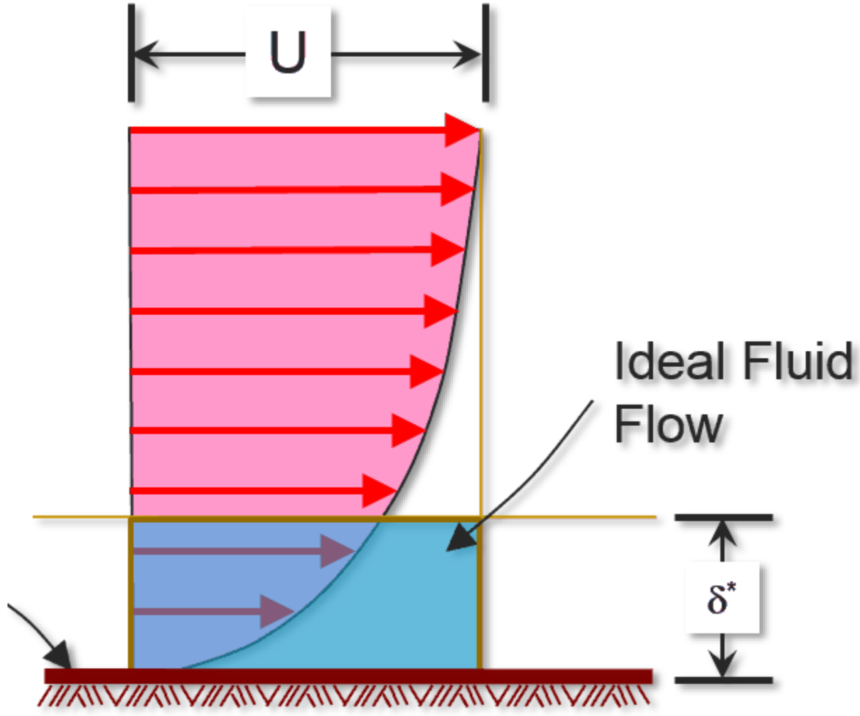
AN INTRODUCTION TO LAMINAR & TURBULENT FLOW

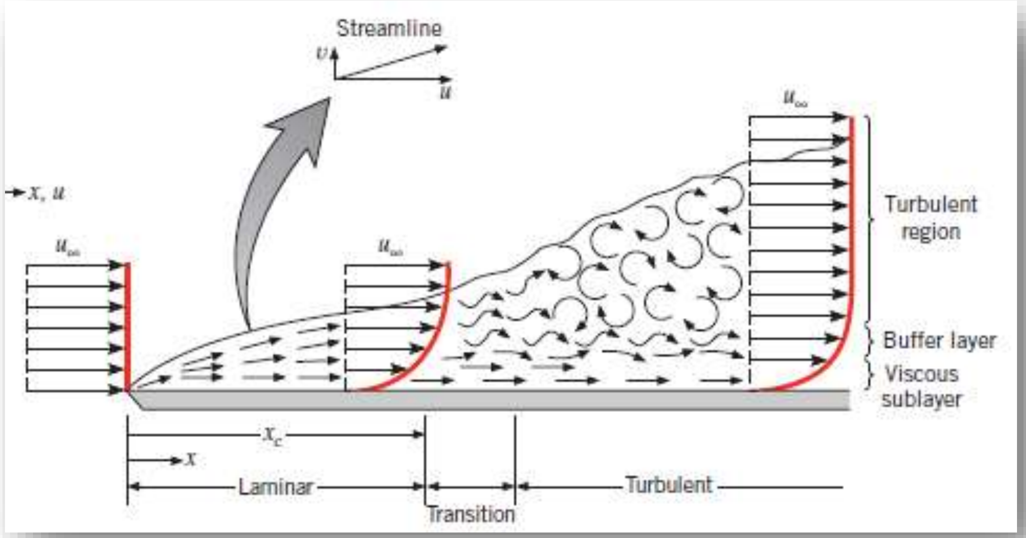
FLUID FLOW – DEPENDENT

- Fluid Flow Confined by Solid Surfaces
- Solid Surfaces Affects Fluid Flow
- Flow Velocity normal to the surface, zero
- Non-Viscous – Ideal : Viscous – Real Flow
- Real Flow – Develops Boundary Layer



Equivalent Flow Rate

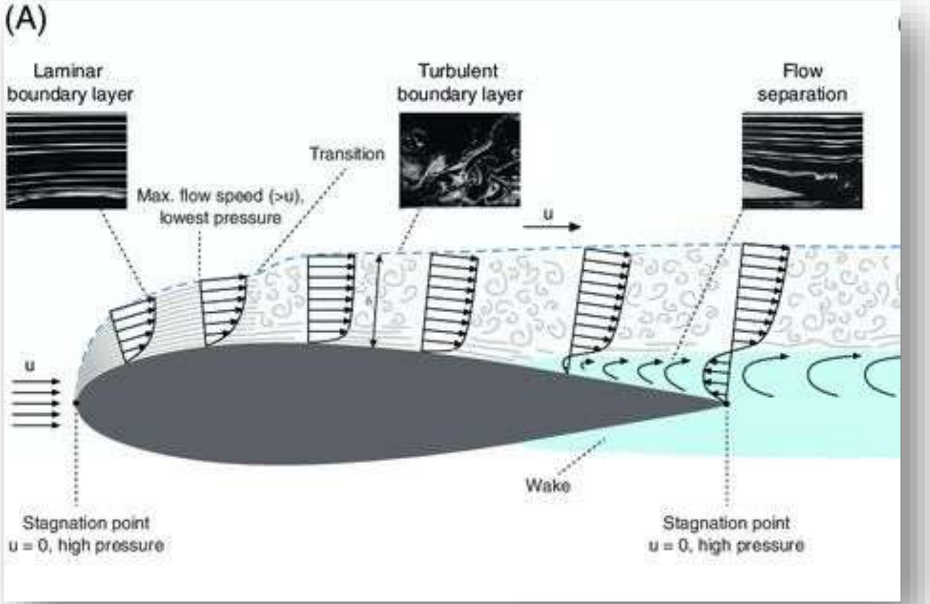
DEVELEPMENT OF BOUNDARY LAYER

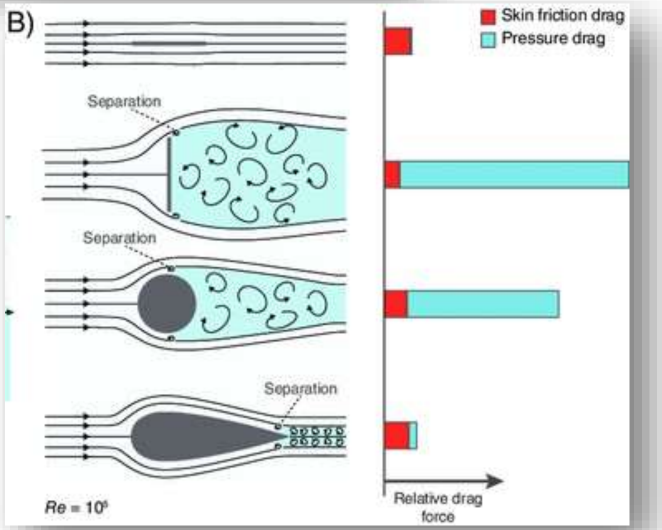


- Thin Layer of Fluid – Close to Surface
- Fluid Layer meets Gradual Transition
- Fast to Slower Flow Near Surface
- Crucial Role in Determining the Flow Behavior
- Velocity, Pressure, Temperature & Other Flow Properties

BOUNDARY LAYER – CATOGARIZES FLOW

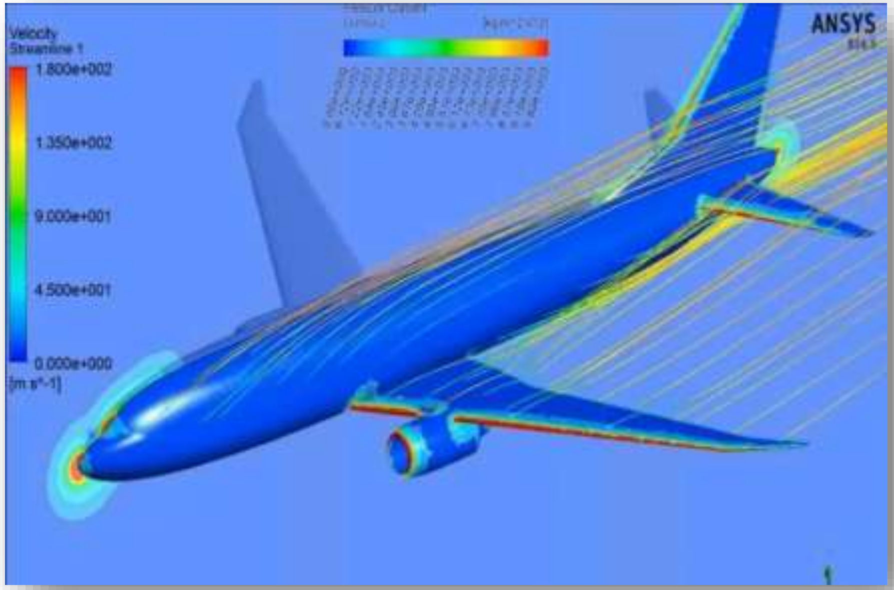
- Streamlined Flow - Laminar
- Grows to Transition
- Developed as Turbulent
- Reynolds Number Indicates Flow
- Significant in Flow Dynamics & Aerodynamics





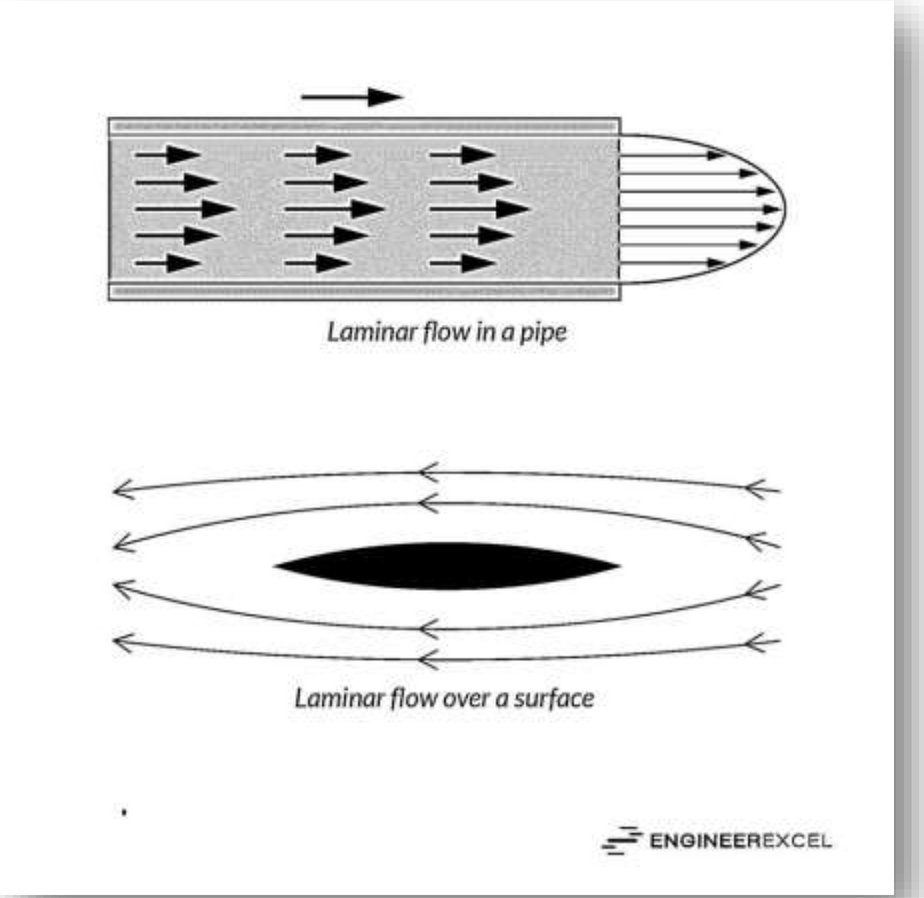
BOUNDARY LAYER - SIGNIFICANCE

- Boundary Layer Critical in Flow Analysis
- Resulting in Shear Forces Distribution
- Determines the Amount of Energy
- Wing stall - Skin Friction & Drag
- Heat Transfer in High-Speed Flight



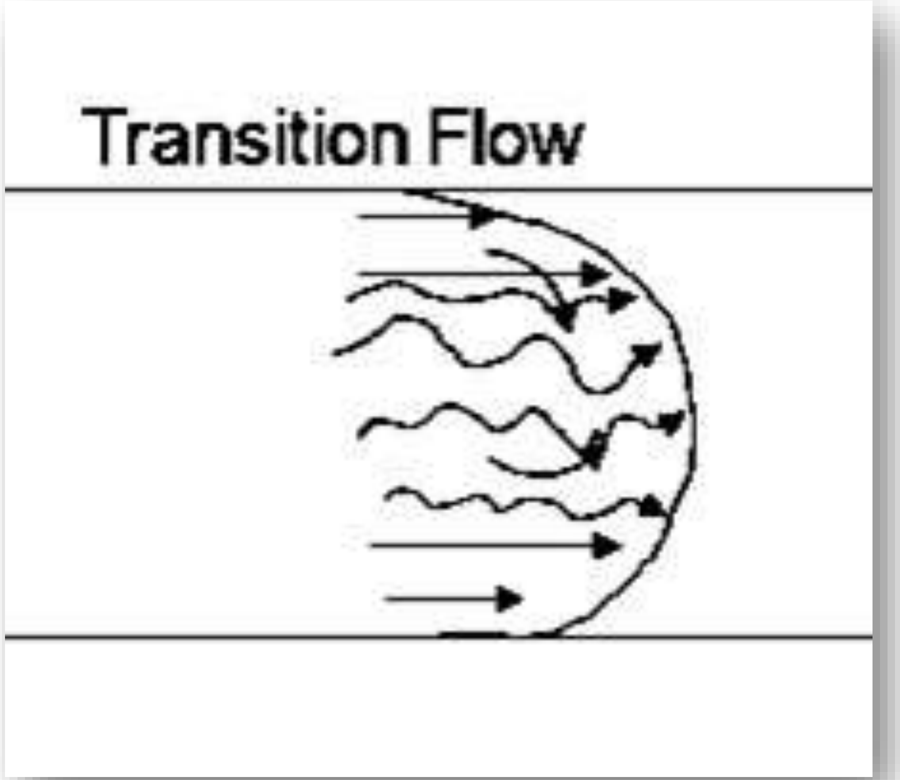
LAMINAR PATTERN IN FLOW REGIME

- Fluid Flows in layers one over other
- No Mixing Between Layers
- Definite & Observable Streamlines
- Characteristic of Viscous Fluid
- Possible at Confined Flow



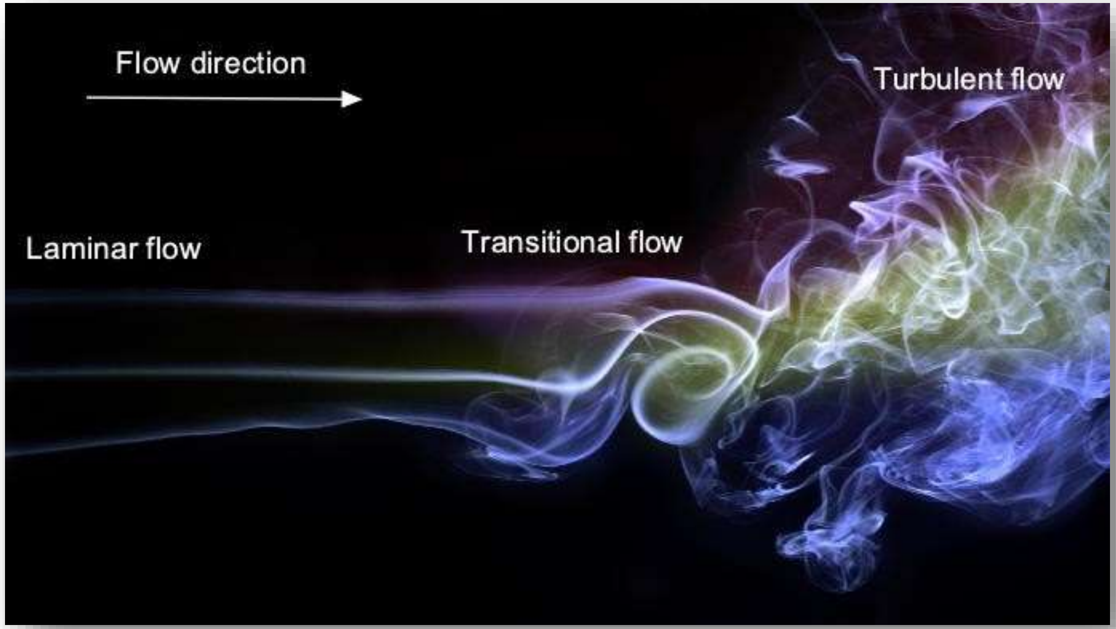
TRANSITION PATTERN IN FLOW REGIME

- Replicates laminar and turbulent flow
- Edges of Laminar State
- Center of the Flow Remains Turbulent
- Difficult to Accurately Measure

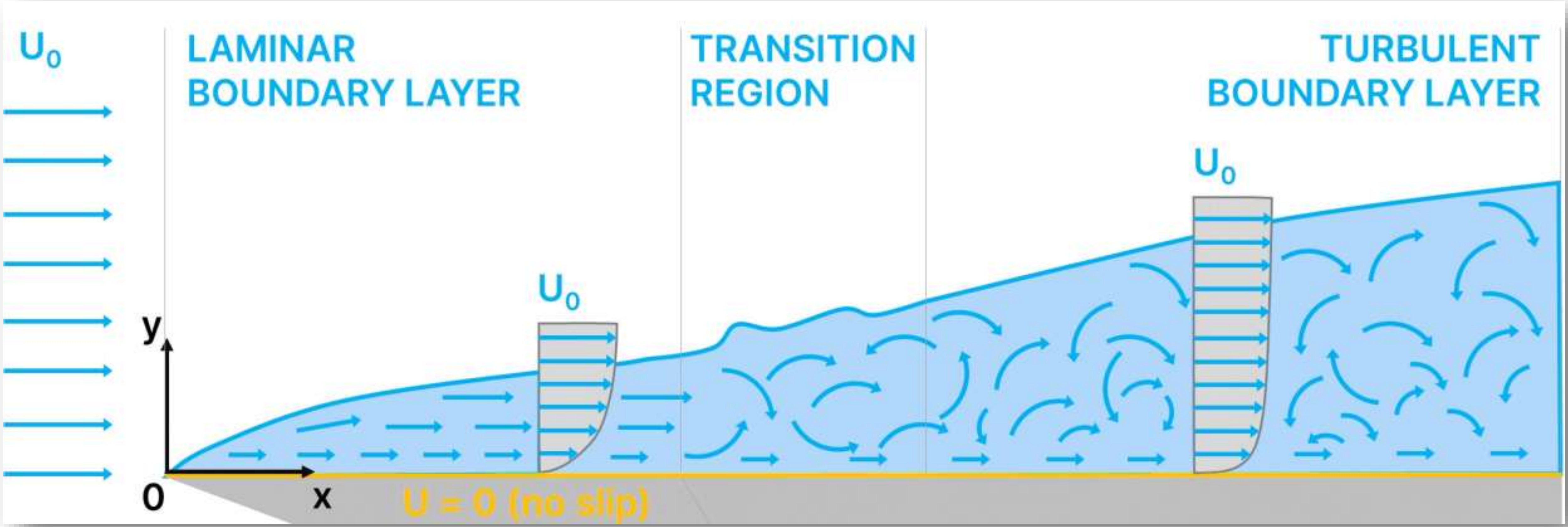


TURBULENT PATTERN IN FLOW REGIME

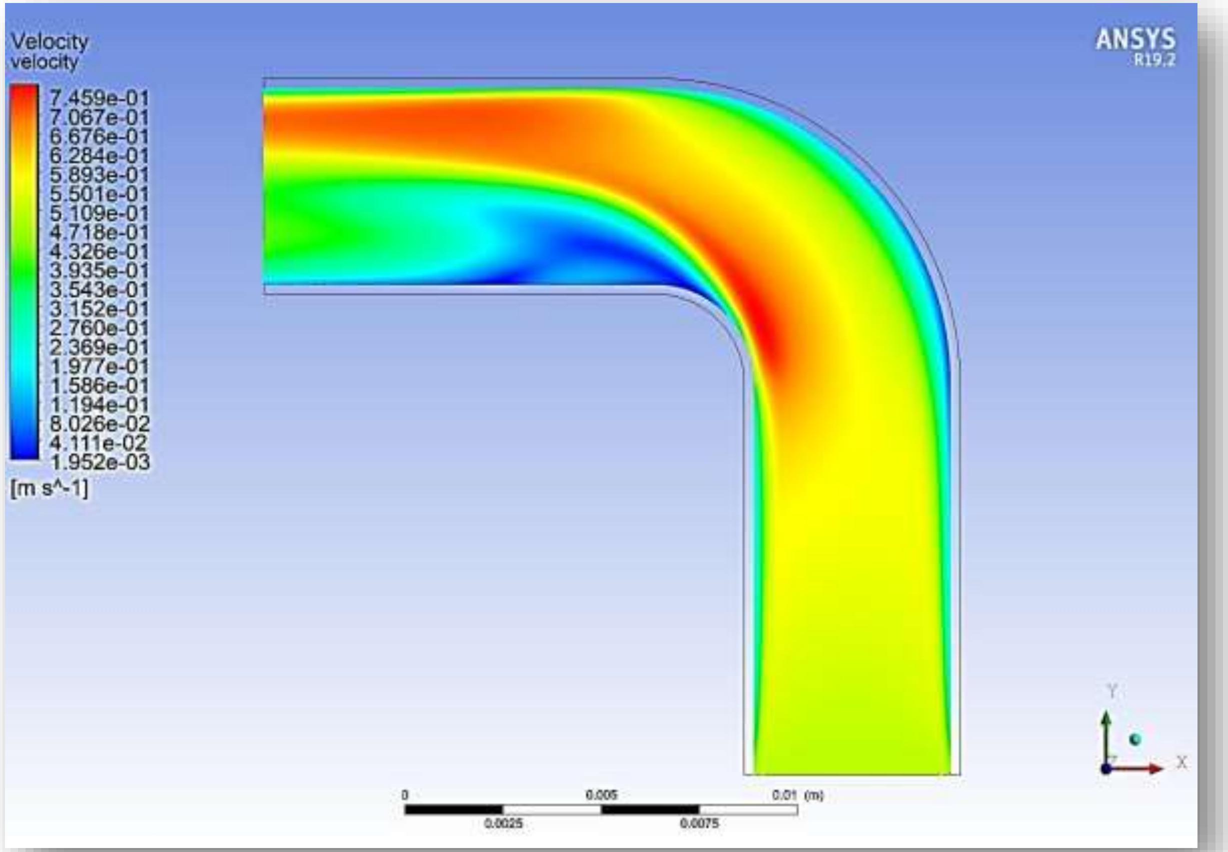
- Chaotic Property Changes
- Pressure & Velocity Varies Rapidly
- Low Momentum Diffusion
- High Momentum Convection
- Shows Disorganized Flow Pattern

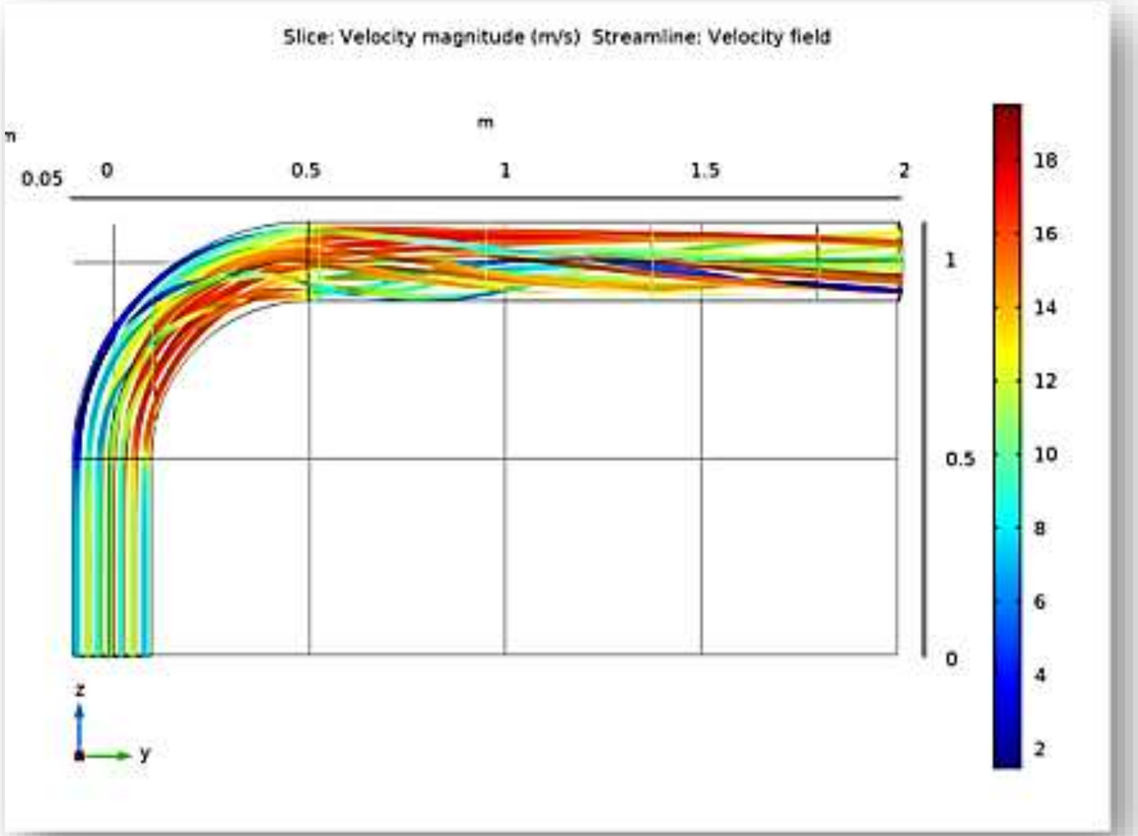


LAMINAR VS TURBULENT

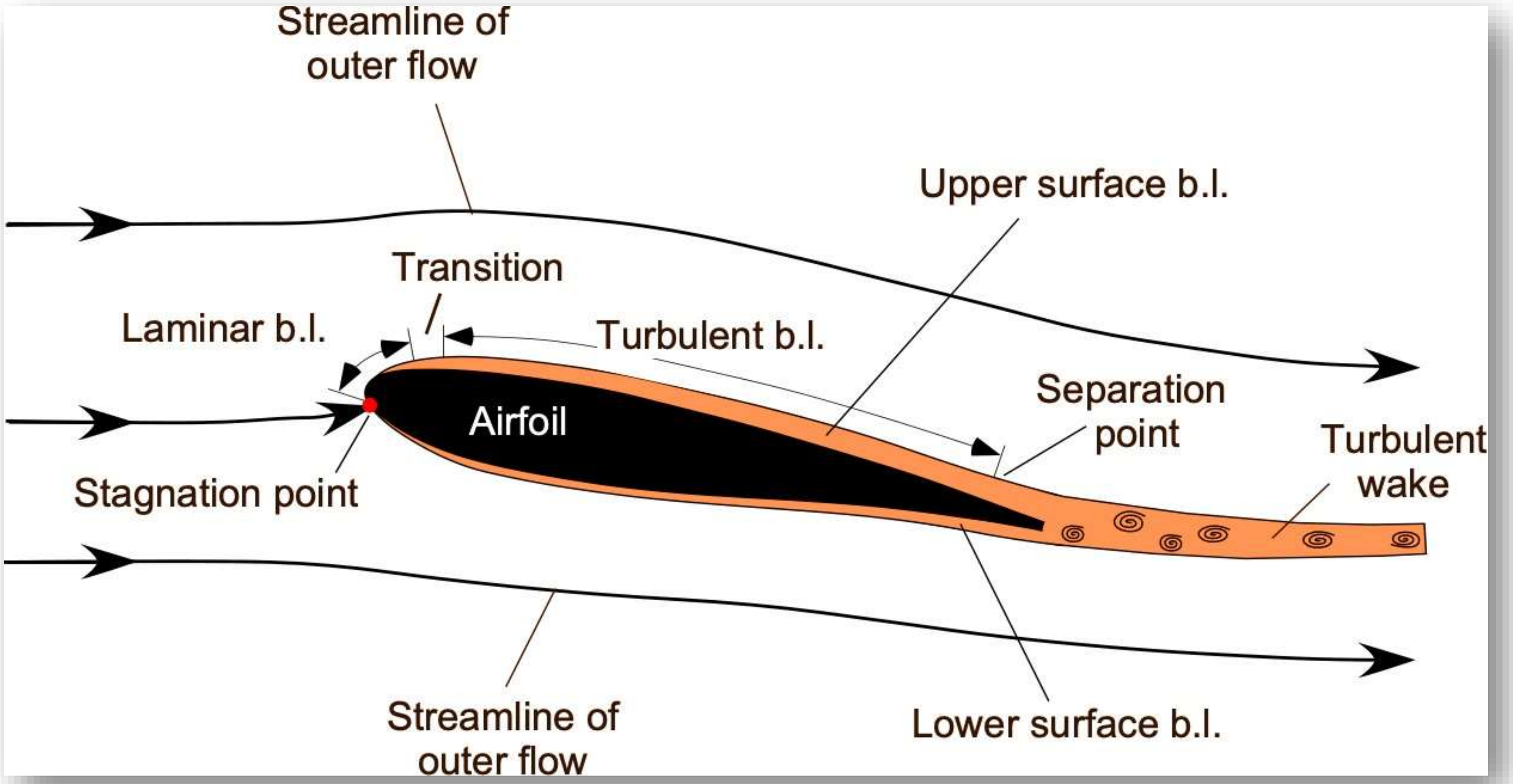


LAMINAR AND TURBULENT IN PIPES

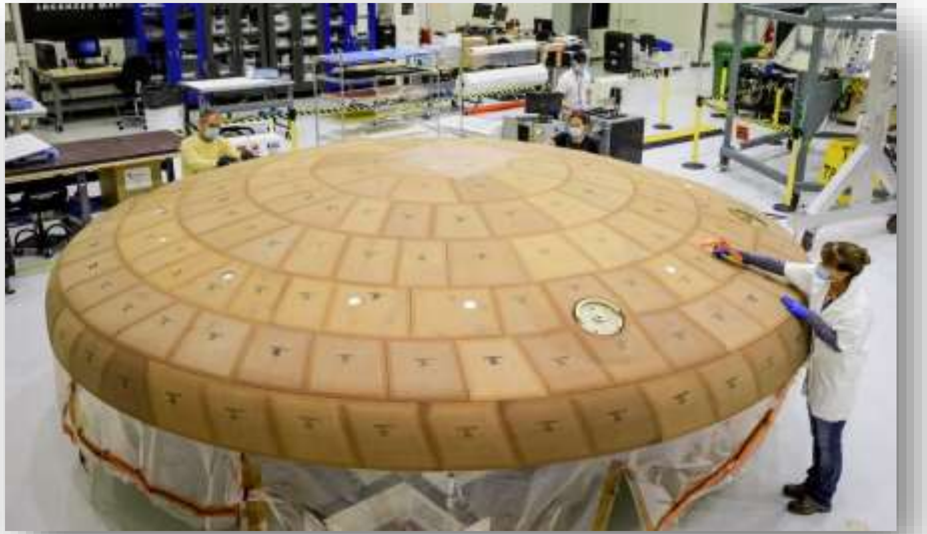




LAMINAR AND TURBULENT OVER AIROFOIL



SIGNIFICANCE OF BOUNDARY LAYER



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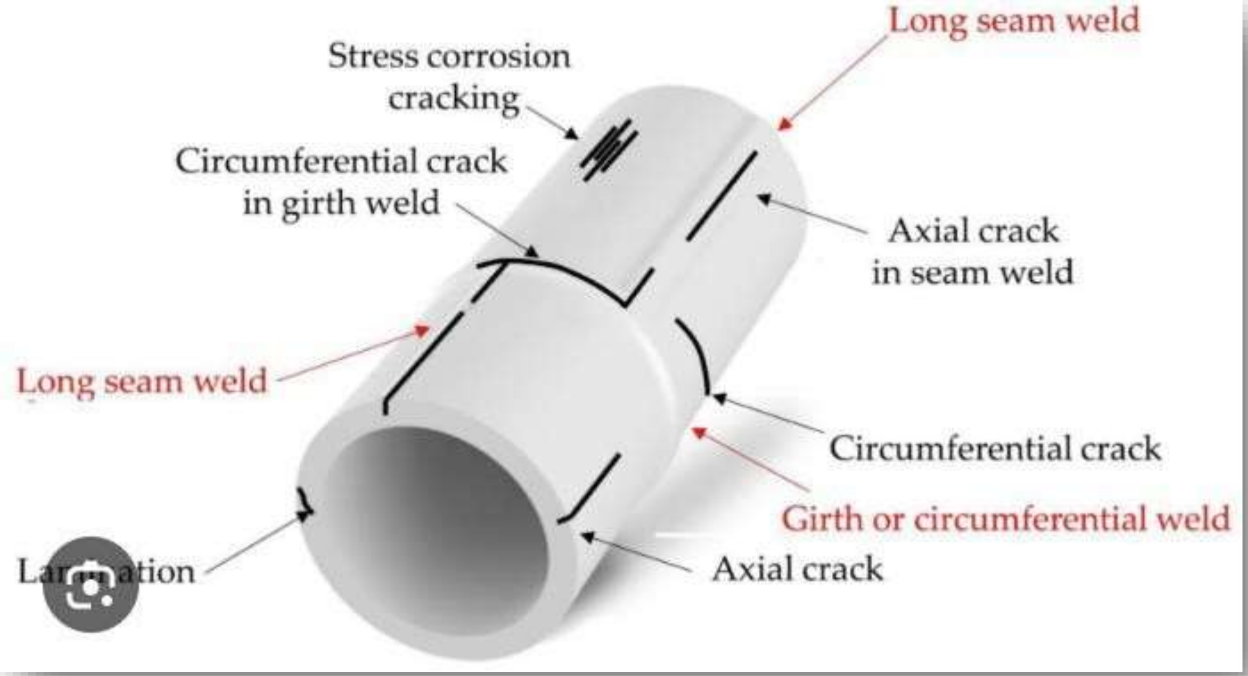


ESTIMATION OF HEAD LOSSES

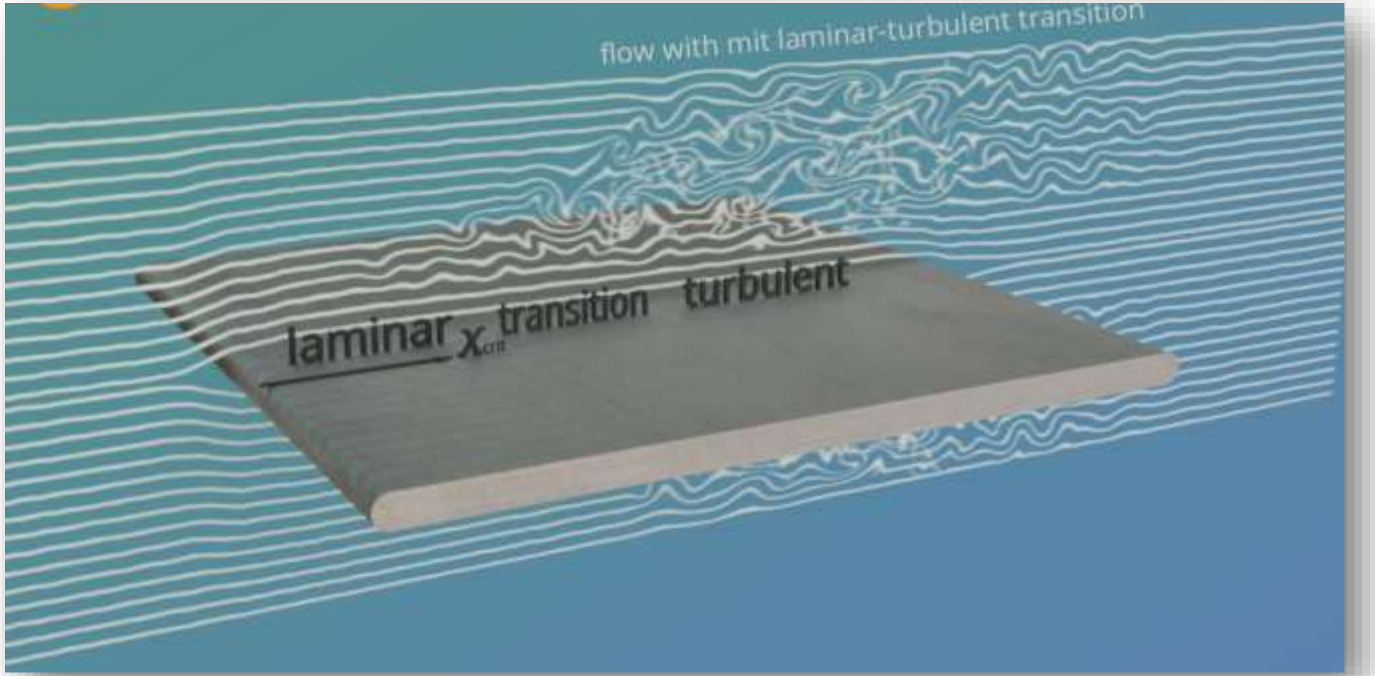
- $H_p + Z_1 - Z_2 + \frac{P_1 - P_2}{S} + \frac{V_1^2 - V_2^2}{2g} = h_f - h_m$

- $Where\ S = \frac{0.001736}{d^{5.3}}$ & $h_m = K_m \frac{V^2}{2g}$

- $h_f = f \frac{L}{D} \frac{V^2}{2g}$ $Where\ f = \frac{64}{Re}$

- $Q = \sqrt{\frac{(h_f - h_m)}{SL}}$

ESTIMATION OF HEAT TRANSFER



$$Nu = C\,(Gr \cdot Pr)^n = CRa^n$$

$$\frac{h \cdot L}{k} = C\left(\frac{\rho^2 g_c \beta\; c_p\, \Delta T\, L^3}{\mu^2} \cdot \frac{\mu}{c_p\, k}\right)^n$$

RECAP . . .

- Laminar Flows are Smooth and Streamlined
- Turbulent Flows are Irregular and Chaotic.
- Reynolds number indicates laminar flow
- High Reynolds number indicates turbulent flow
- Flow Behavior Drastically Changes
- In Complex Systems, Laminar and Turbulent flow becomes crucial for efficient operational design