Problem Set # 6

1. An factory smoke stack releases intense small spherical patch of dust particles of total mass 54 kg in an isotropic turbulent atmosphere characterized by a zero mean wind field. If the density (concentration) of the dust particles at the center of the patch (location of release point) after 5 minutes is found to be \( \rho = 2 \frac{kg}{m^3} \), what is the turbulent diffusivity. If these particles are known to be hazardous at concentrations greater than \( \rho = 0.5 \frac{kg}{m^3} \) levels how far from the plume should you be at 5 minutes release time. How far after 1 minute release time? When is it safe to be at the center of the plume?

2. Suppose you release 1000 oceanic Lagrangian surface floats in a field of two dimensional turbulent eddies. You use a satellite tracking system and observe that these eddies have an rms velocity field of \( <(u')^2>^{\frac{1}{2}} = 10 \frac{cm}{sec} \) and a decorrelation time 10 days. (a) Using random walk theory estimate the turbulent diffusivity. (b) After 50 days what do you expect the density of these floats to be (numbers/ km^2) at the center of the release point? How far have 68% of the floats gone? (c) How long is it practical to be able to track these floats within 50 km of their release point. (d) If you wanted to track these floats for a longer time what would you have to do initially?

3. A patch of dye initially 5 m vertically by 100 m horizontally is located in a constant vertical velocity shear of \( \frac{du}{dz} = \alpha = 0.1 \frac{sec}{m} \) Microstructure turbulence measurements in this region suggest a vertical diffusivity of \( k_z = 10^{-4} \frac{m^2}{sec} \). How far does the patch disperse horizontally and vertically in 1 second, 1 minute, 1 hour, 1 day? When does shear dispersion effects become more important than the laminar stretching effects in determining horizontal structure?