Step 1: Problem Identification and Statement

The objective of this assignment is to develop software that presents the user with a menu to: calculate the model parameters/ linear regression model using a data file provided by the user, calculate the Freezing Temperature with a salinity value supplied by the user, and the model parameters calculated on the first option, or to exit the program. The program assumes two inputs from the user: a data file and a salinity value.

Step 2: Gathering of Information and Input/Output Description
Relevant information:

Seawater is mainly composed of water, containing approximately 3.5% of substances like salts, metals, and gases that result from volcanic eruptions and the erosion of rocks. The saltiest ocean waters are found in the Atlantic near the equator, where evaporation surpasses precipitation. The salinity of seawater quantifies the quantity of dissolved substances within it. This salinity is often determined using a device that gauges the water's electrical conductivity, as higher levels of dissolved materials lead to better electrical conduction.

In colder regions, determining the Freezing temperature of the Seawater with different salt concentrations has great relevance in many areas of engineering and science. In Civil Engineering, typical applications include the different densities of Salt water and the limited temperature that the water can be used before getting frozen.

The Freezing temperature is calculated through the formula.

$$T = m \times S + b \text{ , where} \qquad (1)$$

T = Freezing Temperature
S = Water Salinity
B = Model Parameter 1
M = Model Parameter 2

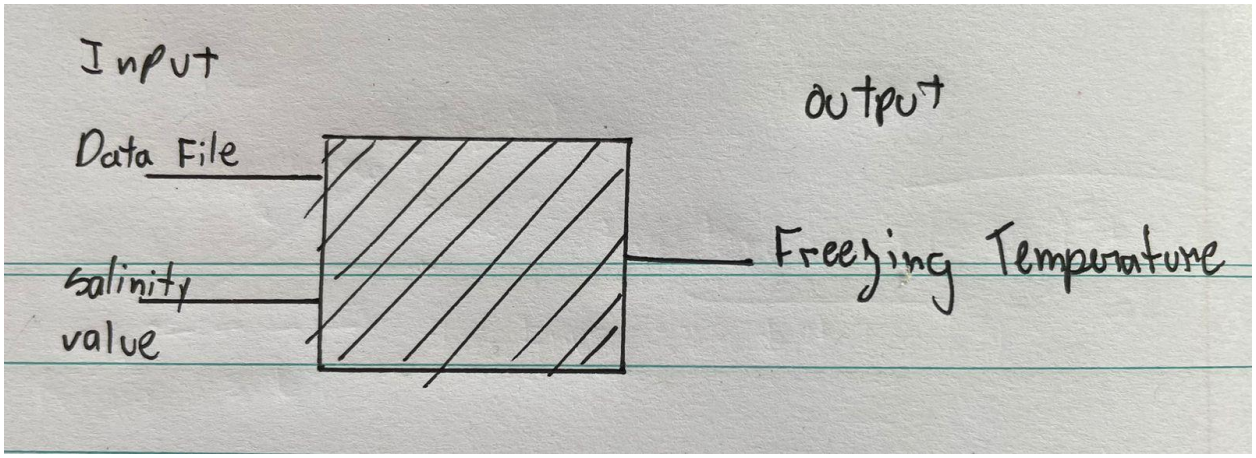
The model parameters ‘b’ and ‘m’ can be calculated using the following formulas:

$$m = \frac{\sum_{k=1}^{n} x_k \cdot \sum_{k=1}^{n} y_k - n.\sum_{k=1}^{n} x_k y_k}{(\sum_{k=1}^{n} x_k)^2 - n.\sum_{k=1}^{n} x^2{}_k}$$

$$b = \frac{\sum_{k=1}^{n} x_k \cdot \sum_{k=1}^{n} x_k y_k - \sum_{k=1}^{n} x^2{}_k \cdot \sum_{k=1}^{n} y_k}{(\sum_{k=1}^{n} x_k)^2 - n.\sum_{k=1}^{n} x^2{}_k}$$

The sums of x and y are made based on the data file provided by the user.

Input/output Description:



The program only requires two inputs from the user: The Data file, in option 1, to calculate the model parameters that are stored on the code, and the Water Salinity value, in option 2, to calculate the freezing temperature - the output of the program. **However, the program informs the value of m and b as a preference of mine.**

Step 3: Design of the algorithm and test cases
Test Case 1: Calculate the model parameters and the Freezing Temperature

```
"Please select one of the options in the menu to move forward
1 - Calculate the linear regression model using the data stored in
the file.
2 - Calculate a freezing temperature given the water salinity using
the linear model of option 1
 3 - exit the program.'

(Input)
Select option: 1

Enter the file name with the following data:
```

Salinity (ppt)	Freezing Temperature (F)
0	32
10	31.1
20	30.1
24.7	29.6
30	29.1
35	28.6

```
(Output)
 M = - 0.0978 B = 32.0347

(Input)
```

```
Select option: 2

Enter the salinity value 3.0

(Output)
Freezing temperature is 31.7413

Select option: 3

(Output)
"Calculation ended, Program exited"
```

Test Case 2: Incorrect Menu option

```
“Please select one of the options in the menu to move forward
1 - Calculate the linear regression model using the data stored in
the file.
2 - Calculate a freezing temperature given the water salinity using
the linear model of option 1
 3 - exit the program.”

(Input)
Select ‘4’

(Output)
"Invalid menu option, please choose one of the options below:
1 - Calculate the linear regression model using the data stored in
the file.
2 - Calculate a freezing temperature given the water salinity using
the linear model of option 1
3 - exit the program."
```

Test Case 3: Selecting the menu option 2, without calculating the linear models on option 1

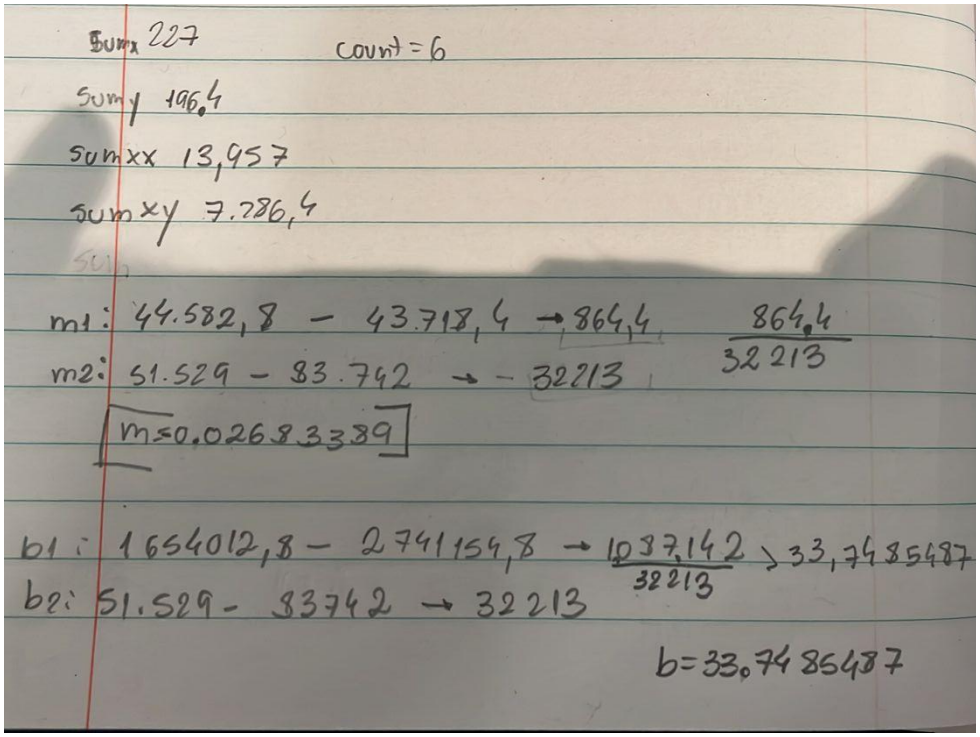
```
“Please select one of the options in the menu to move forward
1 - Calculate the linear regression model using the data stored in
the file.
2 - Calculate a freezing temperature given the water salinity using
the linear model of option 1
 3 - exit the program.”

(Input)
Select ‘2’
```

```
(Output)
“ERROR, value of the model parameters not found, please select 1 to
calculate them.”
```

Test Case 4: Calculate the model parameter and the freezing temperature

```
Please select one of the options in the menu to move forward
1 - Calculate the linear regression model using the data stored in
the file.
2 - Calculate a freezing temperature given the water salinity using
the linear model of option 1
 3 - exit the program.’

(Input)
Select option: 1

Enter the file name with the following data:

Salinity (ppt) Freezing Temperature (F)
3 37
53 42.7
37 30.1
1 29.6
45 29
88 28

(Output)
 M = - 0.02683389 B = 33.7485487

(Input)
Select option: 2

Enter the salinity value 2.5

(Output)
Freezing temperature is 33.6815

Select option: 3

(Output)
"Calculation ended, Program exited"
```

- Proof of the results (manual calculation):



Algorithm design:

---------- Start of Main Function (sample) ----------

```
main() function:

Assign 0 to m
Assign 0 to b
Assign 0 to optionverif
Assign 0 to option

Print " Welcome to the calculator of the Freezing Temperature of
Seawater, please choose an option:", Newline.
Print: " 1 - Calculate the linear regression model using the data
stored in a file", Newline.
Print " 2 - Calculate a freezing temperature given the water salinity
using the linear model of option 1", Newline
Print " 3 - Exit the program", Newline
```

```
Read input into option

——Loop of Option different of 3———
Repeat while option is different from 3

—— Option 1 selected - Calculate Model Parameter ——
     If (option is equal to one)
          Create input file stream inFile
          Create string filename
          Create x and y

          Print " Please inform the name of the file, with its
extension, that have the data to calculate the linear model ",
Newline
          Read input into filename
          Open file filename for reading into inFile
          If (inFile is in fail state)
               Print "Failed to open input file"
               Exit Program

          Assign 0 to sumx
          Assign 0 to sumy
          Assign 0 to sumxx
          Assign 0 to sumxy
          Assign 0 to count

          Create string header
          Read string of inFile into header

          Repeat while don't reach the end of the file of inFile
          Read value of inFile into x and y
          Add x to sumx and store into sumx
          Add y to sumy and store into sumy
          Add the multiplication between x and x to sumxx and store
into sumxx
          Add the multiplication between x and y to sumxy and store
into sumxy
          Increment count in 1

     Close inFile

     Create m1
     Create m2
     Create b1
     Create b2
```

```
     Assign (sumx * sumy) - (count * sumxy) to m1
     Assign (sumx * sumx) - (count * sumxx) to m2
     Assign m1/m2 to m

     Assign (sumx * sumxy) - (sumxx * sumy) to b1
     Assign (sumx * sumx) - (count * sumxx) to b2
     Assign b1/b2 to b

     Print "Model parameter m is ", Print m value, " Model parameter
b is ", Print b value, Newline, Newline

     Print " Welcome to the calculator of the Freezing Temperature
of Seawater, please choose an option:", Newline.
     Print: " 1 - Calculate the linear regression model using the
data stored in a file", Newline.
     Print " 2 - Calculate a freezing temperature given the water
salinity using the linear model of option 1", Newline
     Print " 3 - Exit the program", Newline
     Increment optionverif in 1
```

—— Option 2 selected - Calculate Freezing Temperature—

```
Otherwise if (option is equal to 2)
     If (optionverif is different of 1)
          Print " ERROR, value of the model parameters not found,
please select 1 to calculate them"

     Otherwise if (optionverif == 1)
          Create sal
          Print " Please inform a salinity value to calculate the
freezing temperature", Newline
          Read input into sal
          Create Ftemp
          Assign (m * sal) + b to Ftemp
          Print " Freezing temperature is" , Print Ftemp value ,
Newline, Newline

          Print " Welcome to the calculator of the Freezing
     Temperature of Seawater, please choose an option:", Newline.
          Print: " 1 - Calculate the linear regression model using
     the data stored in a file", Newline.
          Print " 2 - Calculate a freezing temperature given the
     water salinity using the linear model of option 1", Newline
          Print " 3 - Exit the program", Newline
```

—— If user inform a invalid Option——

```
Otherwise
     Print “Invalid menu option, please choose one of the options
below:", Newline
     Print "1 - Calculate the linear regression model using the data
stored in the file.", Newline
     Print "2 - Calculate a freezing temperature given the water
salinity using the linear model of option 1", Newline
     Print "3 - exit the program", Newline
     Read input into option

Print “Calculation ended, Program exited”;
Return 0
```

—— End of Pseudocode——

Step 4: Implementation

```
*************************************************************
Author: Pedro Felix Fernandes
Date Created: September 08, 2023
Description:

_____________________________________________________
Assignment 1 - Civil Engineering Case Study – Freezing Temperature of
Seawater

_____________________________________________________
Civil Engineering Case Study – Freezing Temperature of Seawater:
The program reads a data file with data of different concentrations
of salinity
and Freezing temperatures. It calculates the model parameters
following the data provided.
After that, the code asks for a salinity value from the user and
calculates the freezing temperature
at that salinity concentration.
*************************************************************/

// Include Libraries
#include <iostream>
#include <fstream> // for reading of data files
#include <string>

//use standard namespace
using namespace std;

// Main Function
int main() {
     //Inputs
```

```
	double m = 0, b = 0;
	int optionverif = 0;
	int option = 0;
	// Output
	cout << " Welcome to the calculator of the Freezing Temperature
of Seawater, please choose an option:" << endl
		<< "1 - Calculate the linear regression model using the
data stored in a file." << endl
		<< "2 - Calculate a freezing temperature given the water
salinity using the linear model of option 1" << endl
		<< "3 - exit the program" << endl;
	//Option selection Input
	cin >> option;

	// Infinite loop while option is different from 3
	while (option != 3) {

		// Option 1 selected - Calculate the Model Parameters
		if (option == 1) {

			//Creation of input file stream
			ifstream inFile;
			//Inputs
			string filename;
			double x, y;

			// User inform name of the file and stores it on
filename
			cout << "Please inform the name of the file, with its
extension, that have the data to calculate the linear model" << endl;
			cin >> filename;

			// Open the file informed by the user
			inFile.open(filename , ios::in);

			// If opening of the fail fails, close the program
			if (inFile.fail()) {

				cerr << "Failed to open input file";
				exit(-1);

			}
			// Creation of the sums to calculate the Model
Parameters
			double sumx(0), sumy(0), sumxx(0), sumxy(0);
```

```
                double count = 0;

                // Creation of variable to store the headers of the
life
                string header;
                getline(inFile, header);

                // Read the information of the file while it doesn't
reach the end of the file
                while(!inFile.eof()){
                     // Assign the first value to x and the second
to y
                     inFile >> x >> y;
                     // Sum the values of x
                     sumx += x;
                     // Sum the values of y
                     sumy += y;
                     // Sum the values of x*x
                     sumxx += (x*x);
                     // Sum the values of x*y
                     sumxy += (x*y);
                     // Increment counter - Define how many lines of
values were on the data file
                     count++;
                }
                // Close file
                inFile.close();

                // Create inputs to store values
                double m1,m2,b1,b2;

                //Calculate the upper side and lower side of m
formula
                m1 = (sumx * sumy) - (count * sumxy);
                m2 = (sumx * sumx) - (count * sumxx);
                //Find the value of model parameter m
                m = m1 / m2;
                //Calculate the upper and bottom side of the b
formula
                b1 = (sumx * sumxy) - (sumxx * sumy);
                b2 = (sumx * sumx) - (count * sumxx);
                // Find the value of the model parameter b
                b = b1 / b2;

                // Inform values of the model parameters to user
```

```
                cout << "Model parameter m is " << m << ". Model
parameter b is " << b << endl<< endl;

                // Prompt the user to select another option of the
menu
                cout << "Please select one of the options of the menu
to move forward "<< endl
                     << "1 - Calculate the linear regression model
using the data stored in the file." << endl
                     << "2 - Calculate a freezing temperature given
the water salinity using the linear model of option 1" << endl
                     << "3 - exit the program" << endl;

                // Declare a variable to verify if option 1 was
selected before option 2
                optionverif++;



           }

           // Option 2 selected - Calculate the Freezing temperature
with the model parameter m and b, with the salinity informed by the
user
           else if (option == 2) {

                // Verification if the option 1 was selected before
                if (optionverif != 1) {
                     cout << "ERROR, value of the model parameters
not found, please select 1 to calculate them." << endl;
                }
                // If option 1 was selected before the program
continues
                else if (optionverif == 1) {
                     // Input
                     float sal;
                     // Prompt the user for salinity value
                     cout << "Please inform a salinity value to
calculate the freezing temperature " << endl;
                     // Store salinity value
                     cin >> sal;

                     // Create vulnerable to store Freezing
Temperature
                     float Ftemp;
```

```
                    Ftemp = (m * sal) + b;

                    // Inform the user the Freezing temperature of
the informed salinity and model parameters of m and b
                    cout << "Freezing temperature is " << Ftemp <<
endl << endl;

                    // Prompt the user for the following step
                    cout << "Please select one of the options of
the menu to move forward " << endl
                         << "1 - Calculate the linear regression
model using the data stored in the file." << endl
                         << "2 - Calculate a freezing temperature
given the water salinity using the linear model of option 1" << endl
                         << "3 - exit the program" << endl;
               }

          }
          // If the user selects another option that is not 1 or 2,
prompts the user for the another option selection
          else cout << "Invalid menu option, please choose an
option:" << endl
               << "1 - Calculate the linear regression model using
the data stored in the file." << endl
               << "2 - Calculate a freezing temperature given the
water salinity using the linear model of option 1" << endl
               << "3 - exit the program" << endl;
          cin >> option;



     }
     // If user selects option 3, display message and exit the
program
     cout << "Calculation ended, Program exited";

     return 0;
}
```

Step 5: Software Testing and Verification

Test Case 1: Calculate the model parameters and the Freezing Temperature

```
 Welcome to the calculator of the Freezing Temperature of Seawater, please choose an option:
1 - Calculate the linear regression model using the data stored in a file.
2 - Calculate a freezing temperature given the water salinity using the linear model of option 1
3 - exit the program
1
Please inform the name of the file, with its extension, that have the data to calculate the linear model
data.txt
Model parameter m is -0.0978131. Model parameter b is 32.0347

Please select one of the options of the menu to move forward
1 - Calculate the linear regression model using the data stored in the file.
2 - Calculate a freezing temperature given the water salinity using the linear model of option 1
3 - exit the program
2
Please inform a salinity value to calculate the freezing temperature
3.0
Freezing temperature is 31.7413

Please select one of the options of the menu to move forward
1 - Calculate the linear regression model using the data stored in the file.
2 - Calculate a freezing temperature given the water salinity using the linear model of option 1
3 - exit the program
3
Calculation ended, Program exited
```

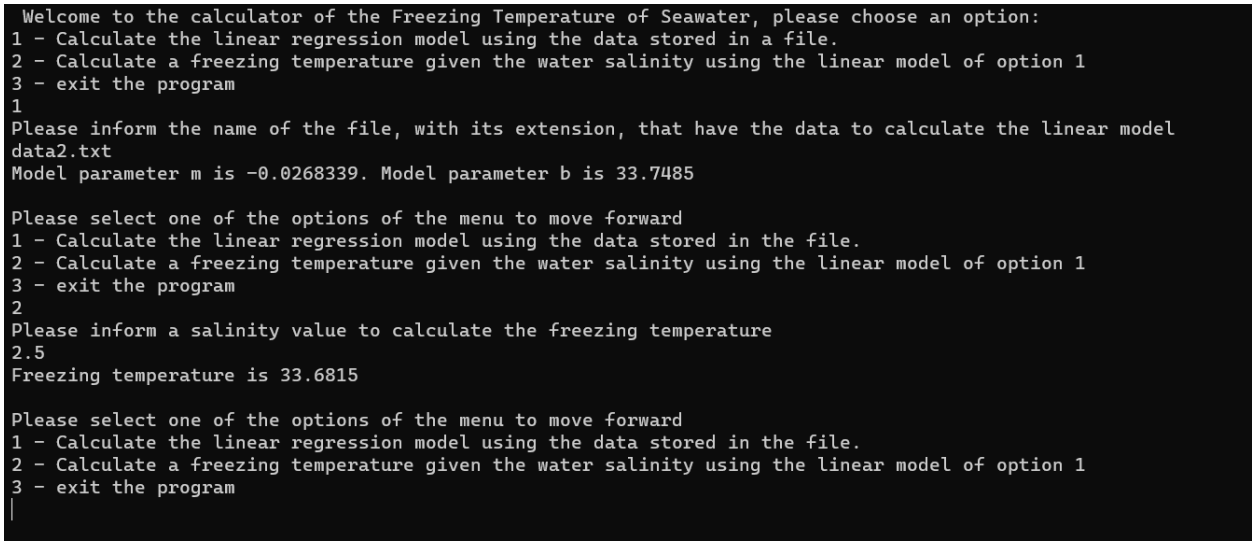
Test Case 2: Incorrect Menu option

```
 Welcome to the calculator of the Freezing Temperature of Seawater, please choose an option:
1 - Calculate the linear regression model using the data stored in a file.
2 - Calculate a freezing temperature given the water salinity using the linear model of option 1
3 - exit the program
4
Invalid menu option, please choose an option:
1 - Calculate the linear regression model using the data stored in the file.
2 - Calculate a freezing temperature given the water salinity using the linear model of option 1
3 - exit the program
```

Test Case 3: Selecting the menu option 2, without calculating the linear models on option 1

```
 Welcome to the calculator of the Freezing Temperature of Seawater, please choose an option:
1 - Calculate the linear regression model using the data stored in a file.
2 - Calculate a freezing temperature given the water salinity using the linear model of option 1
3 - exit the program
2
ERROR, value of the model parameters not found, please select 1 to calculate them.
```

Test Case 4: Calculate the model parameter and the freezing temperature



User Guide

This program will help you determine the Freezing temperature of any water with different salinity using a data file as a model parameter to calculate the temperature. You will be asked to provide the data file with the sample data to define the parameter models and the salinity value on the second option to determine the freezing temperature. The program will display the results on the terminal. To terminate the software, simply type ‘3’.