

CS 2112 Fall 2022

Assignment 1

Introduction to Java

Due: Thursday, Sept 8, 11:59PM

This assignment is an introduction to the Java language and basic programming concepts to help you become familiar with Java syntax, the Java class library, and certain important language constructs.

Updates

- 8/26 - Fixed typos in spec.

1 Instructions

Read all these instructions carefully and make sure you understand them before you begin. If there is anything you are not sure about, read carefully and think about the handout. If necessary, ask for a clarification on [Ed](#). If there is any genuine ambiguity in the assignment, you are free to resolve it in a reasonable way, provided you clearly identify the ambiguity and can justify your approach.

This first CS 2112 assignment is very explicit about what you need to do. In the future, much more of the design will be left up to you. Nevertheless, you should get an early start, because there will be one-time startup costs, such as getting the JDK and Eclipse installed on your machine, figuring out how to navigate the Java class library, and learning where to go for help. Getting started early ensures you have plenty of time to surmount unexpected difficulties that arise.

1.1 Grading

Submissions will be graded for both correctness and style. A correct program compiles without errors or warnings and behaves according to the requirements given here. A program with good style is clear, concise, and easy to read.

A few suggestions regarding good style may be helpful. Use brief but mnemonic variable names. Use consistent spacing and indentation. Include comments as necessary to explain the **programmer's intent**, but don't belabor the obvious.

In particular, you should follow common Java conventions regarding naming and code structure. In CS 2112, we use: [Kernighan & Ritchie style \(Java variant\)](#). The [2110 Java style guide](#) is a useful reference, as is the [Google style guide](#), though we do not follow all the prescriptions of either guide, such as mandatory braces.

1.2 Partners

You must work alone for this assignment. The course staff are happy to help with any difficulties that might arise. Use Ed for questions and don't be shy about coming to office hours if you need help.

1.3 Assignment structure

This assignment consists of eight written questions and six coding questions. Materials can be found in the archive A1release.zip on [CMS](#). Download and extract the contents. The materials for the written questions (§2) are in the folders written and polynomial, and those for the coding questions (§3) are in coding.

2 Written Questions: Semantics and Object Diagrams

semantics: the study of the meanings of words and phrases in language
—Merriam-Webster

Programming language semantics is about the meaning of programs. In object-oriented languages like Java, the meaning of programs depends heavily on the meaning of **objects**. An **object** is a collection of related data, as well as operations on that data. A useful way to understand objects is to draw **object diagrams**. In an object diagram, each object is represented by a box tagged with its run-time class and associated data.

The data associated with an object is stored in its **fields**, also called **instance variables** because a distinct variable exists for each object instance. Every field has a **name**, which is like an ordinary variable name, and a **type**, which determines what kind of data it represents. The type of a field can be either a **reference type** if it references another object that is created by the program or a **primitive type** such as `int` or `boolean`, for which the possible values in some sense exist even before the program starts running. A field that references another object is represented in the object diagram by an arrow from the field to the object, whereas field of primitive type is conventionally represented by writing the value of the field directly into the field.

Figure 1 shows the object diagram for a newly created instance of the following class:

```
1 class Color {
2     String name;
3     int r = 0, g = 0, b = 0;
4 }
```

The object has four fields. The field `name` is of type `String`, which is a reference type. The other three fields, `r`, `g`, and `b`, are `ints` a primitive type that can represent any integer between -2^{31} and $2^{31} - 1$. There are eight primitive types: `boolean`, `byte`, `char`, `short`, `int`, `long`, `float`, and `double`. All other types are reference types.

The initial value of `name` is `null`, meaning the field does not have an assigned value yet. In the object diagram, this is represented by the “ground” symbol \perp shown in Figure 1.

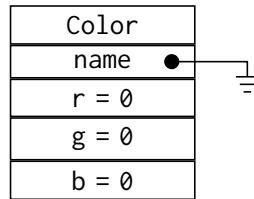


Figure 1: An object diagram for a newly created object of type Color

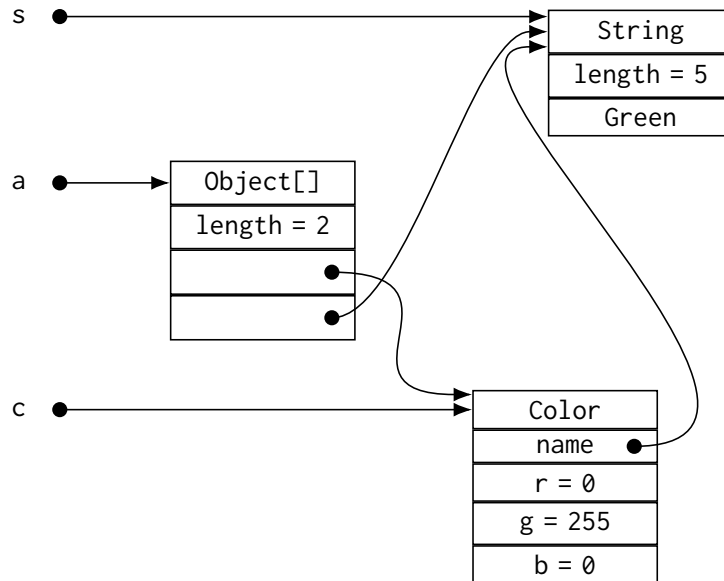


Figure 2: An object diagram after executing the code snippet

(We could also represent it by writing name=null in the field.)

Now suppose we execute the following code snippet:

```

1 String s = "Green";
2 Color c = new Color();
3 c.name = s;
4 c.g = 255;
5 Object[] a = new Object[2];
6 a[0] = c;
7 a[1] = s;

```

The resulting object diagram is shown in Figure 2. The object that the variable a points to is an array object. Array objects have an instance field length to keep track of how many elements they contain. The drawing of the String is a “white lie” because it shows the characters of the string inside the string object itself. The actual internal representation of String objects is not accessible and has changed from one release of Java to the next. In the current Java release, String objects reference a char array containing their characters, but this is not important and we do not expect you to show this.

For the following problems, you are welcome to experiment by running the code provided to understand what it does. All the code for these questions can be found in the written folder.

1. Suppose we change line 7 in the code snippet above from `a[1] = s;` to `a[1] = a;`. Draw the resulting object diagram.

The code for this question can be found in the file `Q1.java`. Submit your answer as a PDF file `Q1.pdf`. Scans of handwritten diagrams are acceptable.

2. Suppose that we do **not** make the previous change, but instead add the following lines at the end of the code snippet:

```
7 Object[] b = a;
8 b[0] = new Color[2];
9 b = (Color[])a[0];
10 b[1] = c;
11 b[0] = b[1];
```

Draw the resulting object diagram.

The code for this question can be found in the file `Q2.java`. Submit your answer as a PDF file `Q2.pdf`. Scans of handwritten diagrams are acceptable.

3. Run the code in `Q3.java`. Draw an object diagram showing the values of the field `total` and the arrays `a` and `b` before and after the `for` loop executes.

The code for this question can be found in the file `Q3.java`. Submit your answer as a PDF file `Q3.pdf`. Scans of handwritten diagrams are acceptable.

4. In the [handout on Java I/O](#), there is a piece of code in the examples of §5.4 and §5.5 that asks whether the user wants to overwrite an existing file.

```
1 if (outFile.exists()) {
2     System.out.print("Output file exists; overwrite [yes/no]? ");
3     if (!sysin.nextLine().equals("yes")) return;
4 }
```

The test in line 3 returns from the method immediately without performing the write if the user does **not** respond with `yes`. You might think that the following alternative test would be just as good:

```
3     if (sysin.nextLine().equals("no")) return;
```

However, there is a subtle but important reason why the former test is preferable. Can you say what it is? Submit your answer in a text file `Q4.txt`.

In the released code (in the `polynomial` directory) you will find files `Polynomial.java` and `Main.java` that respectively implement a polynomial abstraction and lightly test it. We want you to understand this code and make some improvements. The next four questions are about this code.

5. Draw object diagrams showing the final state of the objects referenced by variables `p`, `q`, and `z` in `Main.main()`. Submit your answer as a PDF file `Q5.pdf`. Scans of handwritten diagrams are acceptable.
6. The correctness of the implementation of one of the `Polynomial` methods relies on the caller satisfying a currently unspecified precondition (other than the implicit precondition that arguments are non-null unless otherwise allowed). Identify this method, show an example of a call that would break the implementation, and state an appropriate precondition to prevent such calls. Submit your answer in a text file `Q6.txt`.
7. The correctness of multiple `Polynomial` methods relies on its representation satisfying a class invariant. Give this class invariant. Submit your answer in a text file `Q7.txt`.
8. In the `Polynomial` method `scaleBy`, suppose we delete the statement on line 109, which is `if (c == 0) return theZero;`. Does this affect the correctness of the method `scaleBy`? Explain why or why not in a couple sentences. Submit your answer in a text file `Q8.txt`.

3 Coding Questions

Implement the following short programs by modifying the given stub files (find these in the coding directory). No points will be deducted for writing inefficient code, provided it isn't excessively inefficient.

You need not use all the library imports provided, but no additional library imports may be added. You may not change the declarations of the methods you are implementing without permission from the course staff. For example, the number and types of the parameters and the return type must remain unchanged. You may, however, add new methods to the classes.

9. Implement method `filterByLen` according to its specification. Be careful to return an array of the correct length. Below is an example usage case.
Example: `filterByLen(4, {"Hello", "and", "Goodbye", "world!"})` returns `{"Hello", "Goodbye", "world!"}`.
10. Write a program that reads in a file from the file system containing a string of text on each line. Then, read in an integer `n` from the console (i.e., entered by the user from keyboard), skip past the first `n` lines in the file, and print the remaining lines **in reverse order** to the console.
If the user enters a value in an incorrect format, e.g., entering a string instead of an integer, keep asking the user to re-enter a value until they input an integer.
11. Implement method `findSymDifference(int[] a1, int[] a2)` that takes two integer arrays and returns a new array containing their symmetric difference. The *symmetric difference* of `a1` and `a2` consists of those elements which belong to exactly **one** of `a1` and `a2`. That is, any elements that belong to both arrays should be excluded from the result. The resulting array does not need to be in any particular order.

12. Implement method `findMaxOnes(int[][] points)` that returns the array from points which contains the most ones. If there is a tie, then the earlier array should be returned.

Example: The following function call should return `{1, 4, 1}`:

```
1 findMaxOnes(new int[][] { {1, 2}, {1, 4, 1}, {1, 1}, {2, 4}, {3, 1} });
```

13. Run the code in `coding.Q13`. Note that the method `isPalindrome(String s)` fails some tests. Fix the code so that it meets the specification and passes all tests.
14. A **linked list** is a data structure composed of nodes containing a value and a pointer pointing to the next node in the list. Linked lists can be implemented with a class having two fields: `value` holding some data in the node, and `next` holding a pointer to the next node in the list. The empty list is represented by the value `null`.

Complete the program `coding.Q14` to convert the arguments provided to the program on the command line into a linked list that is printed out.

4 Submission

Some of the problems ask you to turn in diagrams. You may turn in scans of hand-written pages. However, high-resolution scans of paper may result in files that are too large to turn in.

A hint about scanning: often a scan will preserve a huge amount of subtle and unnecessary detail about the grain of the paper. By adjusting the contrast and brightness of the image to wash out that detail, you can usually substantially reduce the amount of space needed. It may also be helpful to reduce image resolution as long as it does not impair readability. Various tools may be used for these transformations, such as Preview (Mac), GIMP (Linux, Mac), and Photos (Windows). To decrease the file sizes, please also run your files through an online PDF compressor. Some good ones are [PDF Compressor](#) and [Small PDF](#). Then, compress exactly these files into a zip file and submit the zip file to [CMS](#). Do not include any other files. In particular, do not include any `.class` files.¹ Please make sure you submit your solution code, not our release code.

- `README.txt`: This file should contain your name, your Cornell NetId, all known issues with your submitted code, and the names of anyone else you have discussed the homework with (excluding course staff).
- `written/Q1.pdf`
- `written/Q2.pdf`
- `written/Q3.pdf`
- `written/Q4.txt`
- `written/Q5.pdf`
- `written/Q6.txt`

¹Note that on many systems, files beginning with `.` are not visible. Search the web for “Show hidden files” to find out how to view them on your platform.

- written/Q7.txt
- written/Q8.txt
- coding/Q9.java
- coding/Q10.java
- coding/Q11.java
- coding/Q12.java
- coding/Q13.java
- coding/Q14.java

Note: The / is the file separator (\ on Windows). It is not a character in the file name.

All Java files must compile and should conform to the prototypes we gave you. In particular, do not change the package structure or any method or field declarations. This is important for compatibility with our testing software. You may add your own private methods and fields if you wish.

To reiterate the important points:

- Make sure your README.txt file has all the requested information.
- Make sure your code compiles.
- Do not change the package structure or any method or field declarations.
- Do not include any .class files or any other files in your submission except those listed above.

Violation of any of these will result in a point deduction, so check carefully before submitting. It's also a good idea to download your submission from CMS after you have uploaded it to verify that it has the exact files you want graded.