INSTRUCTIONS TO CANDIDATES

1. This examination paper consists of TWELVE (12) questions and comprises TWELVE (12) printed pages.
2. This is an OPEN BOOK examination.
3. Answer all questions.
4. Write your answers in the ANSWER SHEETS provided.
5. Fill in your Matriculation Number with a pen, clearly on every page of your ANSWER SHEETS.
6. You may use pencil to write your codes. Pen is preferred for other questions.
7. You must submit only the ANSWER SHEETS and no other document.
Q1. What is the output of the following code?

```java
int sum[][] = new int[4][4];
for (int k = 0; k < 4; k++) sum[k][0] = 1;
for (int k = 0; k < 4; k++) sum[0][k] = 1;
for (int m = 1; m < 4; m++)
    for (int n = 1; n < 4; n++)
        sum[m][n] = sum[m-1][n-1] + sum[m][n-1];
for (int n = 1; n < 4; n++)
    System.out.print(sum[3][n] + " ");
```

A. 2 4 6
B. 2 4 8
C. 2 4 10
D. 4 6 10
E. 4 10 20

Q2. What is the output of the following code?

```java
int a[] = {1, 1, 2, 3, 5, 8, 13, 21};
for (int n = 0; n < 5; n++) {
    a[n] = a[n+1];
    a[n+1] = a[n+2];
    a[n+2] = a[n+3];
    a[n+3] = a[n] + a[n+1] + a[n+2];
}
System.out.println(a[7]);
```

A. 42
B. 44
C. 78
D. 82
E. 84
Q3. Given the following definitions of classes AA and BB. What is the output of the Test program?

```java
class AA {
    private void f() {
        System.out.print("AA.f " );
    }

    protected void g() {
        System.out.print("AA.g ");
    }

    public void h() {
        f(); g();
        System.out.print("AA.h ");
    }
}

class BB extends AA {
    private void f() {
        System.out.print("BB.f ");
    }

    public void g() {
        System.out.print("BB.g ");
    }
}

class Test {
    public static void main( String[] args ) {
        BB bb = new BB();
        bb.h();
    }
}
```

A. BB.f BB.g AA.h  
B. AA.f AA.g AA.h  
C. BB.f AA.g AA.h  
D. AA.f BB.g AA.h  
E. The program causes compile-time error.
Q4. Which of the following code samples can be compiled successfully? Assume that all the classes are defined in separate files.

Sample 1

```java
class AA {
    public AA(int i) {
        System.out.print("AA");
    }
}
class BB extends AA {
    public BB(int i) {
        System.out.print("BB");
    }
}
```

Sample 2

```java
class CC {
    public CC(int i) {
        System.out.print("CC");
    }
}
class DD extends CC {
    public DD(int i) {
        super(i);
        System.out.print("DD");
    }
}
```

Sample 3

```java
class EE {
    // Empty
}
class FF extends EE {
    public FF(int i) {
        System.out.print("FF");
    }
}
```

A. Samples 1 and 2 only.
B. Samples 1 and 3 only.
C. Samples 2 and 3 only.
D. Samples 1, 2 and 3.
E. None of the above.
Q5. In the program fragment below, which of the outputs is the best estimated value?

```java
int N = 1000000;
int count = 0;
double x, y;
for (int i = 0; i < N; i++) {
    x = Math.random();
    y = Math.random();
    if (x*x + y*y <= 1.0 ) count++;
}
System.out.println( count*1.0 / N );
```

A. 0.5  
B. 0.785  
C. 1.0  
D. 3.142  
E. There is no way to estimate.

SECTION B (7 Questions: 80 Marks)

Q6. Which company developed the Java programming language? [1 mark]

Q7. Identifying errors [8 marks]
Assuming that the classes Pen, Paper and Pencil have been defined, identify the error(s) in each of the following code fragments.

(a) Identify the error(s) in the following code fragment. [4 marks]

```java
1. public class TeachingAssistant {
2.   // code omitted
3.   public void gradePaper (Paper paper, Pen pen) {
4.     // code omitted
5.   }
6. }
7. // new class
8. public class Professor {
9.   private TeachingAssistant ta;
10.  private Pen _pen;
11.   // code omitted
12.  public void giveTAWork (Paper paper) {
13.     ta.gradePaper (pen, paper);
14.  }
15. }
```
Q7. (continued…)  

(b) Identify the error(s) in the following code fragment.  [4 marks]

```java
1. public class Student {
2.     private Pencil _pencil;
3.     
4.     public Student() {
5.         // code omitted
6.         _pencil = new Pencil();
7.     }
8.     
9.     public void takeNotes() {
10.         this.write(Pencil _pencil);
11.     }
12. }
```

Q8. Outputs of codes [19 marks]

(a) What is the output of the following program fragment?  [2 marks]

```java
int n = 13;
switch (n) {
    case 1: System.out.println("Ace");
    case 11: System.out.println("Jack");
    case 12: System.out.println("Queen");
    case 13: System.out.println("King");
    default: System.out.println(n);
}
```

(b) What is the output of the following program fragment?  [5 marks]

```java
String str = "Java_is_fun";
for (int i = 0; i < str.length(); i++) {
    if ("aeiou".indexOf(str.charAt(i)) > -1)
        str = str.substring(0, i) + "*" +
            str.substring(i+1);
}
System.out.println(str);
```
Q8. (continued…)
(c) What is the output of the following program if the input $n$ is $1729$? [12 marks]

```java
import java.util.*;

class Digits {
    public static void main( String[] args ) {
        Scanner sc = new Scanner(System.in);
        System.out.print("Enter an integer: ");
        int n = sc.nextInt();

        System.out.println("Method M1: "+M1(n));
        System.out.println("Method M2: "+M2(n));
        System.out.println("Method M3: "+Integer.parseInt(M3(n)));
    }

    public static int M1 (int n) {
        int sum = 0;
        while (n > 0) {
            sum += n % 10;
            n /= 10;
        }
        return sum;
    }

    public static int M2 (int n) {
        int n1 = n;
        while (n1 >= 10) {
            n1 = 0;
            while (n > 0) {
                n1 += n % 10;
                n /= 10;
            }
            n = n1;
        }
        return n1;
    }

    public static String M3 (int n) {
        String s = new Integer(n).toString();
        String s1 = "";
        int len = s.length();
        for (int i = 0; i < len; i++)
            s1 += s.substring(len-i-1, len-i);
        return s1;
    }
}
```
Q9. **Resistor [10 marks]**

A resistor is a circuit device designed to provide a specific resistance between its two ends. Resistance is expressed in ohms ($\Omega$) or kilo-ohms ($k\Omega$). Resistors are usually marked with coloured bands that encode their resistance, as shown in figure 1 below. The first two bands represent digits and the third is a power-of-ten multiplier.

![Image of resistor with coloured bands](image)

Figure 1: Colour Bands of a resistor

The table below shows the number value of each band colour. For example, if the first band is red (represents 2), the second is black (represents 0), and the third is orange (represents 3), the resistance is $20 \times 10^3 \Omega$ or 20 k$\Omega$.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Number Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0</td>
</tr>
<tr>
<td>Brown</td>
<td>1</td>
</tr>
<tr>
<td>Red</td>
<td>2</td>
</tr>
<tr>
<td>Orange</td>
<td>3</td>
</tr>
<tr>
<td>Yellow</td>
<td>4</td>
</tr>
<tr>
<td>Green</td>
<td>5</td>
</tr>
<tr>
<td>Blue</td>
<td>6</td>
</tr>
<tr>
<td>Violet</td>
<td>7</td>
</tr>
<tr>
<td>Grey</td>
<td>8</td>
</tr>
<tr>
<td>White</td>
<td>9</td>
</tr>
</tbody>
</table>

A `Resistor` class containing the default constructor is provided on the next page. You are to fill in the other constructor, which takes in three strings representing the three band colours, calculates and sets the resistance for the resistor. You may write other methods necessary to calculate the resistance. You do not need to write the main method. You may assume that the three colour strings are correct in spelling but may be a mixture of upper-case and lower-case letters.

For example, a sample application code using the resistor class may be as follows:

```java
Resistor resistor1 =
    new Resistor( "black", "GREEN", "oRangE" );
System.out.println(resistor1.getResistance());
```
Complete the constructor `Resistor(String b1, String b2, String b3)`. You may write additional methods to support the constructor. [10 marks]

```java
public class Resistor{

    private static String[] colour = {
            "black","brown","red","orange","yellow",
            "green","blue","violet","grey","white"};

    // data members
    private String band1;
    private String band2;
    private String band3;
    private double value;  // Resistor value (Ohms)

    // default constructor
    public Resistor(){
    }

    // Constructor taking three strings as parameters
    // and calculating the resistance
    public Resistor(String b1, String b2, String b3){

        // *** to be completed ***
    }

    // set the resistance value
    public void setResistance(double val){
        this.value = val;
    }

    // get the resistance
    public double getResistance(){
        return this.value;
    }
}
```
Q10. Overlapping Rectangles [27 marks]

The code below defines a `MyRectangle` class with four public data members representing the x- and y-coordinates of the bottom-left vertex and top-right vertex of a rectangle, whose sides are parallel to the x- or y-axis.

```java
class MyRectangle {

    // Data members
    public int vertex1X; // x-coordinate of bottom-left vertex
    public int vertex1Y; // y-coordinate of bottom-left vertex
    public int vertex2X; // x-coordinate of top-right vertex
    public int vertex2Y; // y-coordinate of top-right vertex

    // Constructor
    public MyRectangle(int v1X, int v1Y, int v2X, int v2Y) {
        vertex1X = v1X;
        vertex1Y = v1Y;
        vertex2X = v2X;
        vertex2Y = v2Y;
    }

    // Returns area of rectangle
    public int area() {
        //******/ to be completed – refer to part (a) ******/
    }

    // Returns the overlap region of this and rect
    public MyRectangle overlap(MyRectangle rect) {
        //******/ to be completed – refer to part (b) ******/
    }

    // Returns the overlap region of all rectangles
    // in the array
    public static MyRectangle overlapAll(MyRectangle[] rectangles) {
        //******/ to be completed – refer to part (c) ******/
    }

    // Returns string representation
    public String toString() {
        //******/ to be completed – refer to part (e) ******/
    }
}
```
Q10. (continued…)

For example, the statement `new MyRectangle(20,80,30,90)` creates a rectangle with bottom-left vertex at position (20,80), and top-right vertex at (30,90).

(a) Complete the `area()` method, which computes the area of a rectangle. [3 marks]

(b) Complete the `overlap(MyRectangle rect)` method. This method returns a rectangle which is the overlapped region of two rectangles. In the event that there is no overlap, it should return a rectangle with both bottom-left vertex and top-right vertex at position (0,0). [9 marks]

(c) Using the `overlap(MyRectangle rect)` method written above, complete the `overlapAll(MyRectangle[] rectangles)` method which returns the overlapped region of all the rectangles in the array. You may assume that there is at least one element in the array.

Your method should be efficient in that the moment it finds that the overlapped region is empty, it should return a rectangle with both vertices at (0,0) immediately. [9 marks]

(d) In the following code `MySquare.java`, `MySquare extends MyRectangle`.

```java
import java.util.*;

class MySquare extends MyRectangle {
    public MySquare(int xCoord, int yCoord, int length) {
        //******/ to be completed – refer to part (d) ******/
        super( . . . );
    }

    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        int x = sc.nextInt(); // x-coord of bottom-left corner
        int y = sc.nextInt(); // y-coord of bottom-left corner
        int len = sc.nextInt(); // length of side

        MySquare square = new MySquare(x, y, len);
        System.out.println(square);
        System.out.println("Area = "+square.area());
    }
}
```

A square is defined by its bottom-left vertex and the length of its side. Complete the `super( . . . )` statement in the constructor. [3 marks]

(e) Below is output of `MySquare.java` program when the user enters: 10 30 5.

```
Class MySquare: [(10,30); (15,35)]
Area = 25
```

Complete the `toString()` method in `MyRectangle` in order to get such output. [3 marks]
Q11. Recursion [10 marks]

The Conway’s recursive sequence is defined by the following recurrence relation for positive integer \(n\).

\[
a(n) = \begin{cases} 
1 & \text{if } n \in \{1,2\} \\
(a(a(n-1)) + a(n-a(n-1)) & \text{otherwise}
\end{cases}
\]

(a) Write a recursive method for the sequence. [4 marks]

(b) What is the value of \(a(5)\)? [2 marks]

(c) What is the total number of recursive methods activated when evaluating \(a(5)\)? [2 marks]

(d) What is the maximum number of activations of the recursive method at any instance of time when evaluating \(a(5)\)? [2 marks]

Q12. Recursion [5 marks]

You are given the following methods:

```java
static String r(int m) {
    if (m > 0)
        return "+" + r(m-1);
    else
        return "";
}

static String s(int m, int n) {
    if (n > 0)
        return "-" + s(m,n-1) + "-";
    else
        return r(2*m);
}
```

Write the output for the following statement:

```java
System.out.println( s(3,2) );
```

[5 marks]