

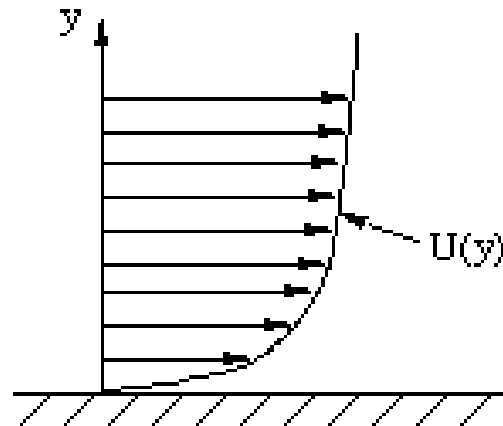
॥ नमस्ते ॥

# Boundary Layers



# BOUNDARY LAYER

- **Definition :- A boundary layer is a thin layer of viscous fluid close to the solid surface of a wall in contact with a moving stream in which (within its thickness  $\delta$ ).**
- **The flow velocity varies from zero at the wall (where the flow “sticks” to the wall because of its viscosity) up to  $U_e$  at the boundary, which approximately (within 1% error) corresponds to the free stream velocity**



- In term of the aircraft, Boundary layer mean Closest airflow of the aircraft surface.
- Due to viscosity of the air , there will be friction between air molecules and the aircraft surface so that air velocity near aircraft surface is reduced this effect is called Retardation.
- Due to the retardation the velocity close to aircraft surface is zero. you can see in following picture that air velocity is zero at surface and it will increase as stream line go away from aircraft surface.

# TYPES OF THE BOUNDARY LAYERS

- There are three Types of the Boundary layers
  1. Laminar
  2. Transition
  3. Turbulent

# 1.Laminar Boundary Layer

- Laminar flow type of fluid (gas or liquid) flow in which the fluid travels smoothly or in regular paths.
- The Boundary layer in which the air stream are parallel to each other or sliding smoothly one above another then it called Laminar Boundary layer.
- Thickness of boundary layer is small, Low Skin Friction Drag , High Form or High Pressure Drag.

## **2. Transition Flow**

- **The Point where the laminar boundary layer changes in to the turbulent boundary layer is called transition boundary layer.**

# **3.Turbulent Boundary Layer**

- Further downstream, the laminar flow becomes unstable and fluid particles start to move perpendicular to the surface as well as parallel to it.
- Therefore, the previously stratified flow starts to mix up and fluid particles are exchanged between adjacent layers.
- Due to this seemingly random motion this type of flow is known as *turbulent*.
- Boundary Layer Thickness is High , Skin Friction drag is high , Form Or Pressure Drag is Low.



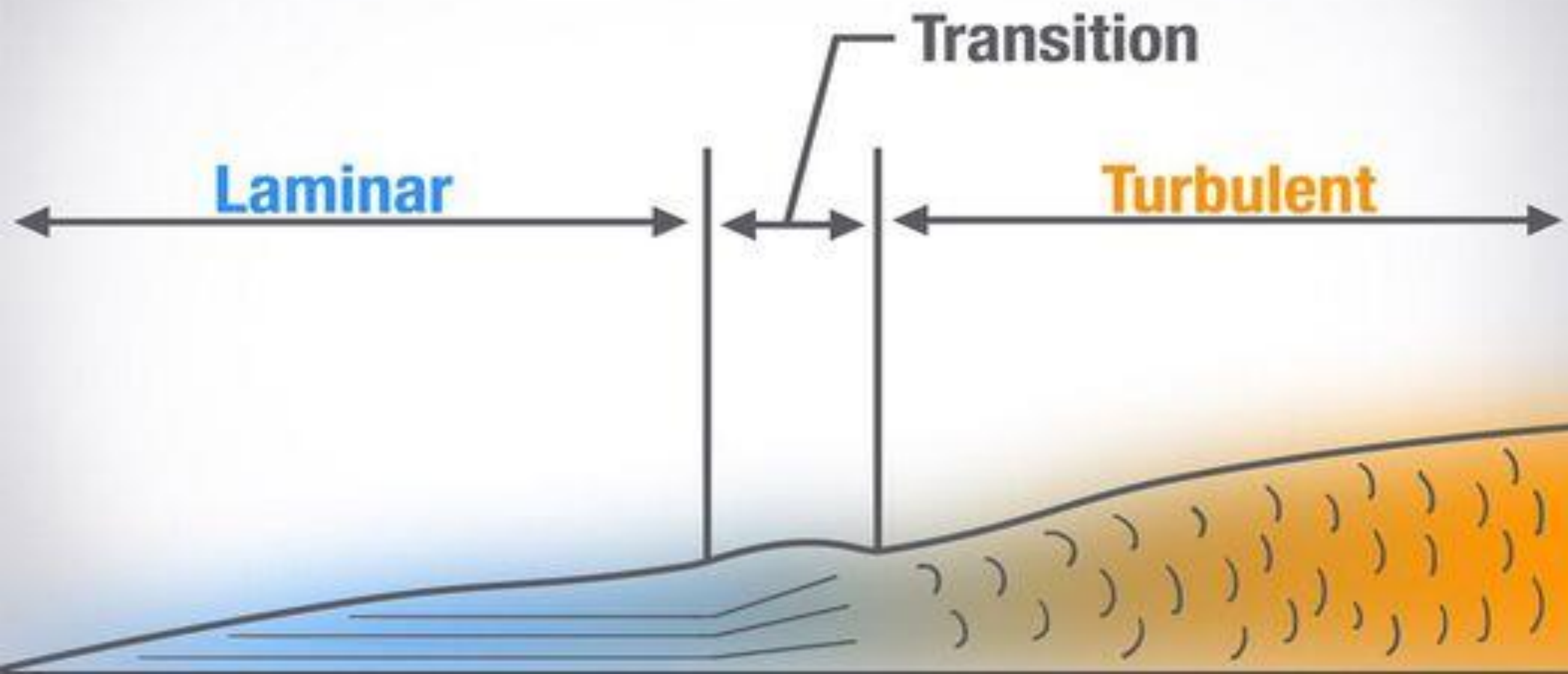
**turbulent  
flow**

**Transition Flow**

**laminar  
flow**

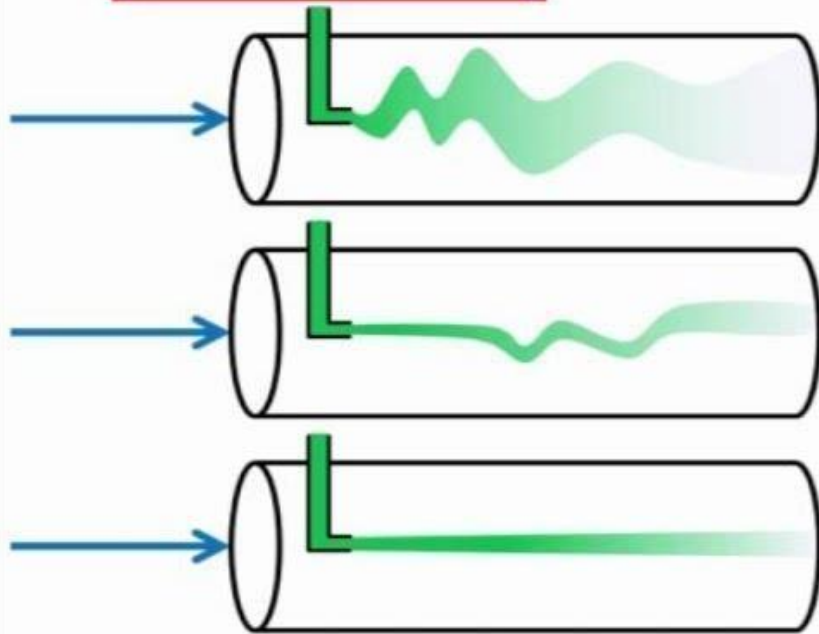


# Laminar To Turbulent Airflow



# Turbulent Flow, Transition Flow & Laminar Flow

$$\text{Re} = \frac{\rho V_{\text{avg}} D}{\mu}$$



$\text{Re} > 4000$

**turbulent** (unpredictable, rapid mixing)

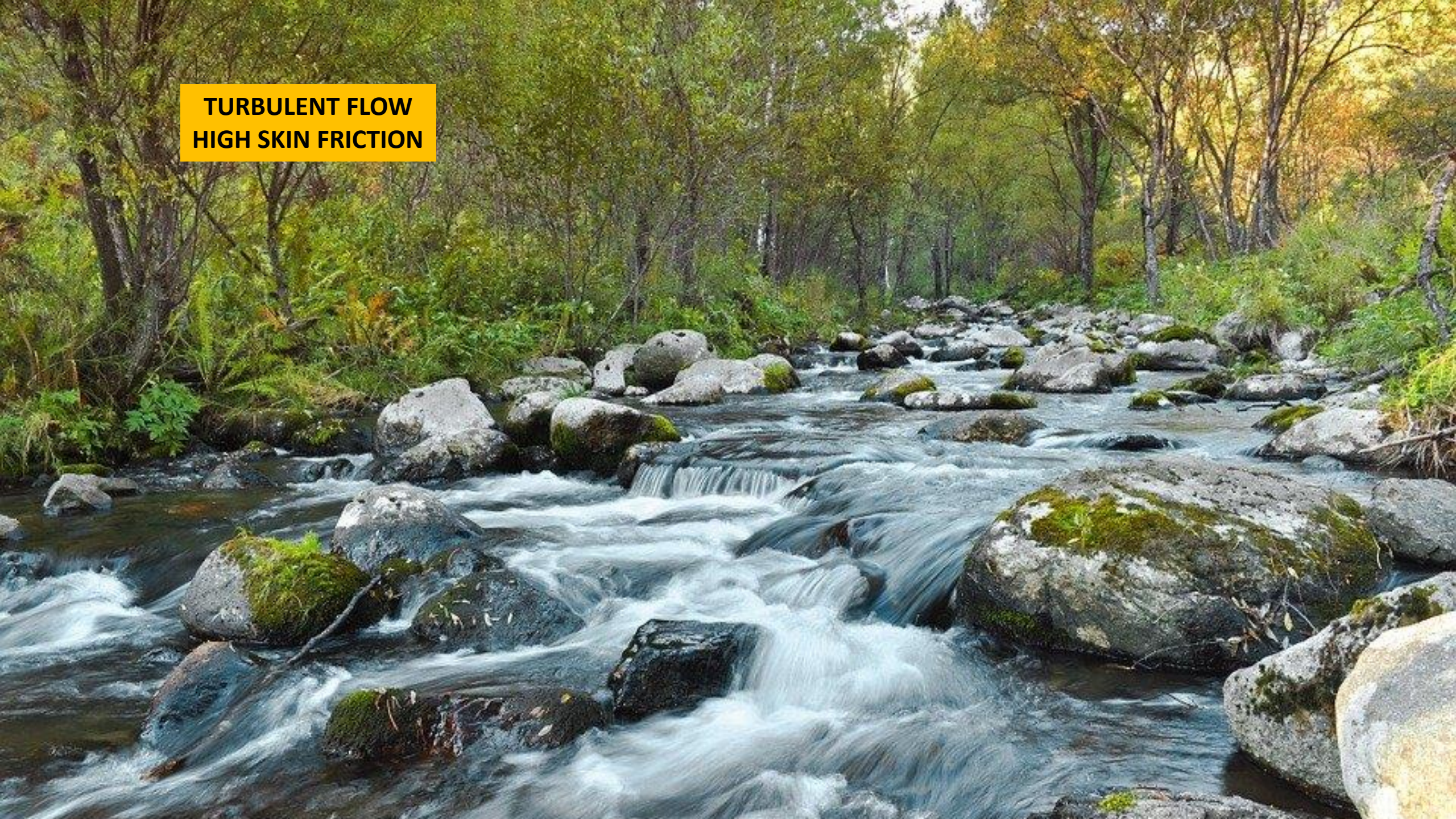
$2300 < \text{Re} < 4000$

**transitional** (turbulent outbursts)

$\text{Re} < 2300$

**laminar** (predictable, slow mixing)

**TURBULENT FLOW  
HIGH SKIN FRICTION**



**LAMINAR FLOW  
LOW SKIN FRICTION**





# CRUEL FACE OF HUMAN

Beautiful girl with branded Leather jackets....

Do you wanna know from where the leather jacket come from?



[I wanna see at my own risk](#)





# धन्यवाद

**Prepared By**  
**Mr.Pankaj Salunkhe**  
**(M.Tech Design , B-Tech Aerospace, DME)**