Project 3 – Shape List

CS 251, Fall 2023

Collaboration Policy

By submitting this assignment, you are acknowledging you have read the course collaboration policy. This project should be done individually. You may not receive any assistance outside of the CS 251 instructional team. ***Do not post your work for this class publicly, now or after class.***

Late Policy

You are given a grace period of 24-hours. You do not need to let anyone know you are using this grace period, you simply continue to work and submit during the time period. Beyond this period, no late submissions will be accepted. Please note that if you are continually using the grace period, then you are off track from our anticipated pace that facilitates spacing of assessments.

What & Where to Submit

1. Gradescope - shape.h, canvaslist.h, shape.cpp, canvaslist.cpp, and tests.cpp

Do not submit any additional files.

Table of Contents

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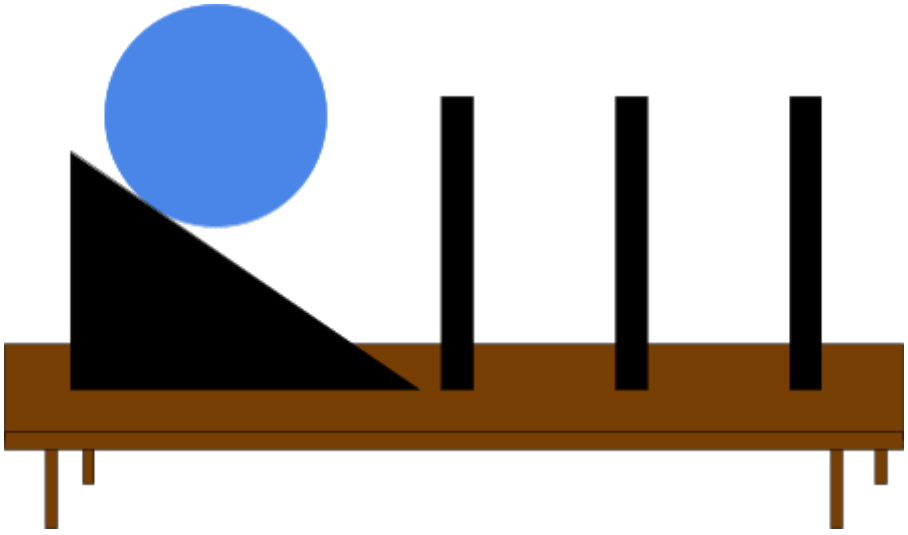
Project 3 – Shape List

CS 251, Fall 2023



Project Summary

Computers repeatedly refresh and redraw images to a screen. In this project we are going to implement a very simplified drawing canvas to mimic this storage of items to be drawn to the screen. We will implement a CanvasList class in C++ that maintains a linked list of shapes that will be "drawn" when the draw function is invoked. We will also implement a Shape class that has three derived classes Circle, RightTriangle, and Rectangle.

The project is designed to cover object oriented programming with test driven development. Throughout the implementation of the project you will craft and use multiple, develop test cases in either the Catch or Google Test framework, and work with and alter a provided main program that will help understand the usage of the objects you are creating.

Primary Project Topics

- Classes
- Linked Lists
- Dynamic Memory
- Test Frameworks

Program and Coding Restrictions

The class definitions are provided and the public aspects of the class cannot be changed. You are encouraged to create private helper functions to help with implementation or function decomposition. Additionally, you may add private data members should you need additional private data members to increase algorithm efficiency.

In addition to passing the implementation harnesses, **you must have a clean valgrind report.** This means your program has zero memory leaks and zero memory errors.

We will use the Catch Framework, you can explore using Google Test on your own and may use it in future projects but for this project use Catch 1.x.

Project 3 – Shape List

CS 251, Fall 2023

Given Files (9) (starter files - do not copy-paste, download & place/upload)

We have provided two header files (`shape.h` and `canvaslist.h`) and two implementation files. You should write the class implementations in the provided separate .cpp files. We provide a `main.cpp` file that has calls for various (but not all) functions to demonstrate usages. We provide a `tests.cpp` and the `catch.hpp` file that can be used to develop tests within Catch 1.x framework style. Finally, we provide a `makefile` that can be used to build, execute, and test using the Catch framework or valgrind.

Milestone 0 - Starter Files & Strategies

Completely read this entire project description and all the provided starter files. If you need a starting point reference for implementing classes, I suggest reviewing or watching the previously released Point Class single file implementation and coding video. You will be implementing across multiple files, so this is meant as a starting point example, not a how-to.

For each milestone you should be building tests in your tests.cpp file allowing you to test your class implementations independently before moving on to other portions of the class or other classes or files. You should also be running valgrind on your program when you are acquiring or releasing memory (new/delete) to make sure your program maintains zero memory errors and zero memory leaks, rather than discovering these errors at the end of your development.

For all your implementations you should be utilizing your classes' functions rather than reimplementing the same code. For example, if you are implementing a member function and you need to put a node into the list then you should be using the appropriate member function to place that item within the linked list, not repeating code.

Milestone 1 - Basic Shape Class

Implement the Shape class, this will be the parent or base class for all the other shapes, but we will not worry about implementing those until later. As you are implementing, remember to create tests in your framework of choice.

Milestone 2 - The `CanvasList` Class

The CanvasList class is a drawing class that maintains a linked list of shapes to be drawn. For this program, drawing will simply mean outputting the details about the shape. See example execution later in this project description.

Milestone 3 - The `Rectangle` Class

Implement the derived Rectangle class as well as tests for the various implementations.

Milestone 4 - The `Circle` Class

Implement the derived Circle class as well as tests for the various implementations.

Milestone 5 - The `RightTriangle` Class

Implement the derived RightTriangle class as well as tests for the various implementations.

Project 3 – Shape List

CS 251, Fall 2023

Milestone 6 - Additional Overall Testing

Implement any additional tests that may be missing as they will test multiple classes at a time whereas many of the tests you have developed to this point are independent and specific to a single class.

Class Descriptions

shape.h: Shape, Rectangle, RightTriangle, Circle

Each of these classes has constructors, destructors (empty but needed), an object copier that returns a new heap allocation of the same pointer type, a print function (see example for output), and accessors and setters for private data members. The copy function uses dynamic memory allocation, none of the other functions do. None of the functions for these classes deallocate memory.

canvaslist.h: ShapeNode, CanvasList

The ShapeNode class is utilized as the node or element of the linked list. It contains two public data members, both pointers.

The CanvasList class is an implementation of a linked list that works with our Shapes classes to build and maintain a list of Shapes that can be printed in two ways. The draw function prints the details of the shapes within the linked list, the printAddresses function prints out the memory addresses of the ShapeNode as well as the address of internal Shape (the address in value).

Several functions within the CanvasList class allocate or deallocate memory where appropriate when either adding or removing nodes from the linked list.

Additional descriptions of functions that are non-obvious based on name:

Shape:

- `copy()` returns a newly created copy of the implicitly provided object that has its own memory location, but all the same properties as the implicitly provided original object.

CanvasList:

- `clear()` releases all allocations of memory (all Nodes and their internal Shapes)
- `front()` returns the private data member that points to the front of the list.
- `find()` returns -1 or the index of the first shape with the given x, y values.
- `insertAfter()` returns and does nothing to the list when the index is out of range
- `pop_front()` and `pop_back()` returns a nullptr or the pointer to the shape if one exists, and releases the node's memory but not the shape's memory.
- `printAddresses()` has a tab character separating the two printouts
- `shapeAt()` returns nullptr or a pointer to the shape at the given linked list index.
- `removeAt()` returns and does nothing to the list when the index is out of range
- `removeEveryOther()` removes every other list node, with first removal being index 1
- All functions that take a pointer to a Shape are taking a Shape that already exists.

Project 3 – Shape List

CS 251, Fall 2023

Requirements Reminders

1. You cannot change the provided public class declarations. You may and are encouraged to add helper functions within the private class area.
2. Your code file must have a header comment with your name and a program overview. Each function must have a header comment above the function, explaining the function's purpose, parameters, and return value (if any). Inline comments should be supplied as appropriate; comments like "declares variable" or "increments counter" are useless. Comments that explain non-obvious assumptions or behavior are appropriate.
3. No global variables; use parameter passing and function returns.
4. The cyclomatic complexity (CCN) of any function should be minimized.

Don't forget to submit your code.
Failure to submit to Gradescope will result in a zero on the project.

Grading Breakdown

Autograded Functionality Scored	Shape Class	15
	Circle Class	5
	Rectangle Class	5
	Right Triangle Class	5
	CanvasList Class	44
	Sub Total	**79**
Manually Scored	Shape & Derived Class Destructors	2
	CanvasList Destructor	2
	CanvasList draw	1
	CanvasList printAddresses	1
	Test Cases & Testing Coverage	15
	Sub Total	**21**
	Total	**100**
Potential Penalties ***(not exhaustive)***	Style Deduction	-10
	Failure to achieve a *clean valgrind report*	-15
	Hardcoding to Pass Tests	-100
	Various Forms of Academic Dishonesty	-100

Project 3 – Shape List

CS 251, Fall 2023

Example Execution - Given main.cpp

Same as the output.txt file contents in the provided files

```
List size: 0
Front: 0


Adding Shape to the front
List size: 1
It's a Shape at x: 1, y: 3


Adding Shape to the front
List size: 2
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3


Adding Shape to the back
List size: 3
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3
It's a Shape at x: 4, y: 6


Adding Circle to the front
List size: 4
It's a Circle at x: 2, y: 4, radius: 3
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3
It's a Shape at x: 4, y: 6


Adding Rectangle to the back
List size: 5
It's a Circle at x: 2, y: 4, radius: 3
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3
It's a Shape at x: 4, y: 6
It's a Rectangle at x: 0, y: 0 with width: 0 and height: 10


Adding Right Triangle to the front
List size: 6
It's a Right Triangle at x: 1, y: 2 with base: 3 and height: 4
It's a Circle at x: 2, y: 4, radius: 3
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3
It's a Shape at x: 4, y: 6
It's a Rectangle at x: 0, y: 0 with width: 0 and height: 10
```

Project 3 – Shape List

CS 251, Fall 2023

```
Deleting last element
List size: 5
It's a Right Triangle at x: 1, y: 2 with base: 3 and height: 4
It's a Circle at x: 2, y: 4, radius: 3
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3
It's a Shape at x: 4, y: 6


Inserting Shape after index 1
Original:
It's a Right Triangle at x: 1, y: 2 with base: 3 and height: 4
It's a Circle at x: 2, y: 4, radius: 3
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3
It's a Shape at x: 4, y: 6
Updated Original:
It's a Right Triangle at x: 1, y: 2 with base: 3 and height: 4
It's a Circle at x: 2, y: 4, radius: 3
It's a Shape at x: 3, y: 4
It's a Shape at x: 4, y: 6
It's a Shape at x: 1, y: 3
It's a Shape at x: 4, y: 6


Addresses:
Node Address: 0x562ac60e82a0     Shape Address: 0x562ac60e8280
Node Address: 0x562ac60e81d0     Shape Address: 0x562ac60e81b0
Node Address: 0x562ac60e8260     Shape Address: 0x562ac60e8240
Node Address: 0x562ac60e8150     Shape Address: 0x562ac60e8130
Node Address: 0x562ac60e80e0     Shape Address: 0x562ac60e80c0
Node Address: 0x562ac60e8190     Shape Address: 0x562ac60e8170
```