**High Performance Computing**

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| **Objective** |
| The objective of this project is to gain experience with developing C++ classes and working algorithms by developing a software that can manipulate charts (a vector of points) by performing various operations on it. |

# Starter Code:

In order to streamline this project the following file(s) are supplied. Do not modify any of these files and do not submit them (your instructor will use the version supplied with this homework for grading purposes)(:

* 1. Point.h and Point.cpp: Review the methods in these two files. You will need to follow a similar approach for developing the Chart and ChartMaker classes for this homework.
  2. main.cpp: This is a very simple top-level main method that creates a ChartMaker object (using the class that you are expected to implement) and calls the run() method.
  3. points.txt, small\_points1.txt, small\_points2.txt: These are simple point data files that can be used for testing. Your instructor will be generating a custom points data file with 1 million points for grading. When working with large sets of points (such as the points.txt file) it is best to use gnuplot to plot the points to observe if the changes appear correct by suitably adapting the following command-line:

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| **$** module load gnuplot  **$** gnuplot –e “plot ‘points.txt’ with linespoints, ‘points\_copy.txt’ with linespoints; pause -1” |

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|  | You may compile multiple files together to create one executable using the following command-line:  **$** g++ -std=c++11 -g -Wall main.cpp Chart.cpp ChartMaker.cpp Point.cpp -o ChartMaker |

# Homework Exercise

This project involves developing a comprehensive Chart class that provides a convenient interface to manipulate a set of points. Each point in a Chart is an instance of the supplied Point class. You are expected to develop a Chart class with the methods documented below. Remember that Chart.h contains just the class definition (similar to Point.h) and Chart.cpp should contain the implementation for the various methods.

## API Requirement for Chart class:

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| **Private Instance variable(s) in Chart:** | |
| std::vector<Point> pointList; | The list of points that constitute this Chart. This class has no other instance variables. |
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| **Public methods in Chart:** | |
| Default (no arguments) constructor | This constructor creates a Chart without any data points in it.  Tip: This is a very simple constructor (no statements in its body |
| Copy constructor | Copy constructor to make a copy of a given Chart. Tip: This is a very simple method-- directly initialize pointList from source chart as part of initializer list for members (see Slide #15 in Cpp-Part3.pptx for example of initializer list for members of class) and the body of this method is empty. |
| Move constructor | The move constructor that initializes this object by moving points from the given source Chart. Tip: very simple method -- directly move pointList from source Chart as part of the initializer list (pointList(std::move(src.pointList))) and the body of this constructor is empty. |
| **Chart**(**const** std::string& fileName); | Constructor to create a chart using points in a given text file. This constructor creates a chart using points in a text file. The text file is assumed to contain pairs of integers representing the x & y coordinate of each point. An example text files containing data points are supplied along with this homework.  The parameter fileName indicates the path to the file from where the point data is to be loaded. If this file name is not valid the behavior of this method is undefined (most likely it will throw an exception).  Tip: Use std::copy to make this method about 3-4 lines long. |
| std::ostream& **operator<<**(std::ostream& os, **const** Chart& c); | Stream insertion operator. It should print each point in the chart c to the given stream os followed by a newline. That is each point’s x & y coordinates must appear on separate lines reflecting the data organization in the supplied points data file(s) (such as: points\_small1.txt).  Note: Body of method (does not include lines for braces) must be no more than 4 lines of properly formatted code. |
| std::istream& **operator>>**(std::istream& is, Chart& c); | Stream extraction operator. It should load all points (until EOF) from the given input stream into the given chart c. The data in the input stream will follow the same organization as the supplied data file(s) (such as: points\_small1.txt).  Note: Body of method (does not include lines for braces) must be no more than 4 lines of properly formatted code. |
| Assignment operator (Chart& **operator=**(**const** Chart& src);) | The assignment operator. This method implements the assignment operator to copy the points from the source into this. This operator enables assignment of one chart object to another as shown in the example below:  Chart c1, c2;  // Do some manipulation with c1 and c2  c1 = c2; // c1 & c2 now have same points.  The parameter src is the source chart from where the data points are to be copied. This method returns a reference to this.  Tip: This is a two line method. |
| **bool** **contains**(**const** Point& p) **const**; | Method to detect if a given point is in this chart. This method checks to see if a given point p is in the list of points associated with this chart (that is the x & y coordinate of p is exactly the same as the x & y coordinate of some point in pointList).  Note: This is a one-liner using the std::find() algorithm.    This method returns true if the given point is in the list of points contained in this chart. [**2 points**] |
| Chart **operator+**(**const** Chart& other) **const**; | Adds points of two charts together. This method is used to add the points from other chart that are not present in this chart to create a new chart. Neither this nor other is modified.  For example if this chart has points {(1, 10), (2, 20), (3, 30)} and the other chart has points {(2, 10), (2, 30), (3, 30)} the returned Chart has points ({1, 10), (2, 20), (3, 30), (2, 10), (2, 30)}.  This method must return a new chart object that contains all points from this and points from other chart.  Note: Using the std::copy\_if() algorithm enables writing this method in 3 lines. [**3 points**] |
| Chart **operator-**(**const** Chart& other) **const**; | Returns a new Chart that contains all points in other removed from points in this chart.  This method is used to remove points from this Chart that are present in other Chart to create a new Chart object. Neither this nor other is modified.  For example if this chart has points {(1, 10), (3, 30), (2, 20), (3, 30)} and the other chart has points {(2, 10), (3,3 0)} the returned chart has points ({1, 10), (2, 20)}.  This method returns a new chart object that contains all points from this but not the points in other.    Note: Using the std::copy\_if() algorithm enables writing this method in 3 lines. |
| Chart **operator\***(**const** Point& scale) **const**; | Creates a new Chart with x & y coordinates of each point in this chart multiplied by the x and y values in scale.  This method is used to multiply points in this chart with the x & y values in the supplied scale. Neither this nor scale object is modified.  For example if this chart has points {(1, 10), (3, 30), (2, 20)} and the scale is (2, 3) the returned chart has points ({2, 30), (6, 90), (4, 60)}.  This method returns a new chart object that contains all points from this scaled by the given scale factor.    Note: Using the std::transform() algorithm enables implementing this method with 3 lines of C++ code |
| Chart **operator/**(**const** Point& scale) **const**; | Creates a new Chart with x & y coordinates of each point in this chart is divided by the x and y values in scale.  This method is used to divide points in this chart with the x & y values in the supplied scale. Neither this nor scale object is modified.  For example if \c this chart has points {(2, 10), (4, 40), (6, 60)} and the scale is (2, 5) the returned chart has points ({1, 2), (2, 8), (3, 12)}.  This method returns a new chart object that contains all points from this scaled (or divided) by the given scale factor.    Note: Using the std::transform() algorithm enables implementing this method with 3 lines of C++ code. [**3 points**] |
| Chart **operator>>**(**int** value) **const**; | Shift the points in the chart to the right by the given amount.  This method shifts the points in this chart to the right by value locations by inserting zeros at the beginning. For example if this chart has points {(1, 10), (2, 30), (3, 30)} then shifting it to the right by 3 results in the new chart having points {(0, 0), (0, 0), (0, 0), (1, 10), (2, 30), (3, 30)}  The parameter value indicates the number of positions by which the point list is to be shifted to the right.  A new Chart object containing points from this shifted to the right.  Note: This method can be written in four statements using methods in std::vector |
| Chart **operator<<**(**int** value) **const**; | Shift the points in the chart to the left by the given amount.  This method shifts the points in this chart to the left by removing points at the beginning of the list. For example if this chart has points {(1, 10), (2, 30), (3, 30)} then shifting it to the left by 2 results in the new chart having points {(3, 30)}.  The parameter value indicates the number of positions by which the point list is to be shifted to the right.  This method returns a new Chart object containing points from this chart shifted to the left.  Note: This method can be written in three statements using methods in std::vector |
| **void** **analyze**(std::ostream& os, **const** **int** scale) **const**; | Method to display a histogram of distribution of unique points in the 4 quadrants.  This method must generate a histogram illustrating the distribution of all unique points in this chart in 4 different quadrants. For example, if this chart contains the points {(1, 1), (-1, 1), (-3, -5), (3, -5), (3, 5), (1, 1), (-3, -5)} then the unique points in the list are {(1, 1), (-1, 1), (-3, -5), (3, 5), (3, -5)} and the number of points in the four quadrants, namely quadrants I, II, III, and IV are: {2, 1, 1, 1} and this method should write the following scaled histogram on the given stream os:  I : \*\*  II : \*  III: \*  IV : \*  where the quadrant with the highest frequency is displayed using scale number of asterisks and other frequencies are suitably scaled.  Using a different example, assuming that the frequency of occurrence of points in the four quadrants is {500, 750, 250, 400} and the scale is 25, then the highest value of 750 is displayed with 25 '\*'s while 500 is displayed with (500 \* 25 / 750) '\*'s, 400 is displayed with (400 \* 25 / 750) '\*'s and so on.  The parameter os is the output stream to which the histogram illustrating the distribution of all unique points in this chart is to be printed.  The scale parameter indicates the scale factor indicating the number of '\*'s to be displayed for the highest frequency of occurrence.  Note: For full credit, this method should be implemented using only algorithms without any loops. Since there are only 4 quadrants, you can manually unroll loops in the worst case scenario. The couple of helper classes from functional header that will come-in handy are: std::bind2nd and std::mem\_fun\_ref. Refer to online documentation on these two helpers for examples on their usage. |

## Requirements for ChartMaker class:

Once you have developed the Chart class the next step is to develop the ChartMaker class that provides the user with a convenient menu to read, manipulate, and save charts. The ChartMaker essentially uses various methods in Chart to perform the necessary manipulations. The ChartMaker is an open ended class and you are expected suitably design it such that it works correctly with the supplied main function in main.cpp and meets the following functional requirements:

1. The ChartMaker performs all operations with a chart which will be referred-to as current in this document. Possibly this current Chart object may be the only instance variable this class may need. All operations performed by this ChartMaker will operate on the current chart.
2. Operations such as print, save, and load directly use the current chart for performing their operations after obtain any necessary inputs (see sample outputs for details) from the user.
3. Operations such as adding to the current charts or subtracting from current chart must prompt and obtain another file of points for use in these binary operations as shown in the sample output. These operations will result in changes to current.
4. Operations such as scaling and shifting must prompt and obtain the scale factors or shift position values from the user (as shown in the sample output) and suitably modify the current chart.

Note that the ChartMaker class should be relatively straightforward to implement. You don’t need nor have to use any algorithms here. Just traditional looping constructs will suffice for this class.

# Sample Outputs

Expected outputs from multiple independent runs of the completed program are shown below. User inputs are shown in red for improved readability

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| $ ./ChartMaker  Enter command (h for help): h  All commands are single characters.  Valid commands are:  l: Load data from file as current set of points  +: Add data from another to to current points  -: Subtract data from another file from current poitns  \*: Scale current points by given pair of values  /: Scale current points by given pair of values  ?: Print histogram current point distribution  <: Shift points to left by a given value.  >: Shift points to right by a given value.  s: Save the current set of points to a given file  p: Print current set of points on screen.  h: Print this message  q: Quit  Enter command (h for help): l  Enter path to file: small\_points1.txt  Enter command (h for help): p  1 1  -1 1  -1 -1  1 -1  1 1  Enter command (h for help): q |

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| $ ./ChartMaker  Enter command (h for help): l  Enter path to file: small\_points1.txt  Enter command (h for help): +  Enter path to file: small\_points2.txt  Enter command (h for help): p  1 1  -1 1  -1 -1  1 -1  1 1  2 2  -2 2  -2 -2  2 -2  Enter command (h for help): q |

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| $ ./ChartMaker  Enter command (h for help): l  Enter path to file: small\_points1.txt  Enter command (h for help): -  Enter path to file: small\_points2.txt  Enter command (h for help): p  -1 -1  1 -1  Enter command (h for help): \*  Enter values to scale x & y coordinates: 100 200  Enter command (h for help): p  -100 -200  100 -200  Enter command (h for help): /  Enter values to scale x & y coordinates: 25 50  Enter command (h for help): p  -4 -4  4 -4  Enter command (h for help): >  Enter positions to shift: 5  Enter command (h for help): p  0 0  0 0  0 0  0 0  0 0  -4 -4  4 -4  Enter command (h for help): <  Enter positions to shift: 6  Enter command (h for help): p  4 -4  Enter command (h for help): q |