Instructions

Make sure that you first read the entire paper and plan how to approach the paper. In general, you can get full marks on a code-writing question more easily than getting full marks by correctly answering six multiple-choice questions. You may wish to consider attempting the code-writing questions first.

In addition, the questions, including the multiple-choice questions are not in any particular order of difficulty. You should answer those questions that you find straightforward first.

Do not forget to include your name and student number on the multiple-choice answer sheet, and double-check your student number as it will be read by computer.

Do not spend too much time on the multiple choice questions.
1. (Total = 12 marks)

(a) Assume that in a certain country, tax is payable at the following rates:

- 15% on your first $50000 income
- 25% on any amount over $50000

Write a method that takes in an annual income value and returns the amount of tax payable. The method should have the following signature:

```java
public float tax(int income)
```

(b) Given below is a Java method:

```java
public void mystery(int[] number, int N) {
    int i;
    for (i = 0; i <= N; i++) {
        if (number[i] < 0 || number[i] > 15)
            i++;
        else
            System.out.println("number[" + i + "] = " + number[i]);
    }
}
```

Suppose that we have an `int` array defined as follows:

```java
int[] a = new int[] {10, 15, -1, 0, 2, 7, 20, 30};
```

What will be printed if `mystery(a, 6)` is called?

(c) Rewrite the method in (b) using a while loop.
2. (Total = 12 marks)

(a) Write a method

```java
public int reverse(int num)
```

which reverses the digits in a number. For example, if the number is 4395, then its reverse is 5934. Your method need not make any allowance for numbers which end with zero (for example, the reverse of 450 will just come out as 54).

(6 marks)

(b) Given below is the `drawLine` method of the `Canvas` class:

```java
public void drawLine(int x1, int y1, int x2, int y2)
```

The method allows you to draw a line connecting two given points, (x1, y1) and (x2, y2), on the current canvas.

Write the following method for the `Canvas` class:

```java
public void drawSquares(int x, int y, int side)
```

The method should take in (x, y) as the coordinates of the top-left corner and `side` as the length of the sides of the outer square to be drawn and produce nested squares as shown below:

```
In the diagram, the edges of each square are 1 pixel wide and adjacent squares have a 1 pixel gap. Thus, if the sides of the largest square are 10 pixels, then the sides of the next smaller square should be 6 pixels, and so on. For the smallest (i.e., the most inner) square, its sides must be at least 2 pixels but at most 5 pixels long.
```

(6 marks)
3.  (Total = 12 marks)

Suppose that we need to develop a simple class called Country for use in a geographical database system. The class will need variables to hold (a) the name of a country, which contains mainly alphabetic characters, (b) its capital city as alphabetic characters, (c) area in square km as a double, and (d) population as an integer. The only constructor for this class requires four arguments, the name, capital, population, and area. The methods needed are getName() which returns the name of the country, getCapital() which returns the name of the capital city, getArea() which returns the area in square km, getPopulation() which returns the population size, and setPopulation(popSize) which changes the size of population to the value popSize.

(a) Write out a skeleton of the Country class, clearly showing all variable declarations and method definitions. Their respective types, signatures, and arguments must be included. You are NOT required to include any code in the methods.

(2 marks)

(b) In an existing Geography class the following method is required:

    public static String largestCountry(Country[] countryList)

It should return the name of the country that has the largest land area. Write out the method in detail.

(5 marks)

(c) Suppose that we are also interested in finding the country that is most densely populated (i.e., having the most number of people per square km). Write a method

    public static String mostDenselyPopulatedCountry(Country[] countryList)

that returns the name of the most densely populated country.

(5 marks)
4. (Total = 12 marks)

(a) The value \( \ln 2 \) (that is, the natural log of 2) can be approximated by an infinite series as follows:

\[
\ln 2 = 1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \cdots
\]

Write a method

```java
public double myLn2(int n)
```

that approximates \( \ln 2 \) using the first \( n \) terms of this series.

(4 marks)

(b) Suppose that we have written a `Complex` class for representing complex numbers:

```java
public class Complex {
    double real; // real part
    double imag; // imaginary part

    public Complex(double r, double i) {
        real = r;
        imag = i;
    }
}
```

Write a method

```java
public Complex[] constructComplexArray(double[] r, double[] i)
```

that takes in two arrays of `double` and returns an array of `Complex` objects. For the two input arrays of float point numbers, the first array stores the real parts and the second array stores the corresponding imaginary parts of the complex numbers. You may assume that the two arrays are of the same length.

(4 marks)

(c) Write a method

```java
public boolean isPalindrome(String s)
```

that determines whether the argument string \( s \) is a palindrome. (A palindrome is a string that reads the same backwards and forwards, such as MADAM or ATOYOTA.)

(4 marks)
5.  (Total = 12 marks)

Consider a class `Picture` that represents the data for a grey-scale image. Assume that this class has an array `int[][] pixels` as a private instance variable, storing the pixel values, in such a way that `pixels[i][j]` is the grey-scale value of the \((i,j)\)-pixel (in Java graphics co-ordinates).

The operation of *pixellation* produces a “blocky” effect on a picture by dividing the picture into \(k \times k\) blocks of pixels, and replacing all the pixels in each block with the average value of the pixels in that block.

Here is an example where each block has size \(2 \times 2\) pixels:

\[
\begin{array}{cccc}
80 & 123 & 12 & 156 \\
14 & 77 & 11 & 210 \\
66 & 90 & 23 & 17 \\
13 & 14 & 18 & 150 \\
\end{array}
\quad\quad\quad\quad\quad\quad
\begin{array}{cccc}
74 & 74 & 97 & 97 \\
74 & 74 & 97 & 97 \\
46 & 46 & 52 & 52 \\
46 & 46 & 52 & 52 \\
\end{array}
\]

Write a method

```java
public void pixellate(int k)
```

that will pixellate the `Picture` using blocks of size \(k\).

Your method need only work if \(k\) is a positive integer, and the number of rows and columns of the `Picture` are exactly divisible by \(k\). You should check that this precondition is met, and take appropriate action otherwise.

Remember that your method should *only affect* the underlying `Picture` data — no attempt should be made to *display* the `Picture`.

(12 marks)
6. (Total = 12 marks)

Suppose we start with a positive integer $x$, and repeatedly apply the rules:

- If $x$ is even, then divide it by 2.
- If $x$ is odd, then multiply it by 3 and add 1.

stopping when $x$ reaches 1.

For example, if we start with 17, then we get the sequence of numbers:

$$17 \rightarrow 52 \rightarrow 26 \rightarrow 13 \rightarrow 40 \rightarrow 20 \rightarrow 10 \rightarrow 5 \rightarrow 16 \rightarrow 8 \rightarrow 4 \rightarrow 2 \rightarrow 1.$$  

(a) Write a method

```java
public int numSteps(int x)
```

that calculates the sequence starting at $x$ and returns the number of steps it takes to reach 1. For example, `numSteps(17)` should return the value 12, because it takes 12 steps for the sequence starting at 17 to reach 1.

(6 marks)

(b) Write a method that will allow the user to determine which positive integer less than or equal to 10000 gives the longest sequence. (You must specify both the method signature and its implementation.)

(6 marks)
7. Multiple Choice Questions [2 marks each]

(1) What is the value of the variable \( x \) after the following statement?
\[
\text{int } x = 7 + 5 \times 9 \div 4 - 10 \mod 3;
\]
A. 16
B. 15
C. 2
D. 15.25
E. (***\) 17

(2) Consider the following variable declaration:
\[
\text{Ship potemkin;}
\]
This declaration
A. has created a \texttt{Ship} object called \texttt{potemkin}
B. (***\) has created a variable called \texttt{potemkin}, but not a \texttt{Ship} object
C. is invalid because you cannot declare an object type without initializing it
D. initializes the variable \texttt{potemkin} to the value 0
E. has created an object of the class \texttt{potemkin}

(3) Which of the following statements is true about running Java programs on different types of machine.
A. Java source code is run directly by the JVM on each different type of computer.
B. Java source code is compiled into machine code, which is different for each type of machine.
C. Java source code is compiled into bytecode, which is a universal machine code that runs on all computers.
D. (***\) Java source code is compiled into bytecode, which is a special machine code for a virtual machine; this must then be run by a different program for each type of real computer.
E. Java source code is first translated into the language Oak, which is a special language used by BlueJ.
(4) Which of the following statements is true about the three types of loop of Java?

A. The for loop must be executed with a single exit condition.
B. (*** ) The do...while loop must be executed at least once.
C. The for loop must be executed at least once.
D. The while loop and do...while loop both have conditions for loop termination, so they might not be executed.
E. None of the above.

(5) You are writing a program for the Olympics Committee. The program needs variables to keep track of the name, gender, age, and specialty of each athlete. What are the most appropriate type to use for these variables?

A. String, String, double, String
B. String, char, double, String
C. String, String, int, double
D. (*** ) String, char, int, String
E. String, char, Integer, String

(6) What are the values of the boolean variables a, b, and c after execution of the following statements?

```java
a = true;
b = false;
c = (a && !b);
a = (a && b) || (a && !(b && !c) && !c);
b = !a && c;
```

A. true, true, true
B. false, false, true
C. true, false, true
D. (*** ) false, true, true
E. false, false, false
(7) In the Java statement

```java
double y = Math.pow(x, 2);
```

what is `pow()`?

A. A method belonging to the object `Math`
B. (***). A class method belonging to the class `Math`
C. A class variable from the class `Math`
D. An instance variable of the class `Math`
E. A constant value defined in the class `Math`

(8) In the method call

```java
System.out.println("hello world");
```

what does `out` refer to?

A. A class method belonging to the class `System`
B. (***). A class variable belonging to the class `System` referring to an object that has a method called `println()`
C. It is the "short name" for the class `System.out`; we could just use `out.println()` if we had imported the class `System`
D. By itself it does not mean anything — the class `System` has a method called `out.println()` that happens to contain a dot
E. A special instruction for BlueJ that is not part of the regular Java language

(9) Consider the following piece of code

```java
int x = 7/5;
int y = (-7)/5;
int z = 7%5;
```

What are the values of `x`, `y` and `z` after these declarations.

A. 1, -1, 1
B. 1.4, -1.4, 2
C. 1, -2, 2
D. (***). 1, -1, 2
E. 1.4, -1.4, 2
(10) The difference between the types `int` and `long` is that

A. `long` can only hold floating point numbers.
B. `long` can hold both integers and floating point numbers.
C. (***) `long` can hold larger integers than `int`.
D. `int` can hold larger integers than `long`.
E. None of the above.

(11) In a Java program, the word `false` is

A. (***) a literal of type `boolean`.
B. equivalent to the value 0.
C. a name that can be used for a variable.
D. a method of the class `boolean`.
E. not legal Java.

(12) Which of the following statements is **not true** about information hiding in object oriented programming?

A. It prevents “information overload”
B. It reduces complexity by restricting access on a “need to know” basis.
C. It is achieved, in part, by making instance variables `private`
D. (***) It makes it harder to call the methods of a class because the implementation details are hidden.
E. It makes it easier for teams of programmers to produce reliable software.

(13) What is the effect of the following Java statement

```java
Die[] dice = new Die[10];
```

A. A `Die` object representing a 10-sided die is formed
B. An array containing 10 newly constructed `Die` objects is formed
C. A label for an array is created, and initialized to the default value `null`
D. Ten labels, each referring to an array of objects of type `Die` are created.
E. (***) An array containing 10 `null` references is formed
(14) Consider the declaration

```java
int[] list = new int[n];
```

where \( n \) is a positive integer. What is the valid way to get the number of items in the array `list`.

A. `list.length()`  
B. `list.size()`  
C. `Array.length(list)`  
D. (*** )`list.length`  
E. `list.length-1`

(15) The class `UniBook` has the following instance variables:

```java
private String author;  
private String title;  
private int yearPublished;  
private double cost;
```

Suppose that you are asked to write, for a tester class, a method `getTotalCost` that computes the total cost of books owned by each student. Which of the following method signatures would be most appropriate for the method?

A. public void getTotalCost()  
B. private double getTotalCost()  
C. public double getTotalCost(double[] booklist)  
D. public double getTotalCost(UniBook book)  
E. (*** )public double getTotalCost(UniBook[] booklist)

(16) What is the value of the variable `d` after the following statements?

```java
double d = 0;  
int i = 1;  
while (i < 5) {
    d = d + (1/(double)i);  
    i = i * (-2);
}
```

A. This loop never terminates.  
B. 1.75  
C. (*** )0.625  
D. 0.75  
E. 1.875
(17) The class `String` contains a method that can be used to turn a `double` into a `String`.

    public static String valueOf(double d)
    {
        Returns a string representation of the double argument.
    }

Which of the following expressions uses this method to obtain the `String` representing the variable `double x`?

A. x.toString()
B. x.valueOf()
C. x.valueOf(x)
D. String(valueOf(x))
E. (***) String.valueOf(x)

(18) Suppose that a class `ClassA` has a method with the following signature:

    public static void method()

and we further suppose that variable `a` is declared and created in another class, `ClassB`, as follows:

    ClassA a = new ClassA();

Consider the following three Java statements that occur in a method belonging to `ClassB`. Which one is a valid Java statement?

1. ClassA.method();
2. a.method();
3. method();

A. 1 only.
B. 2 only.
C. (***) only 1 and 2.
D. only 1 and 3.
E. all of them.

(19) In Java code what does `red` refer to in the term

    java.awt.Color.red

A. It is a class method belonging to the class `java.awt.Color`.
B. It is a method belonging to the object `java.awt.Color`.
C. It is an instance variable belonging to the object `java.awt.Color`.
D. It is the name of a class in the package `java.awt.Color`.
E. (***) It is a class variable belonging to the class `java.awt.Color`. 
(20) Consider the following class, where each object represents an employee of a certain organization. The instance variable supervisor represents the supervisor of this employee (and is null for the CEO of the organization), while staff represents the number of staff who directly report to this employee. If this employee is an entry-level staff member, then he/she does not supervise anyone and has the value null for the variable staff.

```java
public class Employee {
    private Employee supervisor;
    private Employee[] staff;

    // irrelevant code omitted

    public int m() {
        if (this.staff == null) {
            return 1;
        } else {
            int total = 0;
            for (int i=0; i<staff.length; i++) {
                total = total + staff[i].m();
            }
            return total + 1;
        }
    }
}
```

If Employee jan represents the staff member Jan, then what does jan.m() calculate?

A. The number of levels above entry-level that Jan has reached.
B. (***) The number of staff subordinate to Jan (including Jan).
C. The number of staff who directly report to Jan.
D. The number of entry-level staff subordinate to Jan.
E. The number of staff subordinate to Jan (excluding Jan).