University of California, Berkeley
CEE C133/ME C180, Engineering Analysis Using the Finite Element Method
Spring 2009
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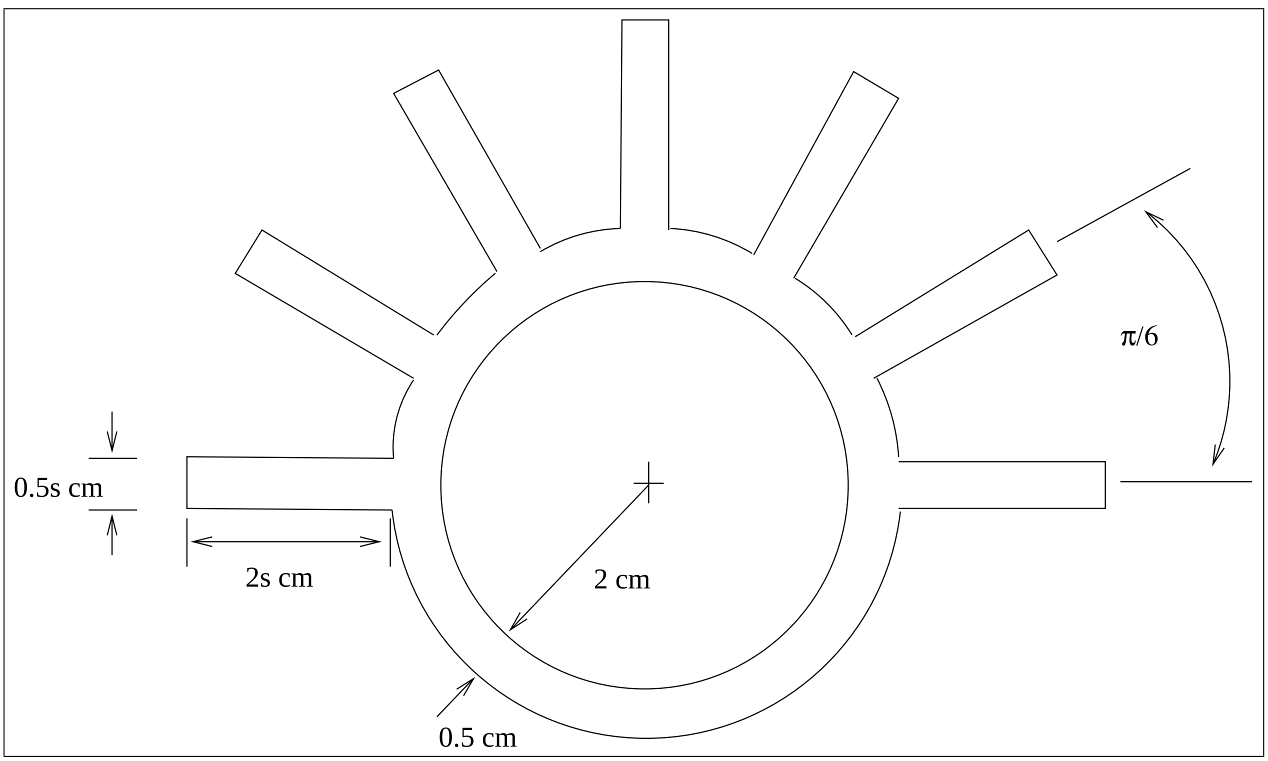
Lab 9

Starting this week, most of the remaining labs will be of a much more practical bent. The due date for this lab will be during your regular lab section, one week after it is assigned, i.e., either Monday or Tuesday, the week starting 06-Apr-2009.

Your assignment is as follows:

- The following figure depicts a simple heat exchanger tube with fins on the outside. The inner tube transports boiling water (i.e., water at $100C$) and the outer surface is subject to convective heat transfer with a forced convection coefficient of $h = 175\frac{W}{m^2-C}$, and a far-field temperature of $10C$. The exchanger is made of a copper alloy with $k = 401\frac{W}{m-C}$. The size of the fins is parametrized by the parameter s.



- This assignment will require the use of the scripting capabilities of COMSOL, in conjunction with MATLAB, to perform a parameter study to determine the overall heat transfer (in Watts) as a function of s, with $0.25 \le s \le 1$.

Use of the scripting features of COMSOL (or any finite element package), usually goes something like the following:

1. Create your model, one step at a time (i.e., geometry, material properties and BCs, meshing, etc.), interactively.
2. Save your model after each step to a temporary script file.
3. Copy and paste the relevant commands to your primary script file, as desired.
4. Repeat, until all steps are scripted.

Note that the COMSOL manual has a nice reference section on all of the COMSOL commands available in MATLAB.

Then, iteration over the parameter can be achieved by wrapping the main model with a driver file, where the main model is inside a loop which loops over the parameter, and collects/plots/analyzes the results as appropriate.

- Be sure to use symmetry boundary conditions when modeling the heat exchanger. Note that [1] contains a fairly detailed explanation on using symmetry in finite element analysis.

To get you into the habit of documenting what you are doing in a proper manner, your results should read like a mini-report, as follows:

- It needs to be typed, with figures properly inserted into the text. Equations should be properly inserted. There is to be no handwriting.
- It should review the particular problem to be solved, and present the governing relations and assumptions employed. The "governing relations" typically means the strong form of the PDE(s) involved, with all of the relevant data necessary to solve them.
- It should contain the solution, and an evaluation of the solution, an indication of the accuracy of the solution, and a discussion of the ramifications of the analysis.

  In particular, it should include plots of the relevant solution quantities, as well as plots of the convergence of the solution. An additional type of plot to consider looking at is the solution along certain cross-sections of the model.

  Of course, this begs the question: how does one quantify error, without the exact solution???

  Note that I have not explicitly specified much that you need to do. Indeed, many times when doing analyses, it is not obvious what quantities you want to look at, i.e., it is not obvious what the most important results are. So, you will really need to explore the model yourself, and make whatever observations you deem relevant.

- These points need not be long discussions; a short paragraph will do for most points.
- Please submit this lab to me on paper (not via email).

References

[1] K.H. Huebner, D.L. Dewhirst, D.E. Smith, and T.G. Byrom. *The Finite Element Method for Engineers.* Wiley Interscience, 2001.