ME 701 – Development of Computer Applications In Mechanical Engineering
Homework 4 – More C++, Fortran, and Python – Due 11/03/2014

Problem 1 – Numerical Solution of the Heat Equation

In class, we explored the numerical solution of the steady-state heat equation in a slab of material,

$$\frac{d}{dT}\left(k\frac{dT}{dx}\right)=\dot{Q},$$

subject to

$$AT(0)+B\left.\frac{dT}{dx}\right|_{x=0}=a \quad \text{and} \quad CT(L)+D\left.\frac{dT}{dx}\right|_{x=L}=b,$$

and where T is temperature, k is the thermal conductivity, $\dot{Q}$ is the heat generation rate, and A, B, C, D, a, and b are constants used to define the boundary conditions. In order to simplify the analysis somewhat, we assumed that both k and $\dot{Q}$ are constant. Your job is to write a short program in C++ or Fortran to solve this equation for arbitrary k, $\dot{Q}$, and boundary conditions.

Deliverables:

1. Derive (following the in-class derivation) the finite-difference equations for the 5-division case (i.e., T_0, $T_1, \ldots T_5$). Note, we considered only the Dirichlet boundary conditions, e.g., $A=1, B=0$, and $T(0)=a$ in class. The more general boundary conditions aren't hard, but make sure you understand them on paper before
2. In C++ or Fortran, write a routine that solves the problem for given L, $\dot{Q}$, k, n divisions, and boundary conditions. The output should be a vector of temperatures at each point.
3. Well-documented code

Problem 2 – SWIG and f2py

A growing trend in scientific computing is to use compiled routines written in C++ or Fortran directly from within a flexible environment like Python. Here, you're going to expose your solution from Problem 1 for use in Python using SWIG (for C++) or f2py (for Fortran).

Deliverables:

1. Makefile with appropriate SWIG or f2py commands
2. Python script used to call the C++ or Fortran function/subroutine and plot the temperature