CEG 2170
Programming Assignment 4

Purpose of Programming Assignment 4

The primary purpose of this assignment is to gain experience with the new concepts of pointers and input files. Secondary to those concepts is to gain further experience with conditional statements, loops, and functions. The subject of this assignment is the thermal expansion of metals.

Overview

When a metal is heated it will expand slightly. Such an expansion depends on the initial and final temperatures as well as the particular kind of metal being heated. Sometimes it is assumed that expansion is a linear function of the temperature increase. A more accurate mathematical model based on experimental data shows that the expansion is a quadratic function of the temperature increase. Assume that heating of the rod of initial length L_0 takes place. The rod will be heated above the reference temperature of 32° Fahrenheit (F) until it reaches $t° F$ and has a measured length of $L = L(T)$.

The equation for the expansion is:

$$L = L_0 * \left(1 + \left(A * \frac{(T - 32.0)}{1000.0} \right) + \left(B * \left(\frac{T - 32.0}{1000.0} \right)^2 \right) \right)$$

Values of A and B are constant and values for seven selected metals are given in the following table. Note that the above equation is valid *only* in the temperature range indicated for the metal name.

Metal ID	Metal Name	A	B	Temp Range F°
1	Aluminum	0.012580	0.003000	32 - 1130
2	Cast iron	0.005441	0.001747	32 - 1160
3	Ingot iron	0.006375	0.001636	32 - 1380
4	Malleable iron	0.006503	0.001622	32 - 90
5	Ingot steel	0.006212	0.001623	32 - 1380
6	Copper	0.009278	0.001244	32 - 1160
7	Nickel	0.007652	0.001023	32 - 1830

* Ref: <u>Standard Handbook for Mechanical Engineers</u>, Seventh Edition, by Baumeister and Marks, 1997, pp. 4-7, 4-8.

Requirements

1. Create a `main` function that calls the `getMetalID` function to get the metal ID from the user. The `getData` function is then called to get the values for A, B, low temperature, and high temperature from the input file. The `getInitialLength` and `getFinalTemperature` functions are called to get the initial length of the metal rod and the final temperature form the user. Using these values, the `getExpandedLength` function is called to compute and get the final length of the metal rod. Finally, `printReport` is called to print the results for this program. Add a loop in `main` that allows the user to repeatedly execute the program until he/she chooses to exit.

2. The `getMetalID` function accepts no arguments and returns the metal ID. This function prompts the user for the metal ID, providing the user with a list of metals from which a selection will be

made. Valid IDs are between 1 and 7 (inclusive) and you are required to verify a valid ID is entered by the user. Continue requesting input from the user until a valid value is entered.

3. The `getData` function accepts the following arguments and <u>returns nothing</u> (i.e., you are not permitted to use a `return` statement in this function). This function opens the `input.txt` input file and reads the A and B constants and low and high temperature values for the metal corresponding to the input metal ID. The `input.txt` file is provided in the assignment's dropbox folder in Pilot. Your program must print an error message and exit if there is an error when attempting to open the input file. The input arguments to this function are:

    a. **File Pointer** - pointer to the input file. You are required to declare the file pointer variable in `main` and pass it to this function.

    b. **Metal ID** – integer ID entered by the user. Use this ID when searching the input file for the corresponding values. You may pass the metal ID by value from `main` into this function.

    c. **A** – pointer to the A constant value. You are required to pass A by reference from `main` into this function.

    d. **B** – pointer to the B constant value. You are required to pass B by reference from `main` into this function.

    e. **Low Temperature** – pointer to the low temperature. You are required to pass the low temperature by reference from `main` into this function.

    f. **High Temperature** – pointer to the high temperature. You are required to pass the high temperature by reference from `main` into this function.

4. The `getInitialLength` function accepts no arguments and returns the initial length of the metal rod. This function prompts the user to enter the initial rod length. A valid length must be greater than zero and you are required to verify that a valid length is entered by the user. Continue requesting input from the user until a valid value is entered.

5. The `getFinalTemperature` function accepts the metal ID, the low temperature, and the high temperature corresponding to the metal rod's material and returns the final temperature. This function prompts the user for the final temperature. A valid temperature must be between the low and high temperatures (inclusive) and you are required to verify that a valid temperature is entered by the user. Continue requesting input from the user until a valid value is entered.

6. The `getExpandedLength` function computes the final length of the metal rod using the equation presented above. Pass the required variables by value from `main` (i.e., those variables required to perform the computation). Return the computed length back to `main`.

7. The `printReport` function prints the all information for this program. Pass the required variables by value from `main` (i.e., those variables required to output the required information – see the sample output). You are required to print the temperature values with 2 digits of precision and the length values with 6 digits of precision. You are also required to print the full name of the metal rod's material. See the sample output for formatting.

Sample Program Interaction

```
"C:\Users\Public\Documents\CEG 2170\Program Assignments\PA4\Hutchison_PA4\bin\Debug\Hutchison_PA4.exe"          —     □     ×

This program calculates the expansion of a metal rod given its
initial temperature and initial length.

1 - Aluminum
2 - Cast Iron
3 - Ingot Iron
4 - Malleable Iron
5 - Ingot Steel
6 - Copper
7 - Nickel

Select the number representing a metal (1 to 7): 8

1 - Aluminum
2 - Cast Iron
3 - Ingot Iron
4 - Malleable Iron
5 - Ingot Steel
6 - Copper
7 - Nickel

Select the number representing a metal (1 to 7): 7

Enter the initial length of the metal rod (inches): 20

Enter the final temperature to the nearest tenth of a degree Fahrenheit: 1000

Material ID          = 7
Material Name        = Nickel
Initial Temperature  = 32.00 degrees F
Initial Length       = 20.000000 inches
Final Temperature    = 1000.00 degrees F
Final Length         = 20.167315 inches

Would you like to perform an other calculation (Y/N): y

This program calculates the expansion of a metal rod given its
initial temperature and initial length.

1 - Aluminum
2 - Cast Iron
3 - Ingot Iron
4 - Malleable Iron
5 - Ingot Steel
6 - Copper
7 - Nickel

Select the number representing a metal (1 to 7): 2

Enter the initial length of the metal rod (inches): 5

Enter the final temperature to the nearest tenth of a degree Fahrenheit: 100

Material ID          = 2
Material Name        = Cast Iron
Initial Temperature  = 32.00 degrees F
Initial Length       = 5.000000 inches
Final Temperature    = 100.00 degrees F
Final Length         = 5.001890 inches

Would you like to perform an other calculation (Y/N): n

Process returned 0 (0x0)    execution time : 24.881 s
Press any key to continue.
```

What to Turn In

Upload your zipped (compressed) project to the Dropbox on Pilot. Be sure your program follows the guidelines given on the Style Requirements document (provided on Pilot) with respect to commenting, variable naming, indenting, etc.

Grading Rubric

General documentation/style (10 points possible; add all that apply):
Complete header information at top of program (2 pts)
Correct indenting (2 points)
Correct use of white space; in general, code is single-spaced with a blank line between sections (such as between variable declarations and input; between input and calculations; between calculations and output). This applies to main and all other functions (3 pts)
Clean and organized presentation of your program input/output presented to the user (3 pts)
Main (25 points)
Variable declarations in main for A, B, low temp, high temp, and the file pointer (5 pts)
Function calls for getMetalID, getInitialLength, getFinalTemperature, getExpandedLength (8 pts)
Function call for getData (5 pts)
Function call for printReport (2 pts)
Repeated execution of the program until the user chooses to exit (5 pts)
Functions (50 points)
getMetalID with error checking (5 pts)
getData (17 pts)
a.   Accepts applicable arguments as pointers (5 pts)
b.   Open input file with error checking (5 pts)
c.   Reads information corresponding to input metal ID (5 pts)
d.   Closes input file (2 pts)
getInitialLength with error checking (5 pts)
getFinalTemperature with error checking (5 pts)
getExpandedLength with correct computation (10 pts)
printReport with proper output, including metal name (8 pts)
Program Miscellaneous (15 points)
Include proper include statements (3 pts)
Meaningful variable names (5 pts)
Proper use of required constants (2 pts)
Proper specification of function prototypes (5 pts)