1. Find, and correct, three syntax errors in the following program.

```
public class Incorrect
   public static void main(String[] args)
   {  x = 3;
      System.out.println( "the value of x is " x );
      System.out.println( "is that OK?" )
   }
}
```

2. Suppose someone has defined for us a class called `Random`. For each of the following parts, write a *single* line of Java that does what is described by the sentence.

   (a) Declare `r` to be a reference variable of type `Random` and assign to `r` a `Random` object.

   (b) Declare a variable of type `int` and assign to it the result of sending the object named `r` the `nextInt` message with parameter 10.

   (c) Send the object named `r` the `nextDouble` message with no parameter and have the result printed in a console window.

3. If `a` is an array, what happens if the following statement is executed? Briefly explain why.

```
System.out.println(a[a.length]);
```

4. Each of the following two program segments prints out the first ten integers. What would be the output of each program segment if we had forgotten to include the pair of braces from each of them? (Without the braces, the body of each loop would be just one statement.) Explain your answer.

```
int n = 10, i = 1;                    int n = 10, i = 0;
while (i <= n)                        while (i < n)
{  System.out.println("i=" + i);     {   i = i + 1;
   i = i + 1;                            System.out.println("i=" + i);
}                                    }
```

5. What does the following program segment print out? Write a `for`-loop that produces the same output. (Your `for`-loop does not need to be equivalent to this `while`-loop. It just needs to produce the exact same print out.)

```
int index = 0;
while (index < 10)
{  index++;
   System.out.println(index);
   index++;
}
```

6. Draw a picture of Java's memory after the following two lines of code are executed.

```
Color[][] c = new Color[3][2];
c[1][0] = new Color( Color.red );
```

7. Suppose that `a` and `b` are arrays of integers. What is the value of `b[0]` and `b[1]` after the following statements have been executed? Explain why. Your explanation should include a simple drawing of Java's memory.

```
a[0] = 1;
b[0] = 2;
b = a;
b[1] = 3;
a[1] = 4;
```

8. What does the following program print? Justify your answer by showing the values of all of the program variables for each iteration of the `for`-loop. (That is, make a table with columns x, y, and `total` and one row for each iteration of the `for`-loop.)

```
public class Mystery
{  public static void main(String[] args)
   {  int y;
      int total = 0;
      for (int x = 1; x <= 10; x++)
      {  y = 2 * x;
         System.out.println( y );
         total = total + y;
      }
      System.out.println( "Total is = " + total );
   }
}
```

9. Suppose that we define the following two classes.

```
public class Class1                      public class Class2
{                                        {
   int x = 10;                              static int x = 0;

   public int methodA(int y)                public static int methodA()
   {  return y + this.x; }                  {  return x; }

   public void methodB(int y)               public static void methodB(int y)
   {  this.x = y + this.x; }                {  x = y; }
}                                        }
```

Draw a map of Java's memory after the execution of the following code (in, for example,
DrJava's interactions pane). Be sure that your memory map includes the (final) values
of all the object and class variables. Clearly denote in your drawing any non-referenced
objects that will be garbage collected.

```
> Class1 ref1 = new Class1();
> Class1 ref2 = new Class1();
> Class1 ref3 = ref2;
> int x = 5;
> ref1.methodB(x);
> ref2.methodB( ref1.methodA(2) );
> ref1 = ref3;
> Class2.methodB( ref1.methodA(Class2.methodA()) );
```

10. What is the output from the following program segment?

```
for (int i = 2; i <= 5; i++)
   for (int j = 5; j > i; j--)
      System.out.println(i + " and " + j);
```

11. What is printed out by the following program segment?

```
for (int i=0; i < 4; i++)
{  for (int j=0; j < 5; j++)
      if ((i+j) % 2 == 0)
         System.out.print("0 ");
      else
         System.out.print("1 ");
   System.out.println();
}
```

12. Consider the following program segment.

```
if ( p < 0 )  System.out.println( "p is negative" );
if ( p == 0 ) System.out.println( "p is zero" );
if ( p > 0 )  System.out.println( "p is positive" );
```

(a) Rewrite the above code fragment using nested `if-else` statements

(b) Explain why your rewritten code fragment is more efficient than the original code fragment.

13. For each of the two program segments below, explain the possible values that `s` can have after the three lines are executed.

```
int s = 0;                    int s = 0;
if (x > 0) s++;               if (x > 0) s++;
if (y > 0) s++;               else if (y > 0) s++;
```

14. Find the error in the following if-statement and correct it.

```
if (x && y == 0)
    System.out.println("That's the origin.");
```

15. Explain what the following program segment does, and then correct it so that it does what it was meant to do. (Hint: Add a pair of braces { and }.)

```
if (x == y)
    if (x == 0)
        System.out.println("x and y are both zero.");
else
    System.out.println("x and y are not equal.");
```

16. What is the output from the following program segment?

```
for (i = 2; i <= 5; i++)
    for (j = 5; j > i; j = j-1);
        System.out.println(i + " and " + j);
```

17. Write a code fragment that declares and constructs an array, and then uses a loop to initialize the array with the following list of numbers:

1, 4, 9, 16, 25, 36, 49, 64, 81, 100.

18. The following program segment initializes a 2-dimensional array m. What are the contents of m after this program segment is executed? You can give your answer by writing m as a matrix.

```
int SIZE = 4;
int[][] m = new int[SIZE][SIZE];
for (int i=0; i < SIZE; i++)
   for (int j=0; j < SIZE; j++)
      if (i > j)
         m[i][j] = i * j;
      else
         m[i][j] = -i * j;
```

19. Write a code fragment, using nested for-loops, whose output in the console will look like the following. Your code fragment does not need to be a complete program, it just needs to output these six lines. (Hint: *Don't* try to compute the output numbers from the loop indices. To get the output numbers, just have a counter that counts up from 10, and print out the counter.)

```
10
11 12
13 14 15
16 17 18 19
20 21 22 23 24
25 26 27 28 29 30
```

20. What is printed out by the following code fragment? Also, indicate which of the following boolean operators get short circuited.

```
boolean b1 = true;
boolean b2 = false;
if ( b1 || !b1 )
   System.out.println("One.");
if ( !b1 && b1 )
   System.out.println("Two.");
if ( !b2 && b1 )
```

```
    System.out.println("Three.");
if ( !(b1 || !b2) )
    System.out.println("Four.");
if ( !(b1 && b2) )
    System.out.println("Five.");
if ( (!b2 || b1) && b1 )
    System.out.println("Six.");
```

21. Write a method that computes the mathematical function

$$f(x, y) = xy - \frac{x^2 + 1}{2y}$$

where x and y are real numbers.

22. Write a method that has as its input an integer **n** and a double **x**, and returns **true** if **x** is between **n** and **n+1**, and returns **false** otherwise.

23. The body of the following method has three statements. Rewrite the body so that it has just a single statement which is the simplest statement that will work.

```
private static boolean isInside(int n)
{   boolean inside = false;
    if ( 0 < n && n < 100) inside = true;
    return inside;
}
```

24. The following code segment creates and initializes a two dimensional ragged array. Draw two representations for the array and its contents. One picture should represent the array as most people think about it, as a two dimensional array with rows and columns. The other picture should represent how Java actually stores the array.

```
int[][] a = new int[6][];
for (int i = 0; i < 3; i++)
{   a[i]   = new int[i+1];
    a[5-i] = new int[i+1];
    for (int j = 0; j < a[i].length; j++)
    {   a[i][j]   =    10*i + (j+1);
        a[5-i][j] = 10*(5-i) + (j+1);
    }
}
```

25. Here are two code fragments. Below are three pictures. These fragments draw two of the three pictures. Determine which fragment draws which picture. Explain your answer by detailing which part of the if-statements draw which part of the pictures. Be very specific about how you can tell which fragment draws which picture.

```
// assume that n is odd
for (int i = 1; i <= n; i++)
{ for (int j = 1; j <= n; j++)
  {
    if (i==1 || i==n ||
        j==1 || j==n ||
        (i==(n/2)+1 && j>=(n/2)+1) ||
        (i==j && i<=(n/2)+1) )
      System.out.print("*");
    else
      System.out.print(" ");
  }
  System.out.println();
}
```

```
// assume that n is odd
for (int i = 1; i <= n; i++)
{ for (int j = 1; j <= n; j++)
  {
    if (i==1 || i==n ||
        j==1 || j==n ||
        (i==(n/2)+1 && j<=(n/2)+1) ||
        (i==j && i>=(n/2)+1) )
      System.out.print("*");
    else
      System.out.print(" ");
  }
  System.out.println();
}
```

```
***************         ***************         ***************
*             *         **            *         *     *       *
*             *         * *           *         *     *       *
*             *         *  *          *         *     *       *
*             *         *   *         *         *     *       *
*             *         *    *        *         *     *       *
*             *         *     *       *         *     *       *
********      *         *      ********         *     *       *
*      *      *         *             *         *   *         *
*       *     *         *             *         *  *         *
*        *    *         *             *         * *          *
*         *   *         *             *         *          * *
*          * *          *             *         *         * *
*           **          *             *         *          **
***************         ***************         ***************
```

26. Suppose that we have defined a class Rectangle with a default constructor. Write a code segment that creates an array of 100 Rectangle references and then initializes the array with default Rectangle objects.

27. Suppose I have defined a class called Thing. The following line performs three distinct steps. What are they? How would you rewrite this single line as two lines? What distinct steps do each of those two lines perform?

```
Thing rose = new Thing();
```

28. Below is the outline of a simple class called `BusyWork`. In the blank space provided in the class, add two methods to the class. The two methods that you add can make use of the two given methods `setNumber()` and `getNumber()`.

   (a) Add a mutating method `increment()` that adds 1 to the value of `m`.

   (b) Add a (non-mutating) returning method `decrement()` that returns a `BusyWork` object whose value of `m` is one less than the value stored in the calling object.

```
public class BusyWork
{
    int m = 0;

    public void setNumber(int newM)
    {
        this.m = newM;
    }

    public int getNumber()
    {
        return this.m;
    }



}//BusyWork
```

29. Consider this code that creates some `Location` objects:

```
Location a, b, c;
a = new Location(10,20);
b = new Location(10,20);
c = b;
```

After this code executes, what are the values of these boolean expressions?

```
a==b
a.equals(b)
a==c
a.equals(c)
b==c
b.equals(c)
```

Also, write two clear sentences that explain the difference between `==` and the `equals()` method.

30. The following questions refer to the `Rectangle` class shown below.

```
class Rectangle
{
   private int width, height;

   public Rectangle(int width, int height)
   {  this.width = width;
      this.height = height;
   }
   public int getWidth() { return this.width; }
   public int getHeight() { return this.height; }
   public void setWidth(int width) { this.width = width; }
   public void setHeight(int height) { this.height = height; }
   public int computeArea() { return this.width * this.height; }
}
```

(a) Is an object of type `Rectangle` mutable or immutable? Explain why.

(b) After the following statements have been executed, how many `Rectangle` objects will exist, not counting garbage objects? Explain your answer by drawing a memory map.

```
Rectangle rect1 = new Rectangle(100,200);
Rectangle rect2 = new Rectangle(50,75);
Rectangle rect3 = rect2;
rect2 = rect1;
rect1 = null;
```

(c) After the following statements have been executed, how many `Rectangle` objects will exist, not counting garbage objects? Explain your answer by drawing a memory map.

```
Rectangle rect1 = new Rectangle(200,50);
Rectangle rect2 = new Rectangle(100,100);
Rectangle rect3 = rect2;
rect2 = null;
rect1 = rect2;
```

31. What does the following program print out? Explain why.

```
public class Mystery
{
   public static void doSomething(int i)
   {  System.out.println("my int is " + i); }

   public static void doSomething(double x)
   {  System.out.println("my double is " + x); }

   public static void main(String[] args)
   {  double z = 3.21;
      int k = -2;
      doSomething( z );
      doSomething( (int)z );
      doSomething( k );
      doSomething( (double)k );
   }
}
```

32. Consider the following class definition. The public interface of this class is that it has three fields named `area`, `length`, and `WIDTH` (which is a public constant), but the implementation should be that the class contains a single (private) double `area`. Write implementations for the constructor and the two set and the two get methods in such a way that `length` is derived from the variable `area`.

```
class RestrictedRectangle
{
   public final double WIDTH = 3.0;
   private double area;

   public RestrictedRectangle(double length)
   {

   }

   public double getArea()
   {

   }

   public double getLength()
   {

   }

   public void setArea(double area)
   {

   }

   public void setLength(double length)
   {

   }
}
```

33. Write a definition for a class `Point` that contains two private data fields, called `x` and `y`, of type `double`. The class should have two constructors, a default one and a constructor that takes two doubles. Objects of this class should be immutable. Provide appropriate get methods and a `toString()` method.

34. Write a method called `sumSubArray` that accepts an array of doubles and two ints. If the two ints are valid indices, then the method should return the sum of the values stored in the array whose indices are between the two ints (inclusive). If the two ints are not valid indices, then the method should return zero.

35. Suppose we have a class `A` which has a constructor that takes a single integer.

   (a) After the following statements have been executed, how many `A` objects will exist (not counting garbage objects) and which objects are they? Explain your answer. (Hint: It helps to draw a picture.)

```
A a = new A(100);
A b = new A(150);
A c = b;
b = a;
a = null;
```

(b) After the following statements have been executed, how many **A** objects will exist (not counting garbage objects) and which objects are they? Explain your answer.

```
A a1 = new A(200);
A a2 = new A(250);
A a3 = a2;
a2 = a1;
a1 = null;
```

36. Here is a simple **Point** and **Circle** class.

```
class Point                                      class Circle
{   private double x, y;                         {   private Point c;   // center
                                                     private double r; // radius
    public Point(double x, double y)
    {   this.x = x;                                  public Circle(Point c, double r)
        this.y = y;                                  {   this.r = r;
    }                                                    this.c = c;
    public double getX(){ return x; }                }
    public double getY(){ return y; }                // more stuff
}                                                }
```

(a) The constructor in **Circle** has a "privacy leak". Explain why.
   Hint: Consider the following code.
```
        Point p = new Point(1,2);
        Circle c = new Circle(p, 10);
        p.setX(100);
```

(b) Rewrite the **Circle** constructor to fix this problem.

37. Suppose that we have classes **A**, **B**, **C** and **D**. Suppose that **B** is a subclass of **A**, that **C** is a subclass of **B**, and **D** is a subclass of **A**. Suppose that we make the following declarations.

```
    A a1 = new A();
    A a2 = new C();
    D d1 = new D();
```

For each part below, explain what, if any, errors would be caused by the statement in that part (be sure to consider both compile time and run time errors).

(a)   `A a3 = new B();`

(b)   `B b1 = new A();`

(c)   `B b2 = (B) a1;`

(d)   `B b3 = (B) a2;`

   (e)   `B b4 = (B) d1;`

38. Suppose that

    ```
    x = y;
    ```

    is a "widening" assignment.

    (a) If `x` and `y` are primitive variables, explain why the assignment can also be referred to as a "widening conversion".

    (b) If `x` and `y` are reference variables, how are the types of `x` and `y` related to each other?

    (c) If `x` and `y` are reference variables, explain why the assignment should not be referred to as a "conversion".

    (d) If `x` and `y` are reference variables, you can even make a case that the assignment should be called a "narrowing" assignment. Explain why. (Hint: What can you say about the methods callable on `x` as compared to the methods callable on `y`?)

39. Let `A` be an array of size $n \geq 2$ containing integers from 1 to $n-1$, inclusive, with exactly one number repeated.

    (a) Write a method
        ```
        public static int findRepeatedNumber(int[] A)
        ```
        that returns the value of the repeated number in the array `A`.

    (b) Rewrite the method so that it uses just a sinlge loop. (Hint: Make use of another array.)

40. (a) What do method overloading and method overridding have in common?

    (b) Give two ways in which method overloading and method overridding are different.

41. (a) Explain the meaning of the keywords `super` and `this` when they are used as method names.

    (b) Explain the meaning of the keywords `super` and `this` when they are used as a "calling object."

42. Only one of the following four class definitions defines a proper abstract class. Which one of the four is it? For the remaining three classes, briefly explain why it does not properly define an abstract class.

    ```
    class A1 {
        abstract void unfinished();
    }

    abstract class A2 {
        abstract void unfinished(){ }
    }

    abstract class A3 {
        abstract void unfinished();
    }

    abstract class A4 {
        private abstract void unfinished();
    }
    ```