

## Important

There are general homework guidelines you must always follow. If you fail to follow any of the following guidelines you risk receiving a **0** for the entire assignment.

1. All submitted code must compile under **JDK 8**. This includes unused code, so don't submit extra files that don't compile. Any compile errors will result in a 0.
2. Do not include any package declarations in your classes.
3. Do not change any existing class headers, constructors, instance/global variables, or method signatures.
4. Do not add additional public methods.
5. Do not use anything that would trivialize the assignment. (e.g. don't import/use `java.util.ArrayList` for an Array List assignment. Ask if you are unsure.)
6. Always be very conscious of efficiency. Even if your method is to be  $O(n)$ , traversing the structure multiple times is considered inefficient unless that is absolutely required (and that case is extremely rare).
7. You must submit your source code, the `.java` files, not the compiled `.class` files.
8. After you submit your files, redownload them and run them to make sure they are what you intended to submit. You are responsible if you submit the wrong files.

## Array List

You are to code an Array List. An Array List is a list data structure backed by an array where all of the data is contiguous and aligned with index 0 of the array.

Your array list must follow the requirements stated in the javadocs of each method you must implement. A constructor stub is provided for you to fill out. **Do not** change the constructor provided or implement a different one.

## Adding

You will implement three `add()` methods. One will add to the front, one will add to the back, and one will add anywhere in the list. When adding to the front or the middle of the list, subsequent elements must be shifted back one position to make room for the new data. See the javadocs for more details.

## Removing

Removing, just like adding, can be done from the front, the back, or anywhere in your `ArrayList`. When removing from the front or from the middle of the list, the element should be removed and all subsequent elements should be shifted forward by one position. When removing from the back, the last element should be set to `null` in the array. **All unused positions in the backing array must be set to null**. See the javadocs for more details.

## Capacity

The starting capacity of your `ArrayList` should be the constant `INITIAL_CAPACITY` defined in `ArrayList.java`. Reference the constant as-is. **Do not** simply copy the value of the constant. If, while adding an element, the `ArrayList` does not have enough space, you should regrow the backing array to twice its old capacity. **Do not** regrow the backing array when removing elements.

## Differences between Java API and This Assignment

Some of the methods in this assignment are called different things in Java's List class. This won't matter until you tackle coding questions on the first exam, but it's something to be aware of. The list below shows all methods with a different name and their Java API equivalent. The format is assignment method name  $\Rightarrow$  Java API name.

- `addAtIndex(int index, T data)`  $\Rightarrow$  `add(int index, T data)`
- `addToFront(T data)`  $\Rightarrow$  `addFirst(T data)`
- `addToBack(T data)`  $\Rightarrow$  `addLast(T data)`
- `removeAtIndex(int index)`  $\Rightarrow$  `remove(int index)`
- `removeFromFront()`  $\Rightarrow$  `removeFirst()`
- `removeFromBack()`  $\Rightarrow$  `removeLast()`

## Grading

Here is the grading breakdown for the assignment. There are various deductions not listed that are incurred when breaking the rules listed in this PDF, and in other various circumstances.

<b>Methods:</b>	
<code>addAtIndex</code>	15pts
<code>addToFront</code>	11pts
<code>addToBack</code>	11pts
<code>removeAtIndex</code>	8pts
<code>removeFromFront</code>	6pts
<code>removeFromBack</code>	4pts
<code>get</code>	10pts
<code>clear</code>	5pts
<code>isEmpty</code>	5pts
<b>Other:</b>	
<code>Checkstyle</code>	10pts
<code>Efficiency</code>	15pts
<b>Total:</b>	100pts

Keep in mind that add functions are necessary to test other functions, so if an add doesn't work, remove tests might fail as the items to be removed were not added correctly. Additionally, the size function is used many times throughout the tests, so if the size isn't updated correctly or the method itself doesn't work, many tests can fail.

## A note on JUnits

We have provided a **very basic** set of tests for your code, in `ArrayListStudentTests.java`. These tests do not guarantee the correctness of your code (by any measure), nor does it guarantee you any grade. You may additionally post your own set of tests for others to use on the Georgia Tech GitHub as a gist. Do **NOT** post your tests on the public GitHub. There will be a link to the Georgia Tech GitHub as well as a list of JUnits other students have posted on the class Piazza.

If you need help on running JUnits, there is a guide, available on Canvas under Files, to help you run JUnits on the command line or in IntelliJ.

## Style and Formatting

It is important that your code is not only functional but is also written clearly and with good style. We will be checking your code against a style checker that we are providing. It is located on Canvas, under Files, along with instructions on how to use it. We will take off a point for every style error that occurs. If you feel like what you wrote is in accordance with good style but still sets off the style checker please email Tim Aveni ([tja@gatech.edu](mailto:tja@gatech.edu)) with the subject header of “[CS 1332] CheckStyle XML”.

## Javadocs

Javadoc any helper methods you create in a style similar to the existing Javadocs. If a method is overridden or implemented from a superclass or an interface, you may use `@Override` instead of writing Javadocs. Any Javadocs you write must be useful and describe the contract, parameters, and return value of the method; random or useless javadocs added only to appease Checkstyle will lose points.

## Vulgar/Obscene Language

Any submission that contains profanity, vulgar, or obscene language will receive an automatic zero on the assignment. This policy applies not only to comments/javadocs but also things like variable names.

## Exceptions

When throwing exceptions, you must include a message by passing in a String as a parameter. **The message must be useful and tell the user what went wrong.** “Error”, “BAD THING HAPPENED”, and “fail” are not good messages. The name of the exception itself is not a good message.

For example:

**Bad:** `throw new IndexOutOfBoundsException("Index is out of bounds.");`

**Good:** `throw new IllegalArgumentException("Cannot insert null data into data structure.");`

## Generics

If available, use the generic type of the class; do **not** use the raw type of the class. For example, use `new LinkedList<Integer>()` instead of `new LinkedList()`. Using the raw type of the class will result in a penalty.

## Forbidden Statements

You may not use these in your code at any time in CS 1332.

- `package`
- `System.arraycopy()`
- `clone()`
- `assert()`
- `Arrays` class
- `Array` class
- `Thread` class

- Collections class
- Collection.toArray()
- Reflection APIs
- Inner or nested classes
- Lambda Expressions
- Method References

If you're not sure on whether you can use something, and it's not mentioned here or anywhere else in the homework files, just ask.

Debug print statements are fine, but nothing should be printed when we run your code. We expect clean runs - printing to the console when we're grading will result in a penalty. If you submit these, we will take off points.

The following file(s) have been provided to you. There are several, but you will only edit one of them.

1. `ArrayList.java`

This is the class in which you will implement the `ArrayList`. Feel free to add private helper methods but **do not add any new public methods, inner/nested classes, instance variables, or static variables.**

2. `ArrayListStudentTests.java`

This is the test class that contains a set of tests covering the basic operations on the `ArrayList` class. It is not intended to be exhaustive and does not guarantee any type of grade. **Write your own tests to ensure you cover all edge cases.**

## Deliverables

You must submit **all** of the following file(s). Please make sure the filename matches the filename(s) below, and that *only* the following file(s) are present. If you make resubmit, make sure only one copy of the file is present in the submission.

After submitting, double check to make sure it has been submitted on Canvas and then download your uploaded files to a new folder, copy over the support files, recompile, and run. It is your responsibility to re-test your submission and discover editing oddities, upload issues, etc.

1. `ArrayList.java`