8 MTF256: Learning outcomes

Week 1

1. What characterizes turbulence? Explain the characteristics. What is a turbulent eddy?

2. Explain the cascade process. How large are the largest scales? What is dissipation? What dimensions does it have? Which eddies extract energy from the mean flow? Why are these these eddies "best" at extracting energy from the mean flow?

3. What are the Kolmogorov scales? Use dimensional analysis to derive the expression for the velocity scale, v_η, the length scale, ℓ_η and the time scale, τ_η.

4. Make a figure of the energy spectrum. Show the relation between the Fourier coeffients of a fluctuating velocity and the energy spectrum. The energy spectrum consists of thee subregions: which? describe their characteristics. Show the flow of turbulent kinetic energy in the energy spectrum. Given the energy spectrum, $E(\kappa)$, how is the turbulent kinetic energy, k, computed? Use dimensional analysis to derive the $-5/3$ Kolmogorov law.

5. What does isotropic turbulence mean?

6. How is the energy transfer from eddy-to-eddy, ε_κ, estimated? Show how the ratio of the large eddies to the dissipative eddies depend on the Reynolds number.

7. Describe the cascade process created by vorticity. Write the vortex stretching/tilting term in tensor notation. What is its physical meaning? Describe the physical process of vortex stretching which creates smaller and smaller eddies. Show and discuss the family tree of turbulence eddies and their vorticity. Show that in 2D flow the vortex stretching/tilting term vanishes.