Assignment – Brain Structure

File "Cort_lobe_poly.vtk" stores the half brain mesh structure.

Data format:
Lines 6 through 191729 list the x, y, z coordinates of vertices, one vertex per line.
Lines 191731 to line 574971, each line represents a triangle, which contains four numbers: the first number is always 3, indicating that three vertices form a triangle, the following three numbers are the indices of the three vertices.

You are forbidden from using 'new/delete' constructs.

Your work:

1. [10 pts] Correctly read the data from the file.
2. [10 pts] Calculate the total surface area. (Summation of the area of all triangles) Print it out on the screen using `std::cout` and include it in your pdf/md report. Generate the area in single and double precision. In both cases print the area with 14 decimal places (use GPT to learn to do this and explain what you did in your report.)
3. [10 pts] For each vertex, calculate the total surface area of the triangles surrounding it. Output the result into a readable file, where each line contains one number (the area of the triangles connected to the vertex). The lines must be sorted by increasing vertex number.
4. [10 pts] Plot two histograms (with titles and axis labels, stored in images/ and included in your report)
    i. A histogram of the length of the edges of all the triangles describing the surface of the brain. Also provide the mean edge length and its standard deviation.
    ii. A histogram of the areas computed in part 3) above.
5. [5 pts] Create a functional Makefile (use your knowledge, GPT, or Copilot). See notes.
6. [10 pts] Develop and implement a strategy to confirm that your code is running correctly. This is an open-ended question. Explain your strategy and execute it. The file `main.cpp` has a hint in that regard.
7. [5 pts] Correct class structure for your code (separation of declaration (`brain_mesh.h`) and implementation (`brain_mesh.hxx`).
8. [10 pts] Correct template implementation (you must be able to execute your code using `<float>` and `<double>`. Integer format should work with either `int` or `long`. The current version of main uses `double` and `long`.
9. [10 pts] Correct implementations of the copy constructor and assignment operators. Add the required functions to both the `brain_mesh.h` files and the `brain_mesh.hxx` file.
10. [10 pts] Document your code. Each function should have a few lines stating what it does. Add descriptive comments as necessary inside the code.
11. [10 pts] Your pdf or markdown report (included in the repository).

You are required to create a class named `BrainMesh` with at a minimum the following public methods:

- One or more constructors
- A destructor
- double totalArea()
- double triangleArea(this, computeTriangle)
  (computeTriangle should be replaced by the arguments necessary to define a triangle)
- double areaAroundVertex(this, int vertex_id)
- Use templates to allow the calculations to proceed in either single or double precision.

  At a minimum, you must provide the following three files:

- main.cpp (start with the file provided, and enhance it as necessary)
- brain_mesh.h (declarations. Add to this file if necessary)
- brain_mesh.hxx (implementation of the functions in `brain_mesh.h`.

  Notes

- Use the C++ compiler (g++ or equivalent)
- You are not allowed to either new or delete to handle dynamic memory allocation
- The main() function must be in a file "main.cpp"
- Create a Makefile to compile and link your code.
- The Makefile should have a "clean" task to remove the executable and object (.o) files.
- The TA (Mani) should be able to type `make` on the command line and have the executable generated.
- Add functions and code to `main.cpp` and `brain_mesh.` as required.
- All figures must have a title, x and y labels and be included in your pdf or Markdown file. This file should be in your repository AND uploaded to Canvas. If you have a Markdown or other file type, please export it as a pdf file before uploading. That is the safest approach to ensure the figures are present.
- Please submit your code, output files, and a report.
- Have sections in your pdf report uploaded for deliverables 1 through 10 above.

  Make use of web-based and AI tools to update your knowledge on anything you don't understand.