

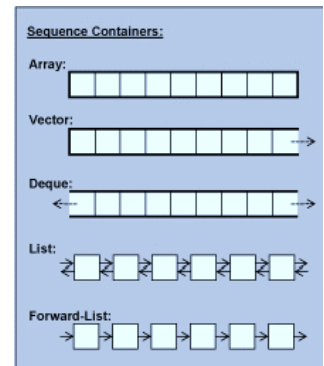
CPSC 131, Data Structures – Fall 2025

Homework 2: Sequence Containers



Student Learning Objectives:

- Familiarization with arrays, extendable vectors, and doubly and singly linked lists
- Understanding the sequence container's insertion, deletion, traversal, and search concepts.
- Reinforce the similarities and differences between the sequence data structures and their interfaces.
- Analyze and understand the differences in the sequence container's complexity for some of the more common operations
- Familiarization and practice using the STL's sequence container interface
- Reinforce modern C++ object-oriented programming techniques
- Reinforce the software development cycle and practice building error free solutions on Linux



Description:

This Grocery List assignment builds on the GroceryItem class from the previous assignment. Here you create and maintain a collection of grocery items to form a grocery list. Grocery items are placed on the list, removed from the list, and reordered within the list. A partial `GroceryList` class interface and a partial implementation have been provided. You are to complete the interface and implementation.

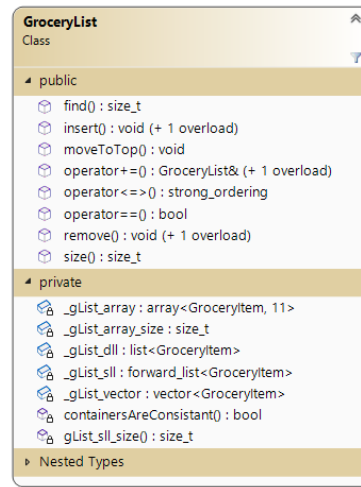
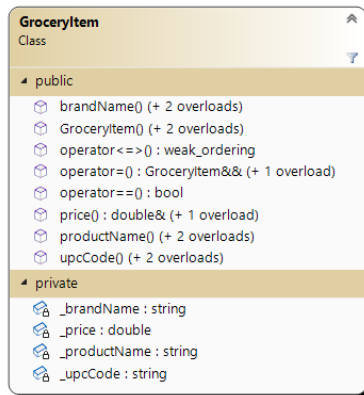
To reinforce the four data structure concepts (arrays, extendable vectors, doubly linked lists, and singly linked lists) discussed in class, your grocery list implementation mirrors grocery item insertion, removal, and reordering requests to each of four STL containers (`std::array`, `std::vector`, `std::list`, and `std::forward_list` respectively). At the end of each operation the four STL containers must be consistent. For example, when your `GroceryList` object receives a request to insert a grocery item, your implementation of `GroceryList::insert()` will insert that grocery item into all four STL containers such that each container holds the same grocery items in the same order.

Grocery List

- | | | |
|--------------------------|--|------------------|
| <input type="checkbox"/> | | Marshmallows |
| <input type="checkbox"/> | | Cranberry Juice |
| <input type="checkbox"/> | | Rosemary |
| <input type="checkbox"/> | | Shaving Cream |
| <input type="checkbox"/> | | Mango Juice |
| <input type="checkbox"/> | | Ice |
| <input type="checkbox"/> | | Frozen Peas |
| <input type="checkbox"/> | | Pita |
| <input type="checkbox"/> | | Beer |
| <input type="checkbox"/> | | Ginger |
| <input type="checkbox"/> | | Cilantro |
| <input type="checkbox"/> | | Cottage Cheese |
| <input type="checkbox"/> | | Cream Cheese |
| <input type="checkbox"/> | | Butternut Squash |
| <input type="checkbox"/> | | Basil |

The following UML class diagrams should help you visualize the `GroceryList` interface, and to remind you what the `GroceryItem` interface looks like.

class `GroceryItem` summary **class `GroceryList` summary**



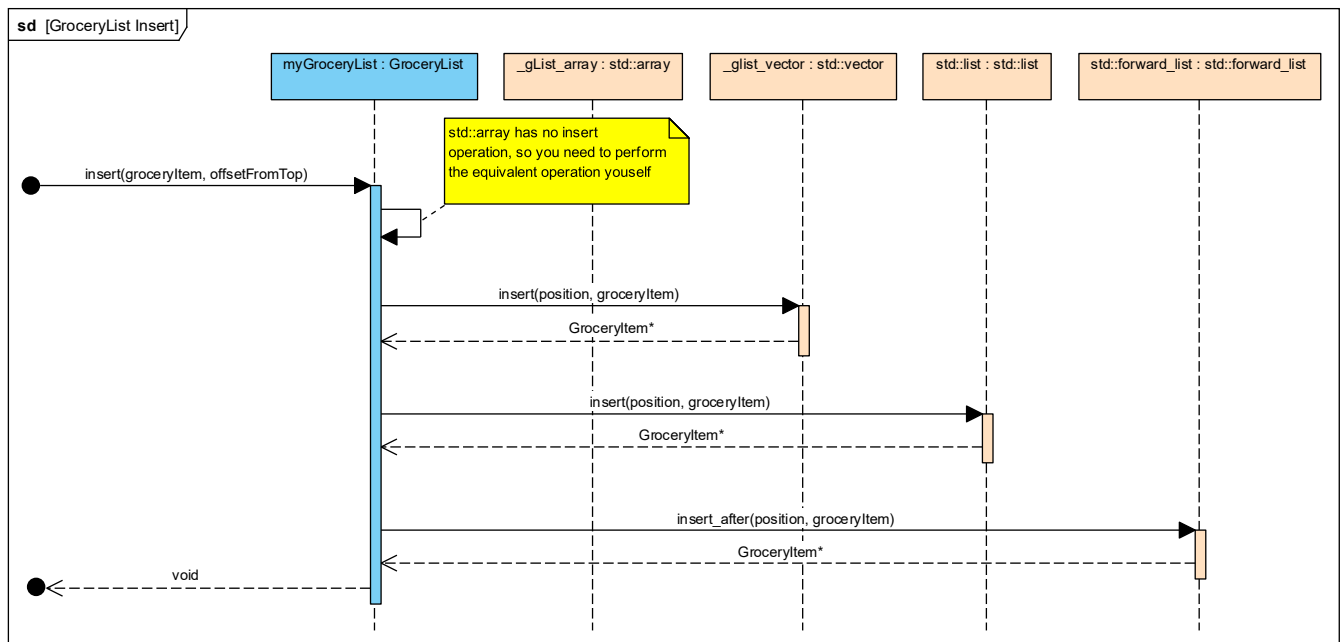
GroceryList function summaries:

1. `find()` takes a grocery item as a parameter and returns the zero-based offset of that grocery item, or the total number of grocery items in the grocery list if the grocery item was not found. For example, if your grocery list contains the grocery items in the picture above, a request to find “Marshmallows” returns 0, “Ice” returns 5, and “Peanut Butter” returns 15.
2. `insert()` takes a grocery item and either a position (TOP or BOTTOM) or a zero-based offset into the list as parameters and inserts the provided grocery item before the insertion point. For example, again if your grocery list contains the grocery items in the picture above, inserting “Peanut Butter” with an offset of 5 places “Peanut Butter” between “Mango Juice” and “Ice”. Duplicate grocery items are silently discarded (not added to the grocery list).
3. `moveToTop()` takes a grocery item as a parameter, locates and removes that grocery item, and then places it at the top of the list. For example, a request to move “Beer” to the top removes “Beer” from its current location and places it before “Marshmallows”. Of course, “Ginger” would then immediately follow “Pita”. The grocery list remains unchanged if the provided grocery item is not in the grocery list.
4. `operator+=()` appends the provided grocery list to the bottom of this grocery list while silently discarding duplicate grocery items. This behavior is similar to `std::string`’s `append` (a.k.a. concatenation) operator. See [std::string::operator+=\(\)](#).
5. `operator<=>()` returns a negative number if this grocery list is less than the other grocery list, zero if this grocery list is equal to the other grocery list, and a positive number if this grocery list is greater than the other grocery list. This behavior is similar to `std::vector`’s three-way-comparison (a.k.a. spaceship) operator. See [std::vector::operator<=>\(\)](#) #7
6. `operator==()` returns true if this grocery list is equal to the other grocery list, false otherwise.
7. `remove()` takes either a grocery item or a zero-based offset from the top as a parameter and removes that grocery item from the grocery list. No change occurs if the given grocery item is not in the grocery list, or the offset is past the size of the grocery list. For example, a request to remove “Frozen Peas” from your above pictured grocery list reduces the size of the grocery list by one and causes “Pita” to immediately follow “Ice”.
8. `size()` takes no parameters and returns the number of grocery items in the grocery list. For example, the size of your above pictured grocery list is 15. The size of an empty grocery list is zero.

How to Proceed:

The following sequence of steps are recommended to get started and eventually complete this assignment.

1. Review the solution to the last homework assignment. Use the posted solution to fix your solution and verify it now works. Your `GroceryItem` class needs to be working well before continuing with this assignment. When you're ready, replace the `GroceryItem.cpp` and `GroceryItem.cppm` files packaged with this assignment with your (potentially updated) files from last assignment.
2. Compile your program using `Build.sh`. There will likely be warnings, after all it's only a partial solution at this point. If there are errors, solve those first. For example, implement `gList_sll_size()` first to remove the "must return a value" error. After completing this step, your program should now execute.
3. Once you have an executable program, start implementing functions with the fewest dependencies and work up. Consider this order: `gList_sll_size()`, `size()`, `find()`, `insert()`, `remove()`, `moveToTop()`, and finally `operator+=()`.
4. Implementing `insert()` and `remove()` is really implementing insert and remove on each of the four STL containers. For example, upon receipt of an "insert" request, `GroceryList::insert()` inserts the provided grocery item into the `_gList_array`, then into the `_gList_vector`, then the `_gList_dll`, and finally into the `_gList_sll`. The following UML sequence diagram summarizes the flow of execution through `GroceryList::insert()`. `GroceryList::remove()` is similar.



You may want to:

- a. Work the `insert()` and `remove()` functions together for arrays, then for vectors, lists, and finally forward_lists. Insertion and removal (or as the STL calls it, erasure) are very close complements to each other.
- b. While working insert and remove for each container, you may want to temporarily turn off container consistency checking by commenting out those functions. But don't forget to uncomment them before you're finished.

Rules and Constraints:

1. You are to modify only designated TO-DO sections using only the techniques discussed in class. **The grading process will detect and discard any changes made outside the designated TO-DO sections, including spacing and formatting.** Designated TO-DO sections are identified with the following comments:

```

//////////////////// TO-DO (X) //////////////////////
...
//////////////////// END-TO-DO (X) //////////////////////

```

Keep and do not alter these comments. Insert your code between them. In this assignment, there are 20 such sections of code you are being asked to complete. 1 is in GroceryList.cppm, 18 of them are in GroceryList.cpp, and 1 in main.cpp.

Hint: In most cases, the requested implementation requires only a single line or two of code. Of course, finding those lines is non-trivial. Most of them can be implemented with less than 5 or 6 lines of code. If you are writing significantly more than that, you may have gone astray.

Reminders:

- Multiple submissions may be available and a waiting period between submissions may be enforced.
- The C++ using directive `using namespace std;` is **never allowed** in any header or source file in any deliverable product. Being new to C++, you may have used this in the past. If you haven't done so already, it's now time to shed this crutch and fully decorate your identifiers.
- A clean compile is an entrance criterion. Deliveries that do meet the entrance criteria cannot be graded.
- Object Oriented programming suggests that objects know how to read and write themselves. Classes you write shall overload the insertion and extraction operators.
- Object Oriented programming suggests that objects know how to compare themselves. Classes you write shall overload the spaceship (`<=>`) and equality (`==`) relational operators.
- Always initialize your class's attributes, either with member initialization, within the constructor's initialization list, or both. Avoid assigning initial values within the body of constructors.
- Use Build.sh on Ubuntu to compile and link your program. There is nothing magic about Build.sh, all it does is save you (and me) from repeatedly typing the very long compile command and all the source files to compile.
- Filenames are case sensitive, both in source code and in your OS file system. Windows doesn't care about filename case, but Linux does.
- You may redirect standard input from a text file, and you must redirect standard output to a text file named output.txt. Failure to include output.txt in your delivery indicates you were not able to execute your program and will be scored accordingly. A screenshot of your terminal window is not acceptable. See [How to build and run your programs](#). Also see [How to use command redirection under Linux](#) if you are unfamiliar with command line redirection.

Deliverable Artifacts:

Provided files	Files to deliver	Comments
GroceryItem.cppm GroceryItem.cpp	1. GroceryItem.cppm 2. GroceryItem.cpp	Replace with your (potentially updated) file from the previous assignment.
main.cpp GroceryList.cppm GroceryList.cpp	3. main.cpp 4. GroceryList.cppm 5. GroceryList.cpp	Start with the files provided. Make your changes in the designated TO-DO sections (only). The grading process will detect and discard all other changes.
	6. output.txt	Capture your program's output to this text file using command line redirection. See command redirection . Failure to deliver this file indicates you could not get your program to execute. Screenshots or terminal window log files are not permitted.
	Readme.txt	Optional. Use it to communicate your thoughts to the grader.
ExceptionString.cppm		Provides a function that helps create meaningful information when exceptions are thrown. You shan't modify this file.
quoted_string_patch.inc		You shan't modify this file. GCC requires a patch to use the std::quoted manipulator with istreams. This patch will be added to your delivery and included during the build process.
RegressionTests/ CheckResults.cppm GroceryItemTests.cppm GroceryListTests.cppm private_frgement_patch.inc		These files contain code to regression test your GroceryItem and GroceryList classes. When you're far enough along and ready to have your class regression tested, then place these files somewhere in your working directory and Build.sh will find them. Simply having these files in your working directory (or sub directory) will add it to your program and run the tests – you do not need to #include or import anything or call any functions. These tests will be added to your delivery and executed during the grading process. The grading process expects all tests to pass.
sample_output.txt		A sample of a working program's output. Your output may vary.