CMPSC 201 – Spring 2016
Programming Project 3
To be done individually
Worth 50 points
Due by 11:00 pm on March 29, 2016

Goals: Developing problem-solving skills and functions

Problem: You will create a program that will approximate the volume of pores in a new composite material. While the material is being formed it is injected with air which creates bubble and pores to decrease the density of the composite material. However, if too many pores and bubbles are created, the material loses its strength and catastrophic failure occurs. You are to create a program that will determine what percentage of the material is due to pores (connected to the surface) and bubbles (totally enclosed within the sample). For the purposes of this analysis all bubbles will be assumed to be the same size and all the pores will be cylinders of the same size.

The sample that is being analyzed is a rectangular parallelepiped (all angles are 90 degrees, but length, width, and height may be different values). The user will be prompted to enter the dimensions of the sample (height, length, and width), the number of the bubbles, the radius of the bubbles, the number of cylindrical pores, the radius of the cylindrical pores and the height of the cylindrical pores.

Your program should include 6 functions in addition to your main function.
- A **void** function that will robustly confirm that the dimension entered is greater than zero. This function should accept two parameters: the dimension and what the dimension corresponds to e.g. the height of the sample, the radius of spherical bubble, etc.(see examples below). This function should contain a **single loop and no selection structures**. If the dimension is incorrect, the user should be told what dimension is incorrect and prompt the user to re-enter the value for the dimension. For example, the message may be something like

    "The height of the sample must be greater than zero.
    Please re-enter the height of the sample."

  or

    "The radius of the bubbles must be greater than zero.
    Please re-enter the radius of the bubbles."

  The check should be robust (i.e. the user will be given the error message and prompted to re-enter the incorrect value as long as it is invalid.

- A **void** function that will robustly confirm that the value entered for the number of spherical bubbles or cylindrical pores is greater than or equal zero. This function should

accept two parameters: the value and what the value corresponds to i.e. number of spherical bubbles or number of surface cylinders. This function should contain a **single loop and no selection structures**. If the value is incorrect, tell the user should be told what value (number of spherical bubbles or number of cylindrical pores) is incorrect and prompt the user to re-enter the number. (You may assume that the number will be a whole number). For example you error message should be something like

> "The number of spherical bubbles must be greater than or equal to 0.
> Please re-enter the number of spherical bubbles."

- A **value-returning** function will accept the radius of a sphere then calculate and **return** the volume of a sphere (vol = $4/3\pi r^3$).

- A **value-returning** function that will accept the radius and height of a cylinder, then calculate and r**eturn** the volume of a cylinder (vol = $\pi r^2 h$).

- A **value-returning** function that accept the height, length, and width of a rectangular parallelepiped then calculate and **return** the volume of the rectangular parallelepiped (vol = hlw).

- A **value-returning** function that will accept 8 parameters: width, length, and height of the parallelepiped sample; the number of spherical bubbles and the radius of the bubbles; plus the number of cylindrical holes in contact with a surface and the radius and height of these cylinders. This function will call the functions to calculate the volumes, then calculate the percent of the sample that is air (combination of spherical bubbles and cylindrical pores). The percentage should be **returned** to the function call.

Your main function should ask the user to input the dimensions of the parallelepiped smple, the number and size of the spherical bubbles, and the number and dimensions of the surface cylinders. For each of these 8 values your main function should call the functions to confirm input is valid. After this confirmation, the function to determine the percentage of air present should be called. Then the main function should output the percentage of air present. The percentage of air should be output using **3 significant digits**. You may assume that the total volume of spherical bubbles and cylindrical pores will not exceed the volume of the original sample.

Make sure you use appropriate data types and that your submission follows the assignment guidelines posted on ANGEL. The value of pi should be declared as a constant of 3.14159.

Three example outputs are given below.

Please remember to follow the assignment guidelines for the course (posted on ANGEL. For example, do not use global variables, do not use break statements in loops, do not use more than one return statement per function, do not put functions definitions before main, etc.

Example 1: (user's input is shown in bold)

Enter the height, length, and width of the sample in centimeters. **25.8 40.67 35.5**

How many spherical bubbles are present? **10**
What is the radius of the spherical bubbles in centimeters? **1.2**

How many cylindrical pores are present? **8**
What are the radius and height of the cylindrical pores in centimeters? **0.8 4**

The material contains 0.337 % air.

Example 2: (user's input is shown in bold)

Enter the height, length, and width of the sample in centimeters. **-3 28 56.5**
The height of the sample must be greater than zero.
Please re-enter the height of the sample. **-4.5**
The height of the sample must be greater than zero.
Please re-enter the height of the sample. **25**

How many spherical bubbles are present? **-50**
The number of spherical bubbles must be greater than or equal to 0.
Please re-enter the number of spherical bubbles. **50**
What is the radius of the spherical bubbles in centimeters? **0.9**

How many cylindrical pores are present? 20
What are the radius and height of the cylindrical pores in centimeters? **1 -2.5**
The height of the cylindrical pores must be greater than 0.
Please re-enter the height of the cylindrical pores. **1.5**

The material contains 0.624 % air.

Example 3: (user's input is shown in bold)

Enter the height, length, and width of the sample in centimeters. **-3 -5 -10**
The height of the sample must be greater than zero.
Please re-enter the height of the sample. **-4.5**
The height of the sample must be greater than zero.
Please re-enter the height of the sample. **10**

The length of the sample must be greater than zero.
Please re-enter the length of the sample. **-7.8**
The length of the sample must be greater than zero.
Please re-enter the length of the sample. **-71**
The length of the sample must be greater than zero.
Please re-enter the length of the sample. **20**

The width of the sample must be greater than zero.
Please re-enter the width of the sample. **-1**
The width of the sample must be greater than zero.
Please re-enter the width of the sample. **-15**
The width of the sample must be greater than zero.
Please re-enter the width of the sample. **-4**
The width of the sample must be greater than zero.
Please re-enter the width of the sample. **30**

How many spherical bubbles are present? **-5**
The number of spherical bubbles must be greater than or equal to 0.
Please re-enter the number of spherical bubbles. **-7**
The number of spherical bubbles must be greater than or equal to 0.
Please re-enter the number of spherical bubbles. **40**

What is the radius of the spherical bubbles in centimeters? **-2.3**
The radius of the bubbles must be greater than zero.
Please re-enter the radius of the bubbles. 0.**5**

How many cylindrical pores are present? -1
The number of cylindrical pores must be greater than or equal to 0.
Please re-enter the number of cylindrical pores. **-7**
The number of cylindrical pores must be greater than or equal to 0.
Please re-enter the number of cylindrical pores. **20**

What are the radius and height of the cylindrical pores in centimeters? **-1 -2.5**
The radius of the cylindrical pores must be greater than 0.
Please re-enter the radius of the cylindrical pores. **0.8**

The height of the cylindrical pores must be greater than 0.
Please re-enter the height of the cylindrical pores. **1.5**

The material contains 1.35 % air.