ME4/560 Practice Problem Set #1

Basics, Streamfunctions, Potential definitions

1. A two dimensional velocity is described by: 
   1. Determine the acceleration and identify the local and convective components.
   2. Assuming inviscid flow determine the pressure gradient (neglect body force).
   3. Use Bernoulli’s Eqn. to determine the two components of the pressure gradient (x and y components) ignore body forces at first and then include them. (Neglect body force).
   4. Show if this flow is rotational.
   5. What is the streamfunction associated with this flow?
   6. Show if this flow satisfies continuity.
2. The velocity potential is given as 
   1. Determine the streamfunction associate with this velocity potential.
   2. Show if this flow is irrotational.
   3. Determine the velocity components for this flow.
3. A velocity field only has an x component given by the following:  where “C” and “a” can be taken as constants.
   1. Determine the vorticity for this flow – what direction is the vorticity?
   2. Determine the streamfunction and sketch streamlines.
   3. Show if continuity is satisfied.
   4. Determine the velocity potential.
4. Show that for an irrotational 2D flow that the streamfunction satisfies the Laplace Eqn. . Is this equation linear or nonlinear?
5. For an incompressible flow show that the velocity potential satisfies the Laplace eqn. If a flow has a velocity potential show that it must be irrotational.
6. Write out the Navier-Stokes Eqn. in tensor notation
7. Is the following expression valid in tensor notation and how would you write this out in Cartesian coordinates, 

8. Given the following velocity in a 2D steady flow, incompressible:

V=3y*i* + 2x*j* (where *i* and *j* are unit vectors in x and y, respectively)

1. Determine the streamfunction in the x-y plane
2. Show if this flow satisfies continuity.
3. Set the streamfunction equal to zero at the origin and find the streamfunction value at x=1, y=2.
4. Sketch streamfunction lines in the first and second quadrants.
5. Select two arbitrary points in the flow and determine the flow rate between these points.
6. Determine the velocity potential for this flow and sketch lines in the first quadrant.
7. A “source” in two dimensions has flow radially outward equally in all directions from a point. The total flow from the source is given as Q (m3/s-m) which is the flow rate per “depth” of the source. Consider the flow to be incompressible and steady. (i) Use continuity to determine how the radial flow varies in the radial, or r, direction in terms of Q. (ii) Sketch streamfunction lines for this flow.
8. (Problem 3.12 in Nunn). Given the velocity components for two two-dimensional flows show that the streamfunction of the combined flow  has velocity components of *u=u1+u2*and *v=v1+v2*.