CS1180

THE UNIVERSITY OF WARWICK

First Year Examinations: April 2015

Programming for Computer Scientists

Time allowed: 2 hours

Answer **ALL** the questions. All questions carry 20 marks each.

Most answers require a single statement or a short piece of Java code to be written. Do not give complete programs or supply irrelevant declarations or input-output statements unless explicitly asked for. Number your answers clearly.

Read carefully the instructions on the answer book and make sure that the particulars required are entered on each answer book.

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1. **Primitive Data Types and Control Statements**

(a) List Java's eight primitive types, along with the range of each of the integer types. [3]

(b) Java can convert variables between various types.

i. Explain, with examples, the difference between an *implicit typecast* and an *explicit typecast*. [4]

ii. Given the following code, what will the output be and why? [3]

```
public static void main(String args[]) {
    short a = 3450;
    byte b = (byte) a;
    System.out.println(b);
}
```

(c) Program control in Java can be managed using `if` and `switch` statements. Rewrite the following code in the most concise form possible using a `switch` statement. [5]

```
Scanner sinput = new Scanner(System.in);
int c = sinput.nextInt();
if (c == -1) System.out.println("Exiting application");
else if (c == 0) System.out.println(
              "Please enter a number between 1 and 3");
else if (c == 1) System.out.println("Entering mode 1");
else if (c == 2) System.out.println("Entering mode 2");
else if (c == 3) System.out.println("Entering mode 3");
else System.out.println(
              "Please enter a number between 1 and 3");
```

(d) Given the following code,

```
int a = 1, b = 2;
if (a == 1)
    if (b == 3) System.out.println("A is 1 and B is 3");
else
    System.out.println("A is not 1");
```

i. What will the output be, and why? [2]

ii. Rewrite the code using a single `if` statement, and fix any semantic errors. [3]

2. **Iterative Statements, Methods, Arrays and Recursion**

   (a) Write a method that, when called with a single integer argument, `n`, creates an array of `n` integers with random values between 0 and 100 inclusive. [5]

   (b) Describe what is meant by method overloading. Using your answer to (a), provide an example of an overloaded method that can be used to set the maximum random value. [3]

   (c) Write a method that, when called with an array and an integer argument, `s`, performs a linear search on the array reporting the array index of the first instance of `s` in the list, or returning -1 if `s` is not found in the array. [6]

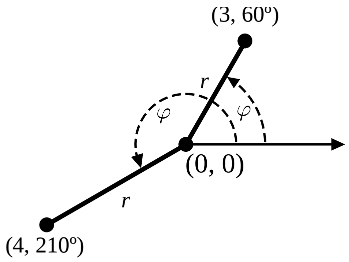
   (d) Finally, write a recursive method that calculates the sum of the differences between opposing pairs (i.e. the difference between `A[0]` and `A[n-1]`, `A[1]` and `A[n-2]`, and so forth). For example, the array { `3, 6, 34, 65` } results in the calculation: $(65 - 3) + (34 - 6) = 90$.
   You may assume the list will always be even in length. [6]

3. **Object Oriented Programming**

   (a) With reference to Object Oriented programming, what is meant by the terms *Encapsulation* and *Data Hiding*? [3]

   (b) The Polar Coordinate System is a two-dimensional coordinate system in which each point on a plane is determined by a distance from a fixed point and an angle from a fixed direction.

      i. Design a class, `PolarPoint` that stores a fixed origin `Point` (that is shared by all instances of the `PolarPoint` class and is initialed using `Point origin = new Point(0,0);`) and a distance and angle from the reference point. You can assume that the angle is always relative to an infinite line extending to the right of the point (see diagram). [5]



      ii. Converting between polar and cartesian coordinate systems can be done using the sine and cosine operations.

$$x = r\cos\varphi + x_{\text{origin}}$$

$$y = r\sin\varphi + y_{\text{origin}}$$

      Write a method that returns a `Point` in the cartesian coordinate system. You may find the `Math.cos(double a)` and `Math.sin(double a)` methods useful. [3]

      iii. Cartesian coordinates can be converted back to polar coordinates using

$$r = \sqrt{(x - x_{\text{origin}})^2 + (y - y_{\text{origin}})^2}$$

$$\varphi = \operatorname{atan2}((y - y_{\text{origin}}), (x - x_{\text{origin}}))$$

      Write a constructor method that creates a `PolarPoint` object from a `Point` object. For this question you may need to use the `Math.sqrt(double a)` and `Math.atan2(double y, double x)` methods. [4]

      iv. Write a function that calculates the shortest straight-line distance between two `PolarPoint` objects (**Hint**: This may be easier using the cartesian coordinate system). [5]

4. **Inheritance, Abstract Classes and Interfaces**

(a) You are asked to write a series of classes for storing document information for an office suite of applications.

i. Define an abstract Document class to store the following attributes: filename, author, date created and date last modified. [5]

ii. Define a WordDocument class that builds upon your previous class but includes the following additional String attributes: title, subtitle, body, header and footer. [4]

iii. Define a SpreadsheetDocument class that extends the Document class and stores a title and a two dimensional array of Cell objects.
The Cell class is defined like so: [3]

```
public class Cell {
    Object value;
    public Cell(Object value) {
        this.value = value;
    }
    public Object getValue() {
        return value;
    }
    public void setValue(Object value) {
        this.value = value;
    }
}
```

(b) Two interfaces are required in the office suite. One indicates that a document can be printed, the other indicates a document can be saved.

i. Define an interface called Printable that would ensure that any class that implements the Printable interface contains a print method. You may assume the print method has no parameters and no return value. [2]

ii. Define an interface called Saveable that would ensure that any class that implements the Saveable interface contains a save method. The save method will take a single String parameter that holds the filename and returns a single value indicating whether the save was successful. [2]

(c) With reference to your answers to (a) and (b), demonstrate how you would build a document class that can be saved and printed. You do not need to provide complete implementations of any method. [4]

5. **Exceptions and Generics**

(a) Exceptions can be used in the Java programming language to allow programmers to detect and gracefully handle errors.

i. Explain the difference between *checked* and *unchecked* exceptions. Define two exception classes, a checked exception called `ParseException` and an unchecked exception called `PrintException`. A single constructor method for each will be sufficient. [5]

ii. You are using the following code in your application:

```
public class UtilFunctions {
    public static int stringToInt(String input)
                                throws ParseException {
        ...
    }
    ...
}
```

Describe, with an example how you would use the `stringToInt` function in your code. [3]

(b) Describe the main motivating factors behind using Generics in the Java programming language. [4]

(c) Rewrite the following data structure using Java generics (You may ignore any potential errors that result from exceeding the size of the array). [4]

```
public class Array {
    private Object[] values;
    private int counter;
    public Array(int size) {
        values = new Object[size];
        counter = 0;
    }
    public void add(Object o) {
        values[counter++] = o;
    }
    public Object get(int i) {
        return values[i];
    }
}
```

(d) The following code has been provided to you, but it fails to successfully compile.

```
public class ETest {
    public static void main(String args[]) {
        int a;
        a = addVals(new Pair<String,Double>("K1", 4.0),
                    new Pair<String,Double>("K2", 4.0));
        System.out.println(a);
    }

    public static <K, V extends Integer> int
            addVals(Pair<K, V> p1, Pair<K, V> p2) {
        return p1.getValue() + p2.getValue();
    }
}
class Pair<K, V> {
    private K key;
    private V value;
    public Pair(K key, V value) {
        this.key = key;
        this.value = value;
    }
    public V getValue() { return value; }
}
```

The following compile time error is generated.

```
ETest.java:3: <K,V>addVals(Pair<K,V>,Pair<K,V>) in ETest
cannot be applied to (Pair<String,Double>,Pair<String,Do
uble>)

int a = addVals(new Pair<String, Double>("K1", 4.0),
                   new Pair<String, Double>("K2", 4.0));
            ^
1 error
```

Identify the source of the error and suggest two ways in which is could be fixed. [4]