Australian National University

2016 Semester 1 - Final Examination

Software Construction

(COMP2100)

Writing Period: 3 hour duration
Study Period: 15 minutes duration
Permitted Materials: One A4 page with notes on both sides.
Note also the standard lab tools are available including: Java, eclipse, gedit, vim, emacs, git, umbrello, dia, gcc, man, the calculator on the computer, ...
The Java API is available at file:///usr/share/doc/openjdk-7-jre-headless/api/index.html

NO calculator permitted (physical electronic device).

Please Read The Following Instructions Carefully.

This exam will be marked out of 100 and consists of 4 questions. Questions are of unequal value. The value of each question is shown in square brackets. Questions that are partitioned into parts show the number of marks given to each part within square brackets.

Students should attempt all questions. Answers must be saved into the question's directory (Q1, Q2, Q3, Q4) using the file(s) described in the question statement. Marks may be lost for giving information that is irrelevant.

Network traffic may be monitored for inappropriate communications between students, or attempts to gain access to the Internet.

The marking scheme will put a high value on clarity so, as a general guide, it is better to give fewer answers in a clear manner than to outline a greater number of less clear answers.

Question 1 [40 marks]

Highest marks are gained by providing clear, concise, and short answers. Save your answers in the text file 'Q1answers.txt' in the directory Q1 (this file is already created with places to add your answers, so edit the file 'Q1answers.txt' and save your answers directly into it). Use your favourite editor for e.g. vim, gedit etc. Please make sure that this file is saved both as you progress through the exam and before the exam ends.

i. [4 marks] Two different authentication methods used by SSH are a) using a password and, b) using a public key. Describe in detail the public key authentication method. Include descriptions for each phase involved in both the client and server.

ii. [4 marks] What is a design pattern? Describe its advantages and disadvantages.

iii. [4 marks] Describe three important Software Quality Metrics used in the context of Software Design.

iv. [4 marks] Describe and illustrate the decorator design pattern. Explain why it is useful.

v. a) [2 marks] Using git, describe the steps involved in setting up a local repository, adding files to it and pushing them to a remote repository such as a gitlab server.

   b) [2 marks] What is a bare git repository? Why is it useful?

vi. [4 marks] What are the main design features of the Dalvik Java Virtual Machine (JVM) used in Android?

vii. [4 marks] Describe the four Android App Components. What are features common to all components? How can components communicate with each other?

viii. [4 marks] What are the advantages of storing persistent data using XML or JSON files rather than using Serializable Java Objects?

ix. [4 marks] Describe Code Coverage in the context of Software Testing. What are the different measures used in Code Coverage?

x. [4 marks] How do you set a variable in bash? Give an example of setting a variable. Describe what ${...}, $(…), and $[…] do in bash. (where "…" represents other text)

Question 2 [30 marks]

The aim of this question is to complete a mini software development project. This involves: i) Understanding the requirements for a simple application, ii) Creating a software design in UML using an appropriate Design Pattern, iii) Implementing the application using Java, iv) Demonstrating the use of some software engineering tools such as git, Makefiles v) Writing JUnit test cases and testing the implementation, vi) Writing appropriate documentation. Your code and answers must all be included in the Q2 directory.

Design and implement a program to model a university car park building. The building must have the following requirements:

- The building can park Vehicles of 3 types: Cars, Motorcycles and Minivans
- Each parking spot may be Small, Compact or Large in size
- A Car may occupy a Compact or Large spot
- A Motorcycle may occupy only a Small spot
- A Minivan may occupy only a Large spot

The program to model the university car park building must have the following requirements:

- The program must be named Carpark
- The program must accept available parking spot numbers using 3 input arguments as given below
    - The first argument represents the number of Small parking spots
    - The second argument represents the number of Compact parking spots
    - The third argument represents the number of Large parking spots
- For e.g. the program may be invoked in the following way: `$ java Carpark 20 10 20`
- After invocation, the program must wait for further input from System.in, then
    - The program must emulate the entrance of the car park with an automatic ticketing system which issues an appropriate entry ticket to a Vehicle based on its type, size and the amount of free parking spots available for that Vehicle type
    - The program must prompt the user for what type of Car the user wants to park. For e.g. "What vehicle would you like to park?"
    - The user may enter either Car, Motorcycle or Minivan
    - The program must keep track of the number of free parking spots

- Depending on the availability of parking spots, the program must either accept the user's vehicle saying "Welcome, please continue to park" or decline saying "Sorry, there are no spots available for your vehicle."
- If a Car wants to park, the program must tell the car whether to park in a Compact spot or a Large spot. Priority must be to fill up the Compact spots first. For e.g., "Welcome, please continue to park in a Compact spot"
- If the user enters, "Bye", the program must exit.

An example session with the Carpark program would look like this:

```
$ java Carpark 2 0 1
> What vehicle would you like to park?
Car
> Welcome, please continue to park in a Large spot
> What vehicle would you like to park?
Minivan
> Sorry, there are no spots available for your vehicle.
> What vehicle would you like to park?
Bye
```

Your tasks are:

a) [10 marks] Write a basic working version of the Carpark program using Java. Sample code is provided in Carpark.java in the Q2 directory to get you started with argument parsing and accepting user input from the command line.

b) [3 marks] Creating a software design for the Carpark in UML. Export the diagram to a file called UML.png in the Q2 directory. Provide a short summary explaining your design in the file named DesignSummary.txt provided in the Q2 directory.

c) [2 marks] Setup and use git within the Q2 directory for revision control and make at least 3 commits.

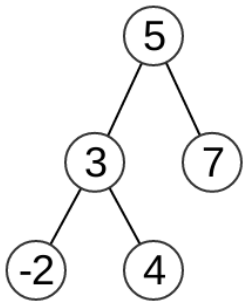
d) [3 marks] Write JUnit unit tests to test the Carpark program. Your tests must account for statement, branch and path coverage.

e) [2 marks] Write a Makefile for building and testing the Carpark program with 3 targets: make, make clean, make test.

f) [10 marks] Overall quality of submission. This includes aspects such as properly formatted code and UML diagram, enough detailed comments within code, appropriately named variables/field/methods/classes, meaningful comments for git commits and use of appropriate design patterns.

Question 3 [20 marks]

The aim of this question is to evaluate your understanding of Tree data structures. Include all code written for this question in the Q3 directory. The diagram below represents a Binary Search Tree.



An abstract class BST is provided in the file BST.java in the Q3 directory.

a) [8 marks] Extend the BST abstract class to create concrete classes which hold integer values, in its nodes along with its left and right children. Implement all the methods specified. Save the newly created Java files in the Q3 directory.

b) [12 marks] Add a recursive function,

`int findCountSum(int targetSum)`, to the BST abstract class. The purpose of this function is to find and count the number of paths from any BST node down to a leaf node which sum to the given value targetSum. This sum includes both the starting node and the leaf node's values. Note that a single leaf node also counts as a path. Implement this function in your concrete classes.

For the BST given in the diagram and the following targetSum values, findCountSum would return as follows:

- When targetSum = 12, findCountSum = 2
- When targetSum = 7, findCountSum = 2
- When targetSum = -1, findCountSum = 0
- When targetSum = 1, findCountSum = 1
- When targetSum = 0, findCountSum = 0
- When targetSum = 6, findCountSum = 1

Write a demo program, BSTDemo in the file BSTDemo.java provided in the Q3 directory with a main() function to construct the BST given in the diagram by calling the insert function similar to the code snippet shown below:

```
BST bt = new MyBST(5);

bt = bt.insert(3);
bt = bt.insert(7);
bt = bt.insert(-2);
```

```
bt = bt.insert(4);
bt = bt.insert(10);
bt = bt.remove(10);

System.out.println("size: " + bt.size());
System.out.println("height: " + bt.height());
System.out.println("findCountSum: " +
                   bt.findCountSum(targetSum));
```

BSTDemo must accept the targetSum as an input parameter and output the size, height and findCountSum.

For e.g.,

```
$ java BSTDemo 7

size: 5

height: 3

findCountSum: 2
```

Question 4 [10 marks]

Code for representing and showing expressions has been provided in the Q4 directory. There are four types of expressions: literal expressions (LitExp) which are just integer values like 5, -4, 8..., variables (VarExp) which are just strings like "x", "y", "count"..., summation expressions (SumExp) which are a list of expressions that are added together like (1+4), (1 + x + y)..., and product expression (MultExp) which are a list of expressions that are multiplied together.

This is a recursive data structure where the expression is stored as a tree. These expressions can be simplified such that they are just a sum of products where the produces are made up of variables and at most one literal.

For example, the expression "(2 + x) * (y + 1)" could be simplified to "2 + x + (2 * y) + (x * y)". Note that literal values within a summation expressions can be summed into one literal value. Similarly literal values within multiplication expressions can be multiplied into one literal value. Also the elements of the summation expression and elements of the multiplication expressions are sorted so the same simplification is always produced. The examples provided below, along with JUnit testing included in the Q4 directory, specify what the "simplify" method is expected to do.

The "simplify" method for MultExp, LitExp, and VarExp have been implemented, your task is to implement the "simplify" method for SumExp. This is the ONLY code you should modify. Do not add to or modify any other methods/classes.

Once you have completed your solution, when you run "DemoExpressions" you should see:

```
(1 + 1) simplifies to 2
(x + 1) simplifies to (1 + x)
(1 + (2 * 3)) simplifies to 7
(7 + (-4) + (-9)) simplifies to (-6)
(7 + x + 8) simplifies to (15 + x)
(2 * 3) simplifies to 6
(3 + y + 5 + 1 + x + (-2)) simplifies to (7 + x + y)
(3 + y + (-5) + x + 2) simplifies to (x + y)
(3 * y * (-5) * x * 2) simplifies to ((-30) * x * y)
(3 * y * (-5) * x * 0) simplifies to 0
((7 + x + 8) * (y + x + 8)) simplifies to (120 + (15 * y) + (23
* x) + (x * x) + (x * y))
((a + b) * (c + d) * (e + f)) simplifies to ((a * c * e) + (a *
c * f) + (a * d * e) + (a * d * f) + (b * c * e) + (b * c * f)
+ (b * d * e) + (b * d * f))
```

All the JUnit tests in TestSimplify must pass.

Hints:

- For sorting elements use the "Collections.sort()" method.
- As "equals" and "hashCode" has been implemented for expressions you can use a HashMap to help combine terms with the same variables in them.
- "extractVars" and "extractLitConstant" provide helpful methods for pulling multiply expressions apart.
