AOS 610 Fall 2018 Prof. Hitchman

Problem Set #1 10 points Due Tuesday, September 25
Please show your work and staple together.

1. (4 pts) *Flow visualization.* You will be issued a packet of six smoke balls. Please be careful to aim the fuse away from your hand when you light them. Upon ignition, the plume will be buoyant and generate some turbulence, but after the wind starts moving the smoke around it can be used to visualize the flow patterns.

a) Use the first three smoke balls to analyze the type of flow that is present around some interesting objects. It could be the corner of your house or a tree trunk. You may be surprised by how air actually moves when the flow is illuminated by the colored smoke.

i) Describe the flow that you observe for each situation.

ii) Estimate the Reynolds number, based on the object's size and the flow speed, and state whether the expected flow is consistent with what you see.

iii) Do you see any evidence of blocked flow or attached vortices?

b) Pick a spot away from objects and light another smoke ball. Using an approximate turbulent diffusion equation

$$\frac{dn}{dt} = K \frac{\partial^2 n}{\partial x^2},$$

where n is smoke concentration, estimate the turbulent diffusion coefficient K by observing characteristic time and space scales for the turbulent envelope as it moves with the wind. This helps to distinguish between the downstream (advection) and cross-stream (turbulent diffusion) directions.

2. (2 pts) Consider *plane Couette flow* of a viscous fluid confined between two flat plates separated by distance b, where the steady state velocity profile is u = U y/b, v = w = 0, and U is the velocity of the upper plate relative to the stationary lower plate.

a) Find the rate of linear strain, rate of shear strain, and vorticity.

b) Defining the streamfunction by u = $-\frac{\partial \psi}{\partial y}$ and v = $\frac{\partial \psi}{\partial x}$, express the streamfunction in terms of U and b.

c) Sketch the streamfunction, labeling your axes.

3. (2 pts) *Dynamical similarity*. Problem 18, p. 473 in Tritton.

4. (2 pts) *Rayleigh convection.* Problem 43, p. 479 in Tritton.