CS 158/159 Homework 2

This assignment is worth 15 points and will be **due Monday February 5, 2018 at 11:00pm**. All assignment deadlines are firm and the ability to submit your assignment will be disabled after the deadline elapses. No late work will be accepted. You are encouraged to start this assignment as soon as possible so that you have ample time to seek assistance should you experience difficulties completing or submitting this assignment.

This programming assignment does not have a single solution, and the assignment you submit must be your own original work. **Collaboration with other students is not permitted on homework assignments.** Any submission may be processed with comparison software and the results will be used to detect unacceptable collaboration between individuals. If you need assistance, you should only consult course staff regarding your program.

Your program must adhere to the course programming standards (available in the course packet and in Blackboard). Please review this document before submitting your assignment, because failure to adhere to it will result in a reduction in points. Your program must include the designated program header (~cs15x/student/hdrProg) at the top of the program (which can be inserted in `vi` using the `hp` shortcut while in command mode). The header must include an appropriate description of your program and must contain your official Purdue career account e-mail address. Also note that course standards prohibit the use of advanced programming concepts not yet introduced in the course, unless otherwise specified.

Each of the example executions provided below represents a single execution of the program. Your program must accept input and produce output **exactly** as demonstrated in the example executions. Your program will be tested with the data seen in the examples below and an unknown number of additional tests making use of reasonable data. Do not include any example outputs with your submission.

A single program file (with the `.c` extension) must be submitted electronically via the `guru` server. An example submission was conducted during the first week in lab00. Any attempts to submit via another method will be denied consideration. You may make multiple submissions before the deadline, but only the last attempt is retained and graded. All previous submissions will be over-written and cannot be recovered. The submission script will reject the submission of any file that does not compile. A program must compile to be considered for partial credit. You should always check the confirmation e-mail you receive after a submission to verify that you have submitted the correct file, to the correct assignment, and to the correct lab section. If you have a concern regarding how to submit work, please visit course staff prior to the assignment deadline.

Problem: In chemistry you may have learned about equations to calculate state variables (pressure, density) of gases. A common equation of state is the Ideal Gas Law, which states pV = nRT, where p is the absolute pressure in Pascals, V is the gas volume in m^3, n is the number of moles of gas, R is the universal gas constant (8.3145 J/mol-K), and T is the absolute temperature. Absolute temperature is the temperature in Kelvin (use 273.15 as conversion value from Celsius).

As a summer intern with a company you met at the EXPO you are analyzing a spherical pressure vessel designed to store Neon gas. It has been required that you determine the mass of Neon gas the spherical pressure vessel can hold using the ideal gas equation. From the results of the ideal gas equation your engineering team will begin to design the pressure vessel with the specified radius and calculated mass of Neon.

During a design review, another intern (also from Purdue) on your team suggested using an equation that is more accurate than the Ideal Gas Law, the van der Waals equation, which adjusts for 'real' gases by using coefficients *a* and *b*.

$$(P + an^2/V^2)(V - nb) = nRT$$

https://en.wikipedia.org/wiki/Van_der_Waals_equation

The parts have been ordered and engineers have been doing other calculations using the mass calculated from the Ideal Gas Law. Using the more accurate van der Waal equation, the team determines the easiest way to store the same mass of Neon is to change the temperature, as the structural plans are more difficult to alter at this point in the design process.

Your program should take as input the (inner) radius of the pressure vessel in meters (you may neglect wall thickness), the temperature of the vessel in Celsius, and the maximum pressure the vessel can hold in MPa. (1 MPa = 10^6 Pascals). It should calculate the mass the vessel will hold using the inputs specified and the Ideal Gas Law. Finally, your program should output the new temperature required using the van der Waals equation in order for the vessel to hold the same mass of gas as previously calculated.

Neon Constants:

$molar\ mass = 20.1797 \frac{g}{mol}$	$a = 2.12 * 10^{-2}\ Pa - m^6$ (Updated January 29)	$b = 17.10 * 10^{-6} \frac{m^3}{mol}$

Example Execution #1:

```
Enter the inside radius of the vessel (m)-> 3
Enter the temperature of the vessel (degrees C)-> 25
Enter the maximum absolute pressure in the vessel (MPa)-> 3

-=============================-
Radius: 3.00                  (m)
Temperature: 25.00            (C)
Pressure: 3.00              (MPa)
Mass of Neon: 2761.96        (kg)
-=================================-
New Temperature: 21.85            (C)
-=================================-
```

Example Execution #2:

```
Enter the inside radius of the vessel (m)-> 3
Enter the temperature of the vessel (degrees C)-> 25
Enter the maximum absolute pressure in the vessel (MPa)-> 15.25

-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
Radius: 3.00                  (m)
Temperature: 25.00            (C)
Pressure: 15.25             (MPa)
Mass of Neon: 14039.96       (kg)
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
New Temperature: 7.67             (C)
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
```

Example Execution #3:

```
Enter the inside radius of the vessel (m)-> 3
Enter the temperature of the vessel (degrees C)-> 30.759
Enter the maximum absolute pressure in the vessel (MPa)-> 3

-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
Radius: 3.00                  (m)
Temperature: 30.76            (C)
Pressure: 3.00              (MPa)
Mass of Neon: 2709.62        (kg)
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
New Temperature: 27.55            (C)
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
```

Example Execution #4:

```
Enter the inside radius of the vessel (m)-> 3.5
Enter the temperature of the vessel (degrees C)-> 17
Enter the maximum absolute pressure in the vessel (MPa)-> 20.3

-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
Radius: 3.50                  (m)
Temperature: 17.00            (C)
Pressure: 20.30             (MPa)
Mass of Neon: 30496.13       (kg)
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
New Temperature: -6.38            (C)
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
```

Additional Notes:

- All variables should be of the `double` data type.
- Course standards prohibit the use of programming concepts not yet introduced in lecture. For this assignment you can only consider material in the first 3 chapters of the book, notes, and lectures. Use of advanced programming constructs beyond this material would result in a loss of points.