Programming Assignment 2:
2D Convection on Unstructured Meshes

Mech 511

Due Date: March 18

In this assignment, you will write a program to solve the 2D convection equation

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = 0$$

using an unstructured triangular mesh.

1. Write a validation plan. Be sure to include tests for all of the key parts of your code, as well as global tests to confirm that your code correctly solves the PDE. Turn in your validation plan, but you do not need to submit the results of your validation tests; if your code doesn't pass a reasonable set of validation cases, it won't solve the final problem, either.

2. Describe the data structures that you will use to store data for this problem, especially connectivity data. Edge-based data structures are likely to prove most convenient, but there are numerous other possibilities.

3. Write and validate a code that solves the convection equation to second-order accuracy in both time and space. Basically, you will implement the algorithm you described in the first homework assignment. You should choose an appropriate explicit time advance scheme.

4. The geometry for the final problem is a square, $\{x, y : -3 \leq x \leq 3, -3 \leq y \leq 3\}$; meshes will be provided. The initial condition is

$$T = \exp\left(-5\left(x^2 + (y-1)^2\right)\right)$$

and the velocity field is

$$\begin{aligned} u &= \pi y \\ v &= -\pi x \end{aligned}$$

which is a rigid body rotation about the origin with period 2.
At time $t = \frac{1}{2}$, the initial data should have rotated one quarter of the way around the origin to lie on the positive x- axis.

Using the meshes provided, compute the solution T at time $t = \frac{1}{2}$, and provide convincing evidence that your scheme is second-order accurate in time and space. In your write-up, be clear about what solver parameters you used to produce results that you present. (Roughly speaking, provide me with all the information I would need to be able to reproduce your results using your code if I were so inclined.)

5. In addition to your report, please submit your code by email.