**MTRE 2610 Intermediate Programming for Mechatronics – Dr. Kevin McFall**

**Laboratory - Complex number class**

**Introduction**

The goal of this laboratory is to create a surface plot in Excel with data produced using complex arithmetic in C++.

**Mapping equally spaced points to index positions**

The array

double y[5] = { -2,3,8,13,18 };

has five elements equally spaced between -2 and 18, inclusive. Consider initializing the array in a loop rather than manually where the minimum *y*min and maximum *y*max (which are -2 and 18, respectively, in the example), as well as the number of elements *n* (5 in the example), could be different.

const int n = 5;

double yMin = -2, yMax = 18, y[n];

for (int x = 0; x < n; i++)

y[x] = ??? ;

The one missing piece is an equation for y which depends on x. For the points to be equally spaced, a linear function



is required. This function is constrained by the desired minimum and maximum values according to

 and

Note the *n*-1 results from the *n*th value appearing at index *n*-1 since indices begin at 0 rather than 1. The first of these equations generates *b* = *y*min which combined with the second equation simplifies to



The question marks in the sample code can be replaced with the linear equation with the desired values of *y*min, *y*max and *n*. In the case of the example,



Note in this case that *y* increases by *m* = 5 for every increment in *x*, i.e. each of the numbers in the series -2, 3, 8, 13, 18 represent an increase of 5.

**Complex arithmetic**

Consider two complex numbers

 and

Collecting real and imaginary components when adding results in



Subtraction is analogously performed as



Multiplication is more complicated



where the first-outer-inner-last technique is applied to distribute multiplication over addition. Division



can be accomplished by first computing the reciprocal of the divisor and then performing multiplication. The reciprocal of a complex number



can be found by employing the complex conjugate. The magnitude of a complex number



is its distance from the center of the complex plane.

**Complex class**

Create a class to instantiate objects representing complex numbers using the class definition

class Complex {

double real, imag;

public:

Complex ( );

Complex (double r, double i);

void setVals (double r, double i);

double getReal ( ); // Return real part

double getImag ( ); // Return imaginary part

double getMag ( ); // Return magnitude

Complex operator+(Complex c ); // Add two complex numbers

Complex operator-(Complex c ); // Subtract two complex numbers

Complex operator\*(Complex c ); // Multiply two complex numbers

Complex operator/(Complex c ); // Divide two complex numbers

};

ostream& operator<<(ostream& out, Complex z); // Write z to the output stream out

Complex operator/(double x, Complex z); // Return reciprocal of z multiplied by scalar x

**Laboratory exercise procedure**

Complete the complex number class and confirm it by displaying the result



using cout and the insertion operator <<.

Create an array of 20 instances of the Complex class all with the same -1.2 imaginary part but with real parts varying between -1.5 and 0.5. Use the index-to-value mapping presented earlier to vary the real part for index values from 0 to 19. For each complex number, compute *z*2 + *z* and write its magnitude to a text file with the 20 magnitudes on a single row separated by spaces with a single endl at the end.

Take the program created in the previous paragraph, and place it inside a loop iterating 24 times. Have the imaginary part of *z* depend on this loop with values between -1.2 and 1.2. This requires a 2-dimensional array, or matrix, of complex instances who size is 24×20. Again, write the magnitudes of each *z*2 + *z* to a text file where each row in the file corresponds to complex numbers with the same imaginary part. Load the text file into Excel by selecting spaces as delimiters. Select all the data and display as a surface plot, similar to the figure below.



**Grading rubric**

1. 50 points: Completed Complex class demonstrates correct calculation of Equation
2. 25 points: Single-row text file created with magnitudes of complex numbers with -1.2 imaginary part
3. 25 points: Surface plot from complex numbers ranging between -1.5 to 0.5 real and -1.2 to 1.2 imaginary