Lab 3: Using Selection and Repetition Structures

Objective

The objective of this lab is to learn to solve engineering problems using C++. We will focus on these issues:

- Understand the requirements of a problem and the algorithm/pseudo code solution
- Implement the solution using C++ **using selection and repetition control structures**
- **Validate data inputs for appropriate values and convert to correct units of measurements.**
- Debug and remove errors
- Test and verify the correctness of the results

Description

For this lab, you will solve 5 problems that are described below: (4 of these problems are from G. Bronson's C++ textbook[1])

1. Newton's law of cooling states that when an object with initial temperature T is placed in a surrounding substance of temperature A, it will reach a temperature **TFin = (T – A) e^{-kt} + A**.
   In this formula, e's value is 2.71828 (Euler's number), k is the thermal coefficient of the material being cooled. Using this formula develop a C++ program that determines the temperature reached by an object 20 minutes when placed in a glass of water whose temperature is 60 degrees. Assume that the object initially has a temperature of 150 degrees and has a thermal constant of 0.0367. **Time t in the formula should be in seconds; Assume that user input is in minutes; you are required to convert time to seconds. Temperature is in Kelvin. Make sure you output a message to the user indicating this.**

2. a. The voltage gain of an amplifier is given by the formula
   Voltage gain = [275 / (23^2 + $(0.5\ f)^2$)$^{1/2}$]^n
   where f is the frequency, in Hertz, and n is the number of stages in the amplifier. Using this formula develop a C++ program that determines the value of the voltage gain for a 4-stage amplifier operating at a frequency of 120 Hertz. Your program should produce the following display:
   At a frequency of XXXX hertz, the voltage gain is YYYY
   Where XXXX is the frequency and YYYY is the voltage gain.
   b. Use your calculator and make sure your program works correctly. Then modify it to determine the voltage gain for **different number of stages from 5 to 12 with the amplifier operating at frequency 9500 Hertz, and print out messages for each. Output should contain a title, header for number of stages and voltage gain, followed by {stages, voltage gain} values.**

   3. A model to estimate the number of grams of a certain radioactive isotope left after N years is given by the formula **Remaining material = (Original material) $e^{-0.0012N}$.** Using this formula develop a C++ program to determine the radioactive material remaining after 1000 years, assuming an initial amount of 100 grams. Verify the output displayed using hand (calculator) calculation. After you verified your program is working correctly determine the amount of radioactive material remaining after 275 years, assuming the initial amount is 250 grams. The radioactive half-life for a given radioisotope is the time for **half** the radioactive nuclei in any sample to undergo radioactive decay. **Modify your program such that it displays the half-life in years the sample inputs.**

   4. The acid level of rain is measured on a pH scale using the formula
   pH = - $\log_{10}$(concentration of hydronium ions)
   where the concentration of hydronium ions is measured in units of moles/liter. (For your information, a pH level of 7 indicates neutral value; levels below 7 indicate the presence of an acid, above 7 indicates presence of an alkaline substance. For example, sulfuric acid has pH of 1, lye has a pH of 13, and water a pH of 7. Marine life cannot survive in water with pH level below 4.) Using the formula for pH, develop a C++ program the computes pH level of a substance based on a user input value for the concentration of hydronium ions. **Your program should also print out a message that indicates whether the given sample is acidic, alkaline or neutral.**

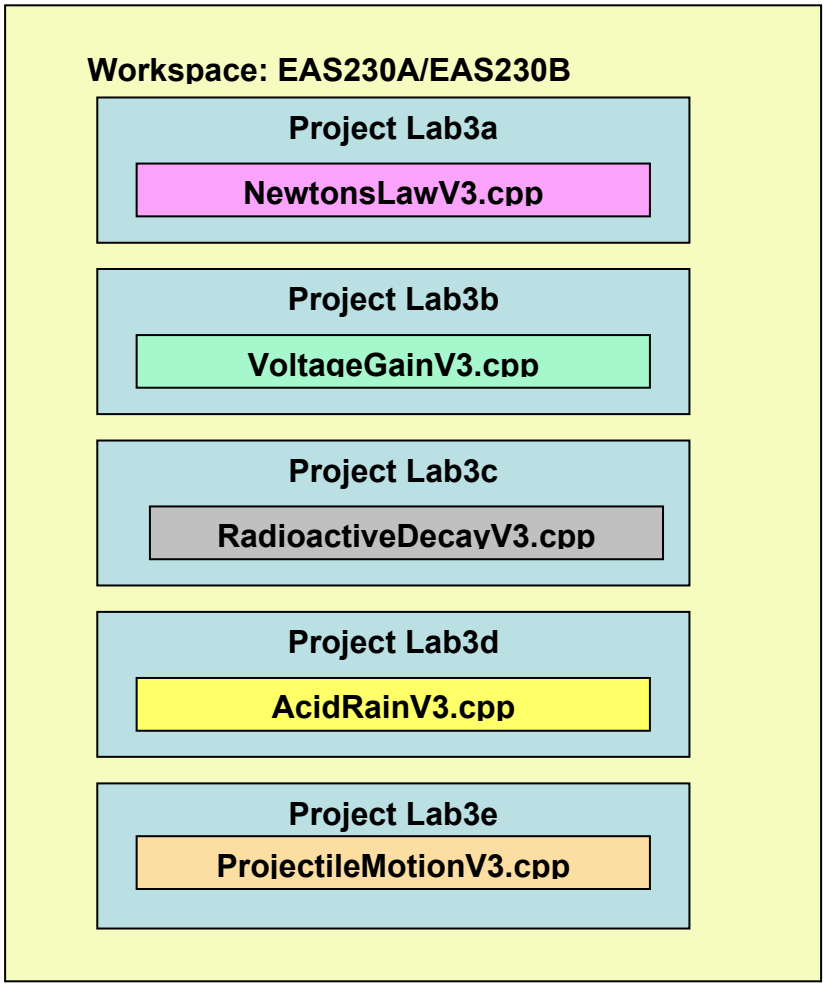
[1] C++ for Engineers and Scientists, Gary J. Bronson, Brooks/Cole Thomson Learning, 1999.

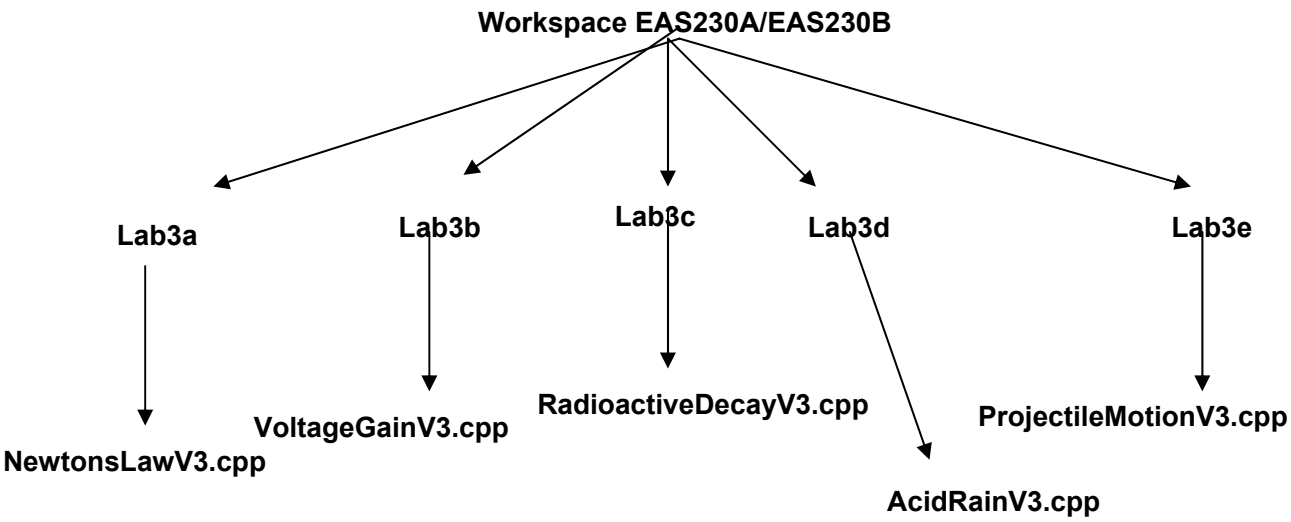
5. The projectile motion of a rocket is defined by the equation (after considering forces of friction etc.) **$h = 2.1*t^2 - 0.0013*t^4 + 0.000034*t^{4.75}$. Use this formula to print out the trajectory of the rocket starting from t = 0 until it hits the ground (h = 0). Print out the various values of t and h value with suitable headings.**

For each solution you will develop an algorithm in pseudo code, then develop and execute a C++ program using the VC++ environment.

Visual C++ Environment and Workspace Structure

In order to keep your lab work organized we will maintain them in a structure as shown below: A tree diagram of the same is given next. You will add project Lab3a through Lab2e to the EAS230A/EAS230B workspace already created for your first lab. Each of the Lab2x will host the C++ program for the problem stated above.





Template for Program Header

Place the following code at the beginning of every source code file (.cpp) that you submit for this class.

```
/************************************************************
* NAME: your name                                           *
* PERSON NUMBER: your person number                         *
* PROGRAM:  Lab name                                        *
* PURPOSE: 1-2 line summary of the purpose of the lab       *
* DATE: Date of last update                                 *
* PLATFORM: Microsoft Visual C++ 6.0 Pro                    *
* Course & Section:                                         *
************************************************************/
```

On-line submission of your code

All source code (.cpp) will need to be submitted using the on-line command which will be given to you during the lecture and lab. The procedure for submission is as follows:

From your unix command-prompt, do the following:
change directories to where your files are located
run the following command for each file

- `submit_eas230a <file>`
  - where `<file>` is the name of the file you need to submit.
  - For eas230b submit_eas230b <file>
- You will have to change directory (cd) to be in the correct directory where the .cpp file located. Ask your TA for help on this.
- You will submit five files: NewtonsLawV3.cpp, VoltageGainV3.cpp, RadioactiveDecayV3.cpp, AcidRainV3.cpp, ProjectileMotionV3.cpp.
- As and when you finish a program, go ahead ad submit it. Don't wait till the last minute to submit all at once.

Evaluation

There are five (5) parts to this lab:
Each part consists of a program and is worth 20%.
The evaluation is as follows:

Data declarations	1%
Input Statements	1%
Calculation Statements	14%
Output Statements	2%
Comments including name box	2%