M241-MATLAB (P. Staley) Project Five

Modular Programming for Minimal Surface Computation

Minimal surface problem background: A soap film stretches between two parallel circular rings. In this idealized setting the soap film assumes a surface whose area is a local minimum. Local minimum means that small perturbations result in a larger surface area. We can assume that cross sections perpendicular to the ring ends will be circular.

Mathematical Model: Divide the axis into eight equal parts. Model the surface as a sequence of cone frustums. Under these assumptions the surface is entirely described by the radii of the circular cross sections at the seven interior nodes. The problem now amounts to minimizing the surface by choosing appropriate values for the radii.

1. Download the MATLAB function conesurf from the class website.
Draw the frustum of a cone and indicate the significance of consurf inputs r1, r2, h, and the intermediate value slant on your drawing.
Add comments to the function indicating the significance of Area, d1, d2, dd1, and dd2.

2. Download the MATLAB function doubleconesurf from the class website.
Draw two connected cone frustums and indicate the significance of consurf inputs r1, r, r2, h1, and h2 on your drawing.
Add comments to the function indicating the significance of A1, A2, Area, d1, d2, d, dd1, dd2, and dd.

3. Download the MATLAB function minsurf from the class website.
Draw two connected cone frustums showing the initial value of r.
Add comments to the function indicating the significance of r1, r2, h1, and h2.
Add comments to the function indicating the significance of d and dd.
The process of improving the estimate of r in the line:
r = r – d/dd ;
has a special name. Add comments to the function identifying that algorithm [hint: see section 3.8 of the Larson calculus book 8^{th} edition]

4. Produce a script M-file that does the following:
4.1 Instantiates an array of nine radii and another of nine partial derivatives. Initialize the former to zeros and the later to [0;100;100;100;100;100;100;100;0].
4.2 Interactively get the left most radius, the right most radius, and the total separation of the outermost rings. For the example you turn in use 10, 10, and 8 respectively.
4.3 Use the minsurf function to compute the interior radii in the order: 5, 3, 7, 2, 4, 6, and 8. This corresponds to middle, then middle of first half, then middle of second half, etc.
4.4 Graph the profile of the estimated minimal surface.
4.5 Use conesurf to compute the entire surface area of the resulting surface.
4.6 Write up the 10, 10, 8 case indicating the following: graph of the surface profile, surface area, and length of the gradient of the surface area with respect to the node radii.

Extra Credit.

Use 2^n subdivisions and nested loops to sequence through the points. Stay with the concept of doing the middle point, then the ¼ and 3/4th points, then the 1/8, 3/8, 5/8,7/8ths points, etc. n should be read in from the user. After the first pass through all the points, offer the user the option to correct another node, if he/she chooses to continue then recomputed the node with the largest partial derivative, and offer to continue with another node, etc.