VIII. Turbulence

A. review of where we've been

- laminar flow, rectilinear streamlines
- role of convection terms in momentum balance:
  - no convection across streamlines
  - convection terms along streamlines cancel
  - no convection term in final balance equation
- solutions apply for Re < some limit; what happens at large Re?
- from here on, adios to non-Newtonian fluids

B. nature of turbulence

- Mixing of momentum throughout the volume of fluid, which means that high momentum fluid and low momentum fluid are brought to the wall
- Transport of momentum to the wall.

C. consequences of turbulence

- $\vec{v}$ fluctuates with time fluctuates in time + space "chaotic"
- significant fluctuations in $\vec{v}$ across average streamlines:
  - convection of momentum across average streamlines:
  - greatly increases rate of momentum transport to the wall.
- must use time-average $\vec{v}$ in equations $\langle v \rangle$ (might lose brackets later) "(and space)"
  - time-average $\vec{v}$ is nearly uniform across tube in tube flow
- too complex for analytical solution

D. results from dimensional analysis

Should be able to relate $\frac{\Delta P D}{\rho L \langle v \rangle^2}$ to $\frac{D \langle v \rangle \rho}{\mu}$

formalize concept in "friction factors"