

NAME:

AME 538

Examination 1

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Fluid Kinematics (50)

1. In a Cartesian coordinate system, a steady flow has the following velocity components:

$$v_1 = x_1 + x_2^2, \quad v_2 = x_1^2 - x_2, \quad v_3 = 0.$$

Consider the point P: (1,2,0)

- a) What is the rotation rate of a fluid element at P?
- b) At P what is the magnitude of the extension rate on the axes in which all of the strain is extensional (i.e. along the principle axes)?
- c) What is the orientation of the principle axes at P?
- d) Sketch the rectangular element centered at P and aligned with the principle axes of elongational strain along with the sense of rotation of the element.
- e) Find equations which are linear in x_1, x_2 for streamlines and vortex lines through P which are valid locally in the neighborhood near P.

Governing Equations (30)

2. Derive the differential mechanical energy equation and place it in conservative form.

Use index notation. Use as your starting point the linear momentum principle expressed in conservative form. Use whatever other principles are necessary.

Give a brief description of each term which tends to change the mechanical energy of a fluid element.

Vorticity Dynamics (20)

3. Consider three ideal irrotational vortices of equal strength and sense of circulation each initially positioned at respective vertices of an equilateral triangle in an incompressible two-dimensional unbounded inviscid flow field.

Give a written description of the motion of the vortices. Use a sketch if necessary.