Overview: You should be in the process of completing (we hope!) your own implementation of the Polynomial methods. In doing so, you encountered two significant problems. In this assignment, we’ll reconsider the decisions that led to those problems, and will address them both.

- **Problem #1: Arrays.** The first problem you encountered was that you were required to use an array for the storage of the polynomials. Arrays, as you know, don’t natively support a lot of operations, which means that you had to do a lot of the dirty work yourself (e.g. shifting of data, if you kept the terms of the polynomials in order by exponent).

  An alternative to doing the implementation from scratch is to adapt another class. We learned about adaptation not too long ago. As a Polynomial object is really just a list of Term objects, we can employ one of Java’s supplied list classes to represent a Polynomial’s collection of Term objects. This won’t be a perfect example of adaptation, because we need operations such as add() and scalarMultiply() that have no corresponding operation in a general-purpose list class. Still, it should be easier than what you had to do in Program 4, once you become comfortable with the operations of the class being adapted.

  Java has multiple general-purpose list classes that we can adapt. Two of them, ArrayList and Vector, are very similar. A third, LinkedList, stores lists of data using a different internal representation, one that we’ll talk about in detail soon. All three implement Java’s List interface, making them mostly interchangeable.

- **Problem #2: Polynomial’s Methods.** A second problem with Program 4 was the Polynomial class, which didn’t include the methods needed to cleanly implement operations such as add() and equals(). Many of you resorted to “peeking” inside the Polynomial objects to get the information you needed. Doing so violates a key program design principle: information hiding. The programmer shouldn’t ever need to “peek” inside of a data structure.

We’ll address both problems in this assignment.

Assignment: Start by making two copies of your Program4.java file; name them Program5A.java and Program5B.java (and adjust the class names within, too!). Also bring along Quantity.java and Term.java. If you did a good job of implementing Term for the last assignment, it shouldn’t need much (if any) updating to be reused here. You may update these files to add more tests, correct logic errors, etc.

Next, create two new polynomial classes in separate files (creatively named PolynomialA.java and PolynomialB.java). As the names suggest, Program5A.java is to test PolynomialA and Program5B.java is to test PolynomialB. Both pairs of files are to use the same Quantity and Term classes.

PolynomialA.java will implement Program 4’s Quantity interface plus its Polynomial methods by adapting either Java’s ArrayList class or Java’s Vector class (your choice). Thus, in PolynomialA you will be replacing the array object that held the Term objects with either an ArrayList object or a Vector object, and rewriting the implementations of the methods that relied on the array representation.

PolynomialB.java will do a similar adaptation, using Java’s LinkedList class instead (no choice here). We haven’t talked about linked lists yet, but our on-going coverage of code reuse, interfaces, and list operations should enable you to use the LinkedList class for this task easily, even without knowing what a linked list is. This is what good interface design does for us.

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So that your implementations of the old polynomial methods in both of these new polynomial classes can better follow the principle of information hiding, we have these additional requirements:

1. **All instance variables in all classes must be private.** No more peeking into other objects to access their state information directly! To make an instance variable private, just prefix its declaration with the keyword “private.” A method can still access the private instance variables of its own object.

2. **Implement one new polynomial instance method: exponentList().** In Program 4, it was hard to cleanly learn which terms another Polynomial object possessed. To learn the terms of another Polynomial object, we’ll add the following method so that we can ask it for its Term object’s exponents:

   - **List exponentList()** — Returns a reference to a List-implementing object that contains Integer objects that hold the values of the exponents of the terms in this polynomial. For example, a polynomial object holding the polynomial \(2x^3 - 1 + x^{-4}\) would return a List containing three Integer objects holding 3, 0, and -4.

With this method and the already-existing `getCoefficient()` method, methods like `add()` should be more straight-forward to write, and able to follow the principle of information hiding. (Note that the three classes `ArrayList`, `Vector` and `LinkedList` each implement the List interface.)

**Data:** As with Program 4, for this program there will be no sample data. After you submit your programs, we will run our versions of the Program5A and Program5B classes on your new PolynomialA and PolynomialB classes. The non-documentation portion of your grade on this assignment will be determined by how well your code passes our testing. As usual, make a point of doing a really good job testing your classes (which, if you did a good job of it on the last assignment, should be easy because you can reuse (and augment!) them for this assignment. Reviewing your tests (and grade!) from Program 4 should help you think of new tests to try.

**Output:** Because the output is dependent upon the construction of the Program5A and Program5B classes, there is no specific output expected.

**Turn In:** Use the ‘turnin’ utility to electronically submit your Term.java, Quantity.java, PolynomialA.java, Program5A.java, PolynomialB.java and Program5B.java files to the cs127b002sXp05 directory at any time before the stated due date and time. Of course, you can turn them in late if you still have late days to use, or don’t mind losing 20% per day if your late days are exhausted.

**Hints, Reminders, and Other Requirements:**

- If you didn’t complete Term.java in Program 4, you’ll need to get it functional, as it is reused here. If you had completed it, you should be able to reuse it here without modification … if you implemented it correctly!

- Be sure to note, in your external documentation for PolynomialA.java, the name of the class you have chosen to adapt: ArrayList or Vector.

  If you happen to already know how to use ArrayList, this is a good opportunity to try Vector, and vice-versa. If both are new to you, we recommend adapting ArrayList.

- Don’t forget to revise your documentation as necessary for this assignment. If you did a good job documenting your Program 4 code, you shouldn’t have to make many changes to document this one. (But be sure to make those changes – your SL will be looking at your documentation closely.)

- You’re still welcome to share testing code (that is, your Program5A/B classes) with your classmates.

- If you find that you have to extensively modify the files that this assignment shares with the last assignment (that is, Term.java and just about all of Program4.java), take some time to reflect on your Program 4 design decisions. What could you have done differently that would have allowed you to avoid changing those files for reuse in this assignment? Remember, one of the advantages of object-oriented languages is their support for code reuse. Whenever possible, you should try to design your code to be easily reusable.

- You must **not** store polynomials in arrays in this assignment! One of the points of the assignment is to get you to work with list objects. We’ll be looking at your code to make sure you’re using lists.