length;++i) {
5         if(variables[i] != lg.variables[i]) { return false; }
6      }
7      return true;
8    }
9    return false;
10 }
```

An alternative approach would be for the classes `AndGate` and `OrGate` to provide their own implementation of `equals()` which *overrides* it.

**(e)** Consider the following snippet of code:

```
1       LogicGate gate = new AndGate(v1,v2,v3);
```

**(i)** [4 marks] The *static type* of variable `gate` is `LogicGate`. Briefly, discuss what this means and how it affects what values variable `gate` may hold.

The static type of a variable or field is its declared type. This limits the possible values for the variable `gate` to the subtypes of `LogicGate` (i.e. `LogicGate` and its subclasses). Only methods declared in `LogicGate` (or its superclasses) can be called on `gate`, even for subclasses with additional methods.

**(ii)** [4 marks] The *dynamic type* of variable `gate` is `AndGate`. Briefly, discuss what this means and how it affects the execution of method `LogicGate.evaluate()`

The dynamic of a variable or field is its actual type at runtime. Since method `LogicGate.evaluate()` calls the abstract method `LogicGate.evaluate(boolean,boolean)`, the actual method which is executed is determined by the dynamic type. Thus, different subclasses can affect the way the `evaluate()` method operates.

**SPARE PAGE FOR EXTRA ANSWERS**

Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

## Question 2. Testing [30 marks]

**(a)** [5 marks] Briefly, discuss the difference between *black-box* and *white-box* testing.

**Black box** testing is done without access to the source code, and is typically based off the specification or e.g. by trying malicious inputs, etc. Black box testing is robust to implementation changes, and avoids programmer bias.

**White box** testing is done with full access to the source code and typically exploits this to achieve high code coverage, etc. This form of testing is prone to programmer bias. For example, tests may reflect the programmers (incorrect) understanding of the specification. Similarly, programmers may not thoroughly test components which they believe are well written.

**(b)** [2 marks] What is *branch coverage*?

The proportion of branching statements (i.e. if, while, etc) where all side of the branch have been tested.

**(c)** [2 marks] What is *simple path coverage*?

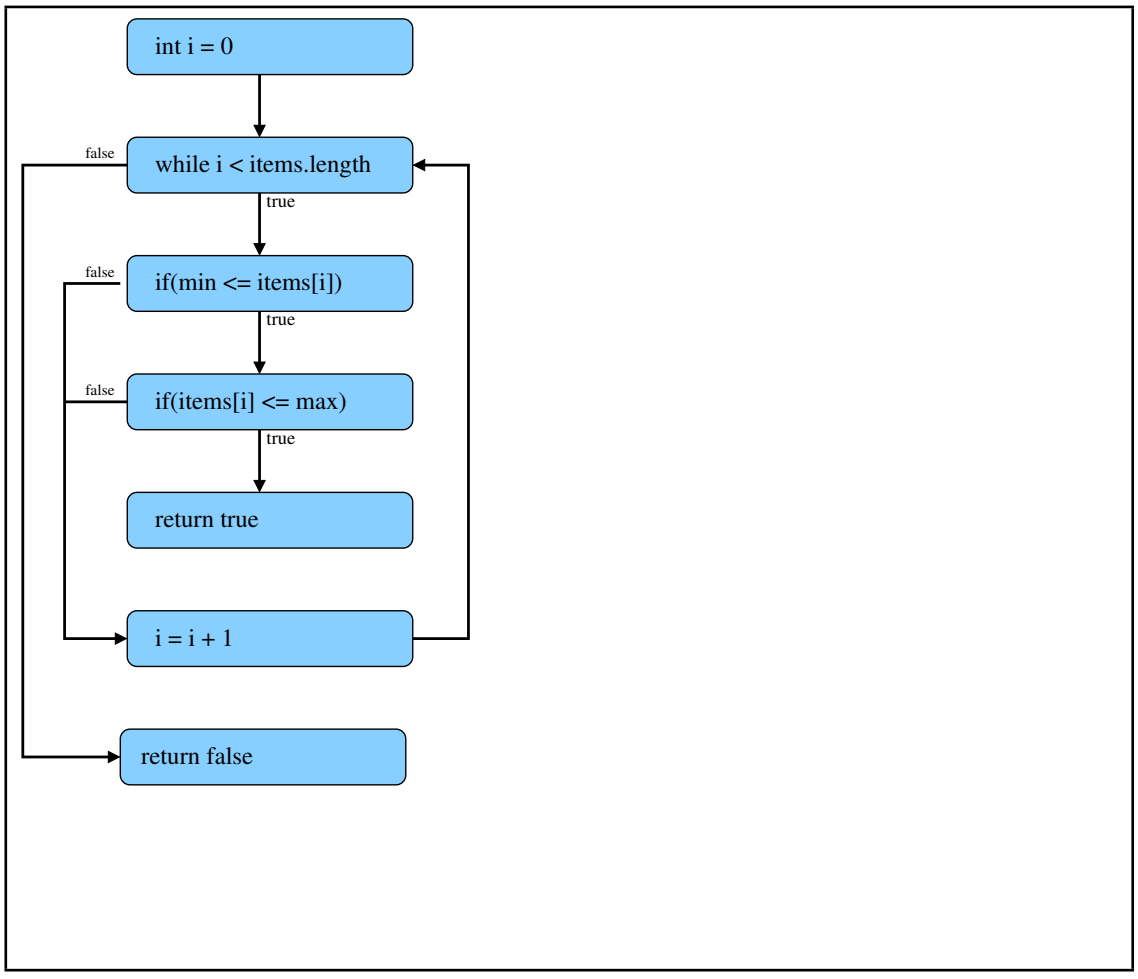
The proportion of execution paths through the program which have been tested, such that all loops are zero times and at least once.

**A simple execution path is a path through the method which iterates each loop at most once.**

**(d)** Consider the following classes which compiles without error:

```
1  class List {
2    private int[] items;
3
4    public List(int[] items) {
5        this.items = items;
6    }
7
8    public boolean hasBetween(int min, int max) {
9        int i = 0;
10       while(i < items.length) {
11          if(min <= items[i]) {
12              if(items[i] <= max) {
13                  return true;
14              }
15          }
16          i = i + 1;
17       }
18       return false;
19 } }
```

**(i)** [8 marks] Draw the *control-flow graph* for the `List.hasBetween(int,int)` method:



Consider the following test cases for the class `List`:

```
1 public class ListTests {
2   public static final int[] ITEMS = {-1,0,1};
3
4   @Test public void testHasBetween_1() {
5     assertFalse(new List(ITEMS).hasBetween(5,10));
6   }
7   @Test public void testHasBetween_2() {
8     assertFalse(new List(ITEMS).hasBetween(-10,-5));
9 } }
```

**(ii)** [2 marks] Give the total *branch coverage* obtained for class `List` from the tests provided in `ListTests`.

2/3 branches covered

**(iii)** [2 marks] Give the total *simple path coverage* obtained for class `List` from the tests provided in `ListTests`.

2/4 simple paths covered

**(iv)** [4 marks] Give two additional test cases which increase the simple path coverage obtained for `List` to 100%.

```
1 @Test public void testHasBetween_3() {
2   assertTrue(new List(ITEMS).hasBetween(0,1));
3 }
4 @Test public void testHasBetween_4() {
5   assertFalse(new List(new int[0]).hasBetween(0,0));
6 }
```

**(e)** [5 marks] Briefly, discuss why *polymorphism* in Java can result in an infinite number of execution paths for a given method.

When a function accepts a parameter of a non-primitive type, there can potentially be an infinite number of subtypes for it (including those which have not been written yet). Each of these classes can override one or more methods in the original type, and provide their own different implementations. Thus, to test our function, we would need to try every possible concrete subtype of the parameter — which is not feasible.

## Question 3. Java Masterclass [30 marks]

As for the self assessment tool, for each of the following questions, provide in the answer box the code that should replace `[???]`.

**(a)** [5 marks]

```
1  //The answer must have balanced parentesis
2  interface Joke{
3   int laughingTime();
4  }
5  class FunnyJoke implements Joke{
6   public int laughingTime(){return 5;}
7  }
8  class BadJoke implements Joke{
9   public int laughingTime(){return 0;}
10 }
11 class SoBadItsGoodJoke extends BadJoke{
12  public int laughingTime(){return 10;}
13 }
14 public class Exercise{
15
16   static int time=0;
17
18   static void joke(Joke j){time+=j.laughingTime();}
19
20   public static void main(String[] arg){
21     joke(new FunnyJoke());
22     joke(new SoBadItsGoodJoke());
23     joke(new BadJoke());
24     assert time==[???];
25   }
26 }
```

| |
|---|
| 15 |

**(b)** [4 marks]

```
1 //The answer must have balanced parentesis
2 class Hero{ int strength(){return 10;} }
3 class [???]{ int strength(){return 100;} }
4 public class Exercise{
5   public static void main(String [] arg){
6     Hero h=new Hercules();
7     assert h.strength()==100;
8   }
9 }
```

```
Hercules extends Hero
```

**(c)** [5 marks]

```
1 //The answer must have balanced parenthesis
2 class ThorHammer{[???]}
3
4 public class Exercise{
5   public static void main(String [] arg){
6     ThorHammer h1=ThorHammer.getInstance();
7     ThorHammer h2=ThorHammer.getInstance();
8     assert h1!=null;
9     assert h1==h2;
10 }  }
```

```
public static ThorHammer getInstance() {return instance;}
 private static ThorHammer instance=new ThorHammer();
```

**(d)** [6 marks]

```
1  //The answer must have balanced parenthesis
2  class Hammer{
3    private int weight;
4    public Hammer(int weight){this.weight=weight;}
5    public int getWeight(){return weight;}
6    public int hashCode() {return this.weight;}
7  }
8  class ThorHammer extends Hammer{[???]}
9
10 public class Exercise{
11   public static void main(String[] arg){
12    assert new ThorHammer().getWeight()==42;
13    assert new Hammer(0).hashCode()==new ThorHammer().hashCode();
14 } }
```

```
ThorHammer(){ super(42); }
public int hashCode() {return 0;}
```

**(e)** [5 marks]

```
1 //The answer must have balanced parenthesis
2 class A{ int m(){return 1;}}
3
4 public class Exercise{
5   public static void main(String[] arg){
6     A a=[???];
7     assert a.m()==2;
8   }
9 }
```

```
new A(){int m(){return 2;}}
```

**(f)** [5 marks]

```
1  // The answer must have balanced parenthesis
2  import java.util.Arrays;
3  import java.util.List;
4
5  class Point{
6    int x;
7    int y;
8    Point(int x, int y) { this.x=x;this.y=y; }
9  }
10 class ColPoint extends Point {
11   int colour;
12   ColPoint(int x, int y, int colour) {
13     super(x,y);
14     this.colour=colour;
15   }
16 }
17
18 public class Exercise{// make this code compile
19   static void printAll([???]){
20     for(Point p:ps){
21       System.out.println(""+p.x+"␣"+p.y);
22     }
23   }
24   public static void main(String[]arg){
25     List<Point> l1=Arrays.asList(new Point(1,2));
26     List<ColPoint> l2=Arrays.asList(new ColPoint(1,2,0));
27     printAll(l1);
28     printAll(l2);
29   }
30 }
```

```
List<?  extends Point>ps
```

inside inher not whole

**SPARE PAGE FOR EXTRA ANSWERS**

Cross out rough working that you do not want marked.
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## Question 4. Exceptions and Assertions [30 marks]

**(a)** [2 marks] Are Assertions in Java enabled or disabled by default?

Disabled

**(b)** [2 marks] Explain how to enable/disable assertions either from the command line or from eclipse.

Use `-ea` from the command-line.

**(c)** [4 marks] Insert sensible assertions with appropriate error messages into the following code to ensure that the parameter cannot be null and that the result will be positive.

```
public static int distanceFromOrigin(Point p){

    int x=p.x*p.x;

    int y=p.y*p.y;

    int result=x+y

    return result;

}
```

Solution:

```
assert p != null:"p can not be null"; (before first statement)

assert result >= 0:"result must be positive"; (before last statement)
```

Note that the result is not guaranteed to be positive, since x+y can go in overflow.

**(d)** [6 marks] One of your colleagues has written a method `dbQuery`. This method connects to a database, executes a query and returns a list of all the data produced. If there is an error working with the database, `dbQuery` simply propagates a checked exception.

You are using `dbQuery` to write a function to load employers data from a database.

```
1  class LoadData{
2    private static
3    List<Data> dbQuery(String id) throws DBException {
4      /*omitted*/
5    }
6    public static Data load(String id){
7      try{
8        List<Data> data=dbQuery("select␣...."+id);
9        if(data.size()!=1){
10         throw new UncheckedDBException(
11           "Data␣size␣is␣"+data.size());
12         }
13       return data.get(0);
14     }
15     [???]
16   }
17 }
```

As for the self assessment tool, provide in the answer box the code that should replace `[???]` to make the code compile. At this stage, you can assume a class `UncheckedDBException` is declared elsewhere.

```
1 catch(DBException e) {
2   throw new UncheckedDBException(e);
3 }
```

**(e)** [5 marks] Identify an alternative solution for question **(d)** and discuss its pros and cons.

An alternative solution would be to return **`null`** instead of rethrowing the checked exception as an unchecked exception. This is not really a good solution as it hides the exception which happened, and introduces the likelihood of an unexpected `NullPointerException`.

**(f)** [4 marks] Provide code for the class `UncheckedDBException`, so that the code before could compile.

```
1  public class UncheckedDBException extends RuntimeException {
2    public UncheckedDBException(String msg) {
3      super(msg);
4    }
5      public UncheckedDBException(String msg, Throwable cause) {
6      super(msg,cause);
7    }
8      public UncheckedDBException(Throwable cause) {
9      super(cause);
10   }
11
12 }
```

**(g)** "Finally" is an important feature of Java exception handling.

**(i)** [4 marks] Briefly, discuss what **`finally`** means in Java.

In Java, **`finally`** is used in conjunction with a **`try`** or **`try-catch`**. It describes a block of code that will always be executed after the **`try`** or **`try-catch`**, regardless of how that block is exited. This means that even if there are thrown exceptions that are not captured, **`finally`** is still executed.

**(ii)** [3 marks] Briefly, describe a situation where using **`finally`** would be sensible.

One example is using finally to deallocate a resource which is allocated by a block of code, and needs to be deallocated under all circumstances (i.e. including if an exception is thrown).

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