Laminar Flow Over a Flat Plate

Description:

- In laminar flow over a flat plate, the fluid flows in parallel layers with minimal mixing between layers.
- This scenario is often analyzed in the boundary layer regime, where the flow starts from a no-slip condition at the plate and gradually develops.

- **Boundary Layer:** The layer of fluid close to the plate where velocity changes from zero (at the plate) to free stream value.
- **Nusselt Number (Nu):** Dimensionless number that represents the ratio of convective to conductive heat transfer. For laminar flow over a flat plate, it can be expressed as $Nu = 0.332 \cdot \mathrm{Re}^{1/2} \cdot \mathrm{Pr}^{1/3}$ where Re is the Reynolds number and Pr is the Prandtl number.
- **Reynolds Number (Re):** $\mathrm{Re} = \frac{U_\infty L}{\nu}$, where U_∞ is the free stream velocity, L is the characteristic length, and ν is the kinematic viscosity.
- **Prandtl Number (Pr):** $\mathrm{Pr} = \frac{\nu}{\alpha}$, where α is the thermal diffusivity.

Laminar Flow Through Pipes

Description:

- In laminar flow through pipes, fluid moves smoothly in concentric layers, with the highest velocity at the center of the pipe and zero velocity at the pipe wall.

- **Hydrodynamic and Thermal Entry Length:** The length over which the flow transitions from a developing to a fully developed state. For laminar flow, this is longer than in turbulent flow.
- **Nusselt Number (Nu):** For laminar flow in a pipe with a constant wall temperature, it can be given as $Nu = 3.66 + \frac{0.0658 \cdot \mathrm{Re} \cdot \mathrm{Pr}}{1 + 0.04 \cdot (\mathrm{Re} \cdot \mathrm{Pr})^{2/3}}$.
- **Reynolds Number (Re):** For flow in a pipe, $\mathrm{Re} = \frac{D_\mathrm{h} \cdot U_\mathrm{avg}}{\nu}$, where D_h is the hydraulic diameter, and U_avg is the average velocity.
- **Prandtl Number (Pr):** Same as above.