Assignment 1: Volume of a 3D model

This assignment is intended to give you some warm-up practice with C++. You should already know everything you need to complete this assignment.

Problem

A 3D model is represented using points, called "vertices" (x,y,z locations) and triangles that are created out of those vertices. A popular file format that stores a 3D triangle model is "obj". Several obj files have been provided to you. Your task is to write a C++ program that reads files of this format, and computes the volume of the 3D model.

The OBJ file format

The OBJ file format is a simple text format. The file has several lines, each line being one of the two forms below

v x y z

f i1 i2 i3

That is, if a line begins with the letter "v", then the next three numbers are the x, y, z positions of a vertex in the model. If a line begins with the letter "f", then the next three integers are the indices of the vertex (read previously) that make up this triangle. Note that the "indices" begin at number 1 and not 0.

The file is always arranged so that all the vertices are specified before all the triangles. That is, the lines with "v" are before the lines with "f".

As a simple example, consider a square made of points (0,0,0), (10,0,0), (0,10,0) and (10,10,0). In OBJ format, this square is expressed in terms of two triangles as follows:

v 0 0 0
v 10 0 0
v 10 10 0
v 0 10 0
f 1 2 3
f 1 3 4

(i.e. the first triangle is made of the 1st, 2nd and 3rd vertex, and the second triangle is made of the 1st, 3rd and 4th vertex).

Several files representing various shapes have been provided to you.

Volume of a triangle model

The volume of a triangle model is simply the sum of the volumes made by each triangle with the origin.

The "volume made by a triangle with the origin" is the volume of the shape formed by joining each vertex of the triangle to the point (0,0,0). Given a triangle whose vertices are (x1,y1,z1), (x2,y2,z2) and (x3,y3,z3), this volume is given by

$$(x1*(y2*z3-y3*z2) - y1*(x2*z3-x3*z2) + z1*(x2*y3-x3*y2))/6$$

Keep in mind that this formula may produce a negative number for some triangles. THIS IS OK, do not take the absolute value.

What to do

1. Write a C++ class `TriangleModel` that represents one triangle model using two lists: a list of vertices and a list of triangle indices ("list" here does not refer to any class, but simply a generic list. You may use whichever representation you see fit).
2. This class has exactly one constructor that takes no parameters, and a destructor.
3. Write a function `bool readInputFile(char *filename)` in this class that reads the provided OBJ file and returns true if successful, false otherwise.
4. Write a function `float getVolume()` in this class that computes and returns the volume of the triangle model.

You may write as many private functions as you'd like, but the above should be the only public functions in this class.

In a separate file, write a main function that accepts the name of a triangle model file as its only command-line parameter, creates a triangle model object, computes its volume and prints the name of the file and its volume on the screen. The program should print an error message is a file is not passed as a parameter, or if the file cannot be read. Under no circumstances should your program crash!

Expected Volumes
For your comparison, the table below shows the expected volumes for the provided files

Name of file	Volume
Sphere-small.obj	3.822675
Sphere-large.obj	4.188534
Cylinder-small.obj	3.133329
Cylinder-large.obj	3.141500
Cone-small.obj	1.044443
Cone-large.obj	1.046932
Truck.obj	31824240640

What/How to submit: Submit only your source code files (*.h/*.cpp) **and a Makefile** as "assignment-1.zip" and submit on ReggieNet. Make sure that your source file(s) are suitably commented.

Viewing OBJ files
If you are interested, a free program "MeshLab" on Windows can be used to view the provided OBJ files.