Practice Questions for Final Exam:
Advanced Java Concepts
+ Additional Questions from Earlier Parts of the Course

1. Given the following hierarchy:
   ```java
class Alpha {
    ...
}
class Beta extends Alpha {
    ...
}
class Gamma extends Beta {
    ...
}
```
In what order are the constructors for these classes called when a Gamma object is instantiated?

2. What class is a superclass of every other class? What does one need to do to use methods inherited from that class.

3. A superclass reference can refer to a subclass object. True or False?
   A subclass reference can refer to a superclass object. True or False?
   Show an example of the true scenario? (Do not define classes, just state which class inherits from which and then write a statement that illustrates one or both of the cases above.)

4. Explain what extends keyword is used for.

5. Show how to open a file for reading characters.

6. How many classes can extend a superclass? How many superclasses can a class extend?

7. Show the output of following program:
   ```java
   public class Test {
      public static void main(String[] args) {
         A a = new A(3);
      }
   }
   class A extends B {
      public A(int t) {
         super();
         System.out.println("A’s constructor is invoked");
      }
   }
   class B {
      public B() {
         System.out.println("B’s constructor is invoked");
      }
   }
   ```

8. Answer the following multiple choice questions. There might be more than one correct answer - mark all that apply.
   (a) A subclass inherits ____________ from its superclass.
      i. private methods
      ii. protected methods
      iii. public methods
      iv. static methods
   (b) When you implement a method that is defined in a superclass, you __________ the original method.
      i. overload
ii. override
iii. copy
iv. call

(c) What is the output of running the class C.

```java
class C {
    public static void main(String[] args) {
        Object o1 = new A();
        Object o2 = new B();
        System.out.print(o1);
        System.out.print(o2);
    }
}
```

```java
class A extends B {
    public String toString() {
        return "A";
    }
}
```

```java
class B {
    public String toString() {
        return "B";
    }
}
```

i. AB
ii. BA
iii. BAB
iv. ABA
v. None of above

(d) If a class named Student has a constructor `Student(String name)` defined explicitly, the following constructor is implicitly provided.

i. public Student()
ii. protected Student()
iii. private Student()
v. None

9. Design a class named Person and its two subclasses named Student and Employee. A person has a name and email address. A student has a GPA. An employee has an office number and a salary. Override the `toString` method in each class to display the class name and the person’s name.

10. Consider the following code.

```java
public class Division {
    public static void main(String[] args) {
        Scanner in = new Scanner(System.in);
        int num1 = 0, num2 = 0;
        try {
            System.out.println("Please enter two integers to divide:");
            System.out.print("numerator: ");
            num1 = in.nextInt();
            System.out.print("\n denominator: ");
            num2 = in.nextInt();
            System.out.printf("The quotient of %d and %d is \d\n", num1, num2, num1/num2);
        }
    }
}
```
What is the output when user enters
(a) 10 and 5
(b) 12 and 5
(c) 12 and 0
(d) 11 and 5.5

11. Write a CalendarDate class that has two private data fields day, and month. Your class should have
   • a default constructor that sets the date to a random day in May (May has 31 days)
   • compareTo method (remember that it returns 0 when two CalendarDate objects are equal, a number < 0 when this
     object is smaller than the parameter object, and a number > 0 when this object is greater than the parameter object)

12. Write a checkDate() method that given an array of CalendarDate objects (as defined in question 11) and another
    CalendarDate object returns true if the object is in the array, and false otherwise.

13. Write a program that opens the file European_capitals.txt whose content is reprinted below:

    Paris 2243833
    Amsterdam 1108297
    Warsaw 1715517
    Rome 2645907
    Prague 1262106
    London 8308369
    Berlin 3415091

    The file contains names of several capitals and their population size. You can assume that there is a single space
    between the name of the city and the number. You can assume that each city is listed on a new line. Your program should
    read in the data from this file into two arrays (one of type String, the other of type int).
    You program should display the following information:
    • name of the city with smallest population
    • name of the city with largest population
    • total population size for all the cities.
    Make sure that the two arrays remain in sync as you are doing this.

14. For the purpose of this question, assume that you are developing static methods for your own statistics library MyStats
    (it is similar to the Java’s Math library that you have been using throughout the semester).

    (a) Write a public static method threeEqual() for MyStats that takes three int values as arguments and returns true
        if all three numbers are equal, false otherwise.
10. Write a public static method median() for MyStats that takes as an argument an array of sorted integer values and returns the middle value. Your method should first verify if the array is sorted, and if it is not it should throw an IllegalArgumentException.

11. Give a single Java expression that a client of MyStats could use to test whether the medians of three arrays of integer values int[] a, int[] b, and int[] c are all equal.

15. Consider the following program.

   ```java
   public class Mystery {
       public static void main(String[] args) {
           int N = args.length;
           String[] a = new String[N * 2];
           for (int i = 0; i < N; i++) {
               a[i] = args[i];
               a[i + N] = args[N - i - 1];
           }
           for (int i = 0; i < a.length; i++)
               System.out.println(a[i] + " ");
           System.out.println();
       }
   }
   ```

   (a) What does this program print out when the following command is executed (from the command line)?
   java Mystery aaa bbb ccc

   (b) What does this program print out when the following command is executed (from the command line)?
   java Mystery xxxx yyyy

16. Consider the following program, which is supposed to read in integer N from standard input, read N strings from standard input, and print them to standard output in reverse order.

   ```java
   public class ReverseInputBuggy {
       public static void main(String[] args) {
           java.util.Scanner in = new java.util.Scanner(Std.in);
           int N = in.nextInt();
           String s;
           for (int i = 1; i < N; i++)
               s[i] = in.next();
           for (int i = N; i >= 0; i--)
               System.out.println(s[i]);
       }
   }
   ```

   This program has three bugs.

   (a) Which bug prevents the program from compiling successfully? Identify the line number where the bug appears and give a correct version of this line of code.
   Line number ______
   Correct version:

   (b) After fixing the first bug, which bug causes the program to crash? Identify the line number where the bug appears and give a correct version of this line of code.
   Line number ______
   Correct version:

   (c) After fixing the first two bugs, which bug causes the program to produce incorrect output? Identify the line number where the bug appears and give a correct version of this line of code.
   Line number ______
   Correct version:
17. Implement the Java class `Digits`, which allows you to access a number by its individual digits. Here is the complete interface:

```java
public class Digits {
    // create Digits version of num
    public Digits(int num) { ... }

    // gets digit i of the number, such that digit 1 is the left-most digit, and digit numDigits() is the right-most digit
    public int getDigit(int i) { ... }

    // returns the number of digits in the number
    public int numDigits() { ... }

    // returns the integer itself
    public int getInt() { ... }
}
```

Here's an example of using the class:

```java
Digits zero(0);
System.out.println(zero.numDigits() + " " + zero.getDigit(1)); // prints: 1 0

Digits digits(5207);
System.out.println(digits.numDigits()); // prints: 4
System.out.println(digits.getDigit(1) + " " + digits.getDigit(3)); // prints: 5 0
System.out.println(digits.getInt()); // prints: 5207
```

Hint: the modulus (%) and integer division operators will be useful in your implementation.

18. Write the Java function `lengthOfSortedSequence` which returns the length of the longest sorted sequence in an array. For this problem a sorted sequence is a sequence of non-decreasing values. Here are some examples:

<table>
<thead>
<tr>
<th>array</th>
<th>return value from <code>lengthOfSortedSequence(array)</code></th>
</tr>
</thead>
<tbody>
<tr>
<td>[-7 3 99 -10 0 0 43 10 20 30 5]</td>
<td>4</td>
</tr>
<tr>
<td>[-1, 2, 3, 5]</td>
<td>4</td>
</tr>
<tr>
<td>[5, 2, 1]</td>
<td>1</td>
</tr>
<tr>
<td>[1]</td>
<td>1</td>
</tr>
<tr>
<td>[]</td>
<td>0</td>
</tr>
</tbody>
</table>

19. Write a Java class `Point` that represents (x,y) point in a plain. The class should implement `Comparable` interface. The points should be compared based on their distance from the origin (point (0,0)). The distance from the origin can be computed using

\[
distance = \sqrt{x^2 + y^2}.
\]

Your class should implement all methods needed for the following code to compile and run successfully:

```java
Random r = new Random;
Point[] myPoints = new Point[10];
for (int i = 0; i < myPoints.length; i++)
    myPoints[i] = new Point(r.nextDouble(), r.nextDouble());
Arrays.sort(myPoints);
```
You do not need to provide any additional methods.

20. Implement the static method `mode`, which returns the value that occurs most often in an array of integers. You may assume the array has at least one element, and all of the values in the array are in the range 0 - 100. If there is more than one value that occurs most often, return the smallest such value (See Example 2 below). Here are some examples:

Example 1: array contains 99 86 99 99 86, `mode(array)` returns 99
Example 2: array contains 23 15 15 74 23, `mode(array)` returns 15
Example 3: array contains 76, `mode(array)` returns 76

For full credit, your answer must only traverse the data in array once. **Hint:** you are allowed to use additional memory.

21. For each of the following Java definitions, fill in the question marks (???) such that the given main class always prints the number 42. If it's not possible to do this, then explain why. Keep your answers as simple as possible.

(a)```java
class C {
    public int foo() {
        return 10;
    }
}
class S extends C {
    ????
}
class Main {
    public static void main(String[] args) {
        S x = new S(42);
        System.out.println(x.foo());
    }
}
```(b)```java
class C {
    private int x;
    public C(int x) {
        this.x = x;
    }
    public int foo() {
        return x;
    }
}
class S extends C {
    public S() {
        ????
    }
}
class Main {
    public static void main(String[] args) {
        S x = new S();
        System.out.println(x.foo());
    }
}
```(c)```java
class C {
    ????
}
class Main {
    public static void main(String[] args) {
        C x = new C();
        C y = new C();
        System.out.println(x.get() + y.get() + 1);
    }
}
```
22. Write the method `sumSeries()` that given an integer argument `n` will return as a double the following sum:

\[
\frac{1}{n} + \frac{2}{n-1} + \frac{3}{n-2} + \ldots + \frac{n-1}{2} + \frac{1}{n}
\]

**Do not write a full program with input and output, just the method.**

Hints/Notes:
- You need only a single loop.
- The return value is a `double`, make sure that as the sum is computed using double division and not integer division.
- You don’t need to check for valid values of `n`, assume it’s an integer > 0.

23. Define a class `PongBall` that is used for a `Pong` game (just like the one you implemented for one of the assignments). The class should have data fields representing its x and y coordinates of the center, and two data fields that indicate increments in both x and y directions when the ball moves. It should have a constructor that initializes the ball’s position to a random location within a window that is 300x300 pixels - you need to decide if this constructor requires any parameters or not. The increments in both x and y directions should be set to 2. Provide a `move()` method that adjusts the ball’s position (you do not need to worry about the boundary conditions) and draws the ball in its new position in the window.

24. What would be printed by the following programs?

(a) `public class CatsAndDogs {
```java
public static void main(String[] args) {
    foo("Cats and Dogs", 4);
}
```
```java
public static void foo(String s, int n) {
    if (n <= 1)
        System.out.println("Cats");
    else {
        System.out.println(s);
        foo(s, n-1);
    }
}
```
}

(b) `public class Numbers {
```java
public static void main(String[] args) {
    int[] list = {1, 2, 3, 4, 5};
    System.out.println(foo(list, 0, list.length-1));
}
```
```java
public static int foo(int[] nums, int begin, int end) {
    if (begin == end)
        return nums[begin];
    else
        return nums[begin] + foo(nums, begin+1, end);
}
```
}

25. Write an iterative and recursive implementation of a method that given two values: a real number `x` and an integer `y`, computes the value of `x^y`.

Given the following recursive method, answer the short questions below:

```java
int puzzle(int base, int limit)
{
    if (base > limit)
```
4    return -1;
5    else if (base == limit)
6        return 1;
7    else
8        return base * puzzle(base + 1, limit);
9  }

What would be printed by the following calls to the recursive method (write your answer next to each statement):

System.out.println( puzzle(5, 2) );
System.out.println( puzzle(2, 5) );
System.out.println( puzzle(0, 0) );

Which lines of code contain the base case(s)?
Which lines of code contain the general/recursive case(s)?
What is the total number of calls made to puzzle method when calculating puzzle(5, 2) (include the initial call)?
What is the total number of calls made to puzzle method when calculating puzzle(2, 5) (include the initial call)?

26. What is the problem with the following recursive method to compute a^n, for positive integer n?

```java
public static double exponent(double a, int n) {
    return a*exponent(a, n-1);
}
```

Describe briefly how this should be fixed. Your solution should still use recursion.