# MAE 214A, Winter 2009

## Homework 2

Due Tuesday, Feb. 3, in class

**Guidelines:** Please turn in a *neat* homework that gives all the formulae that you have used as well as details that are required for the grader to understand your solution. Note that the work must be your own; no use of solutions from other sources.

**1.** Write an equation for the fluctuating velocity $u_i'$ and use it to derive the transport equation for turbulent kinetic energy, $K$. Explain the physical role of each term in $K$ equation.

**2.** In thermally-stratified flow, the change in density can be taken to be proportional to the change in temperature leading to the following transport equation for the density:

$$\frac{\partial \rho}{\partial t} + u_j \frac{\partial \rho}{\partial x_j} = D \frac{\partial^2 \rho}{\partial x_j^2} \, , \tag{1}$$

where $D$ is the thermal diffusivity. Use the above to obtain an equation for the density fluctuation, $\rho'$, and then derive a transport equation for the density variance, $< \rho'^2 >$. Explain the physical significance of each term in the density variance equation. Assume that the *flow* is incompressible.

**3.** Obtain the entrainment rate, $d\dot{Q}/dx$, of the round jet where $\dot{Q} = \int \bar{U} dA$ is the integrated axial volume flux. *Use the velocity profile, Eq. (5.82) of Pope.* How does the entrainment rate vary with $x$. What is the physical significance of the entrainment rate? Can you relate the entrainment rate to the radial velocity pofile?

**No need to turn in the solution of the following problem**

**4.** Derive the self-similar form for the mean velocity profile in a round jet, Eq. (5.82) of Pope.