Spring 2018 CSI33 Final Projects

General information for all the projects:

.1) Only one person can work on a particular project, no group work

.2) **We have very limited number of meetings left in the semester, therefore you will not be presenting your project in class.**

.3) **The due date to submit your project is May 23rd 11:59pm.** Give precise instructions on how to run your program.

CSI33: Final Project Submission Guildelines

1. Program should be well commented:
   1. plenty of internal comments,
   2. function specification should be given for every method/function you defined

2. Project should contain class definitions in separate files, standalone methods (in case of sorting algorithms) should be stored in separate files as well.

3. The program demonstrating the use of classes and methods you defined should be stored in a separate file as well.

4. If you have any restrictions on input: state them in the comments at the top of the file.

   For example, one of the projects is working with the polynomials. There are many ways to enter a polynomial, so person who will be using it later should know how to use it.

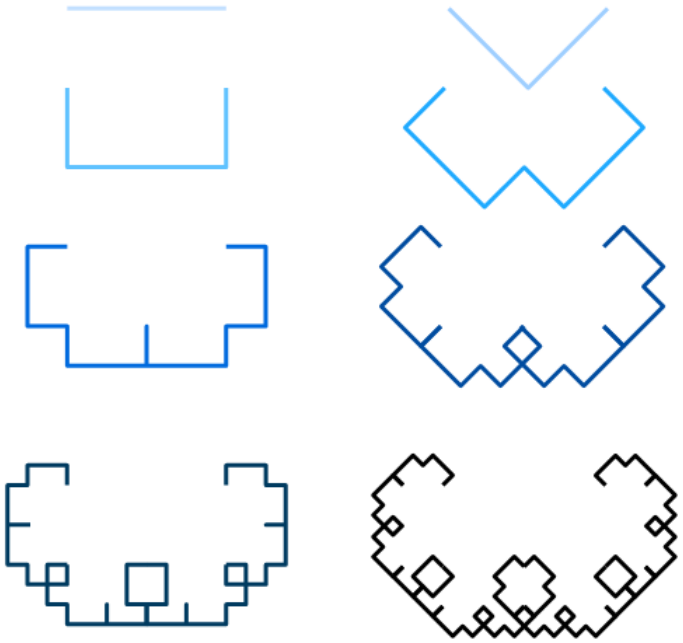
5. In general, describe someplace how to use/run your code. It can be done in a separate **readme** file.

6. You cannot use any non-standard libraries.

Please, be aware that I won't be able to suggest any corrections to be done to the project (as we are limited in time for the Final Grades submission). Therefore make sure that you did your best, and then send me your work.

Here is the link to the Doodle poll:

Project 1 (Recursion):
C-curve
(see our book, page 220 exercise 11)



Project 2 (Cryptography):
Encoding and decoding messages using the Vignere Cipher.

Here is the information about it (in the beginning the general introduction along with description of two easier algorithms is given, and the Vignere Cipher's description is given at the end):
www.natna.info/CSI33/cryptography.pdf

Project 3 (Polynomials, ADTs):
Write a class in Python to represent a polynomial. The class should store a list of the coefficients and the degree of the polynomial. You may assume a maximum degree of 100 for the polynomial. Write the methods for the addition, subtraction, and multiplication operators, input and output operators for the class. Also provide a method for evaluating the polynomial at a specific value. Write unit tests for your **Polynomial class**, as well as a program that plays with the **Polynomial class**.
(see page 352, exercise 6 + page 400, exercise 3)

Project 4 (Polynomials, ADTs):
Write a class in C++ to represent a polynomial in one variable, using dynamic arrays. The class should store an array of the coefficients and the degree of the polynomial. You may assume a maximum degree of 100 for the polynomial. Write the methods for the addition, subtraction, and multiplication operators, input and output operators for the class. Also provide a method for evaluating the polynomial at a specific value. Write program that tests your **Polynomial class**.
(see page 352, exercise 6 + page 400, exercise 3)

Project 5 (Algorithms):
Read about and implement ***Randomized Quicksort*** using C++ (using the provided algorithm)
The worst-case running time for quicksort is still Theta(n^2), but on average it runs in Theta(n log n) time. It's randomized version works even better. You are asked to implement the randomized version.

Here is the original QuickSort Algorithm:
www.natna.info/CSI33/QuickSort-page1.jpg,
www.natna.info/CSI33/QuickSort-page2.jpg,
www.natna.info/CSI33/QuickSort-page3.jpg, and

Here is the Randomized QuickSort:
www.natna.info/CSI33/RandomizedQuickSort-page1.jpg,
www.natna.info/CSI33/RandomizedQuickSort-page2.jpg

After you programmed the Randomized QuickSort and tested it, run the algorithm by hand on the following list: [1,6,3,4,8,2,5,7]. Show all the steps. Whenever a random choice is needed, write up the indices on pieces of paper. Put them all into a hat/container, mix them thoroughly and pull out a number – here is a random number. Submit it with your project submission.

Project 6 (Algorithms):
Read about and implement Radix sort using C++ (using the given algorithm)

Radix sort is called a linear sort (you can read about it in the information provided in the pictures).

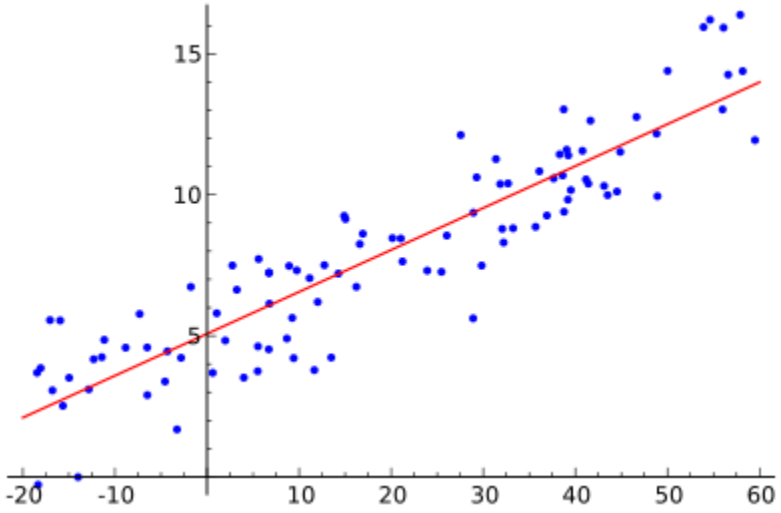
Here is the information and algorithm for the Radix Sort:
www.natna.info/CSI33/RadixSort-page1.jpg,
www.natna.info/CSI33/RadixSort-page2.jpg, and

Here is the algorithm for one of the stable sorts:
www.natna.info/CSI33/CountingSort-page1.jpg,
www.natna.info/CSI33/CountingSort-page2.jpg,
www.natna.info/CSI33/CountingSort-page3.jpg

After you programmed the Radix Sort and tested it, run the algorithm by hand on the following list: [1,6,3,4,8,2,5,7]. Show all the steps. Submit it with your project submission.

Project 7 (Statistical Analysis):
Read about two-variable data, linear regression line and correlation coefficient.
Here are few of the useful links:
https://www.youtube.com/watch?v=T7LauV6AnRg
http://www.dummies.com/how-to/content/how-to-calculate-a-regression-line.html
http://onlinestatbook.com/2/regression/intro.html

Write a program that accepts two variable data from a data file, which is formatted in such a way that each line has an even number of values separated by white space, and value of first variable, say *x*, is followed by the value of the second variable, say *y*. The program should process the data, plot points and draw regression line, if possible, in a graphical window, displaying the axis and the scale.



Project 8 (Propositional Logic, Truth Tables):
Write a program that given a compound proposition builds the truth table for it.

For example,

p	q	r	$p \vee q$	$r \rightarrow (p \vee q)$	$q \wedge (r \rightarrow (p \vee q))$	$(q \wedge (r \rightarrow (p \vee q))) \rightarrow p$
0	0	0	0	1	0	1
0	0	1	0	0	0	1
0	1	0	1	1	1	0
0	1	1	1	1	1	0
1	0	0	1	1	0	1
1	0	1	1	1	0	1
1	1	0	1	1	1	1
1	1	1	1	1	1	1

You can read about Propositional Logic in your Discrete Math I (CSI30) book. If you don't have it then let me know.

Project 9 (Calculus I) Newton's method
Write a program that will be using Newton's method to approximate the indicated root of an equation.
Input: equation in one variable, in the form *polynomial(x) = 0,* where for *x^6* will be used for x^6;
initial approximation x_1; and
the *n*, which is the n^{th} approximation that needs to be found
Output: the n^{th} approximation
See the pdf file with method's description (note that the first page is flipped, sorry):
www.natna.info/CSI33/CSI33NewtonsMethod.pdf

Project 10 (Simulation - stacks, queues):
Consider a real life situation: *airplanes taking off and landing on a runway.* Research about it on the internet, then formulate a question (for example it may be: "Do we need one more runway?" or "Do we need a larger crew in control tower?"), then design a simulation that can help you to answer this question.

Project 11 (Graph Coloring, from CSI 35)
A *coloring of a simple graph* (undirected, no loops, no multiple edges) is the assignment of a color to each vertex of the graph so that no two adjacent vertices are assigned the same color.
The *chromatic number of a graph* G, $\chi(G)$, is the least number of colors needed for a coloring of this graph. Write a program that finds the chromatic number for a given graph and gives assignment of vertices to colors. You can assume that the information about the graph is given in a file, and you can use either adjacency list representation, adjacency matrix representation, or incidence matrix representation. State in the documentation which representation is expected.
For more information refer to the Rosen textbook, Chapter 9.

Project 12 (Huffman Codes, from CSI 35)
Consider a problem of using bit strings to encode the letters of English alphabet (no distinction between upper case letters and lower case letters is made), such that the fewest number of bits is used when encoding a message. Huffman coding is one of the algorithms that given the frequencies (probabilities of occurrences) of symbols in a message produces a prefix code that encodes the message using the fewest possible bits, among all the possible binary prefix code for these symbols. You can find more information in the Rosen book (Chapter 10).

Write a program that given a text message that contains only letters of the alphabet, spaces, commas, question marks, exclamation symbols, semicolons, colons, dashes, and periods, creates an encoding of the message using Huffman codes. The original message is stored in a file. The codes must be output into a separate file, and the encoded message should be output into a file "encoded.txt". Don't forget to count the frequencies of symbols and don't forget to convert all letters to lowercase.
Limitation: you should not read the entire file in, instead read the line by line. It means that the program will be reading file twice: for frequency counting and for encoding.