CHEN.3030 Fluid Mechanics

III. Fluid Kinematics

Prof. John R. White
Chemical and Nuclear Engineering
UMass-Lowell, Lowell MA

See Chapter 3 (sections 1–5) in your text by Hibbeler

Streamlines, Pathlines, & Streaklines

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Flow Visualization Example #1

Consider a uniform flow field with the following time-dependent velocity vector:

$$\vec{v} = 3\hat{i} - 4\hat{j} \quad \text{for} \quad 0 < t \leq 5s \qquad \text{and} \qquad \vec{v} = 5\hat{i} \quad \text{for} \quad t > 5s$$

Notice that the speed (m/s) is constant -- only the flow direction changes with time.

a. **For this system, sketch the streamlines at t = 2 s and at t = 8 s.**

b. **Sketch a pathline at 10 s for a single particle emitted at the origin at t = 2 s.**

c. **Sketch a streakline at 10 s for a continuous dye stream started at t = 0 s.**

A 2-D Steady Flow Field

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Flow Visualization Example #2

Consider the 2-D steady flow field described by

$$\vec{v}(x,y) = u(x,y)\,\hat{i} + \upsilon(x,y)\,\hat{j} = 2x\,\hat{i} - 2y\,\hat{j}$$

a. **Plot the velocity vector field and the direction field for this system (in separate plots).**
b. **Combine a contour plot of the velocity magnitude (speed in m/s) with the direction field plot.**
c. **Generate the stream function for this system and plot several streamlines over the direction field plot.**
d. **Develop an expression for the acceleration vector for this system and create some plots similar to those requested above to visualize this vector field.**

A Uniform Unsteady Flow Field

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Flow Visualization Example #3

Consider the uniform unsteady velocity field given by

$$\vec{v}(x,y,t) = u(x,y,t)\,\hat{i} + \upsilon(x,y,t)\,\hat{j} = 5\,\hat{i} - 2t\,\hat{j}$$

Note that the flow field is uniform (i.e. spatially independent) but it is unsteady (i.e. time dependent).

a. **Generate separate plots that show the magnitude (m/s) and direction of travel vs. time.**

b. **If a single drop of dye is released at t = 0 at the origin, compute and plot the path of this fluid particle over a 5 second period (i.e. the pathline).**

c. **If a continuous stream of dye particles is emitted at the origin starting at t = 0, compute and plot the spatial distribution of these particles at t = 5 seconds (i.e. the streakline).**