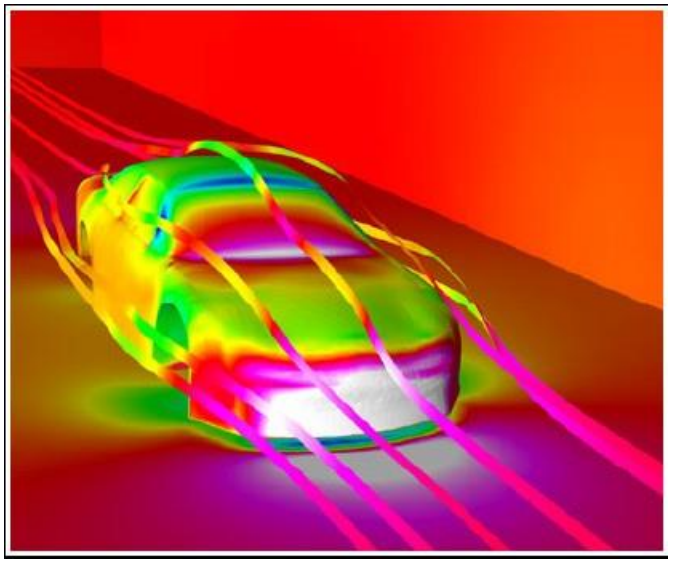
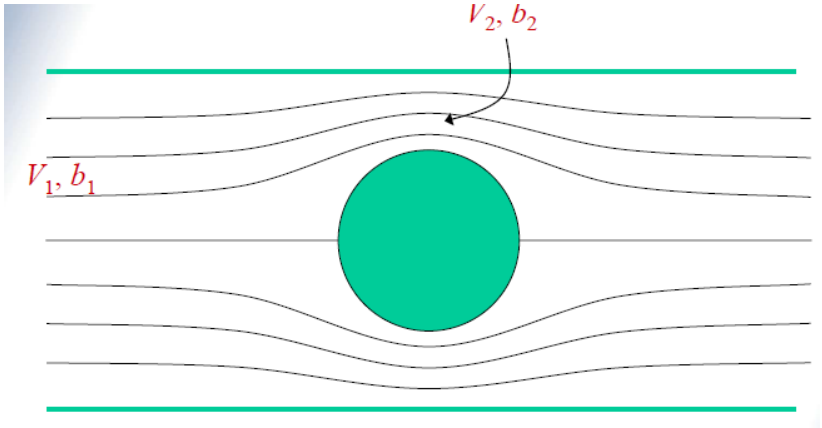
# Fluid Kinematics

- Branch of fluid mechanics which deals with response of fluids in motion without considering forces and energies in them.
- The study of *kinematics* is often referred to as the *geometry of motion.*



CAR surface pressure contours and streamlines



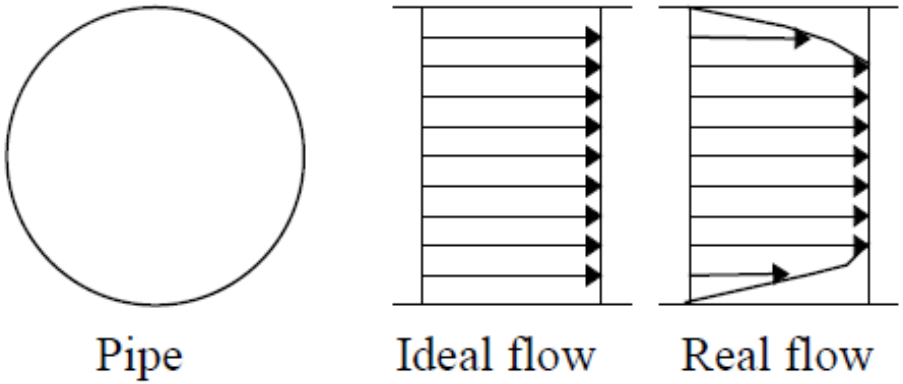

Flow around cylindrical object

# Types of Flow

- Ideal and Real flow
- Incompressible and compressible
- Laminar and turbulent flows
- Steady and unsteady flow
- Uniform and Non-uniform flow

# Ideal and Real flow

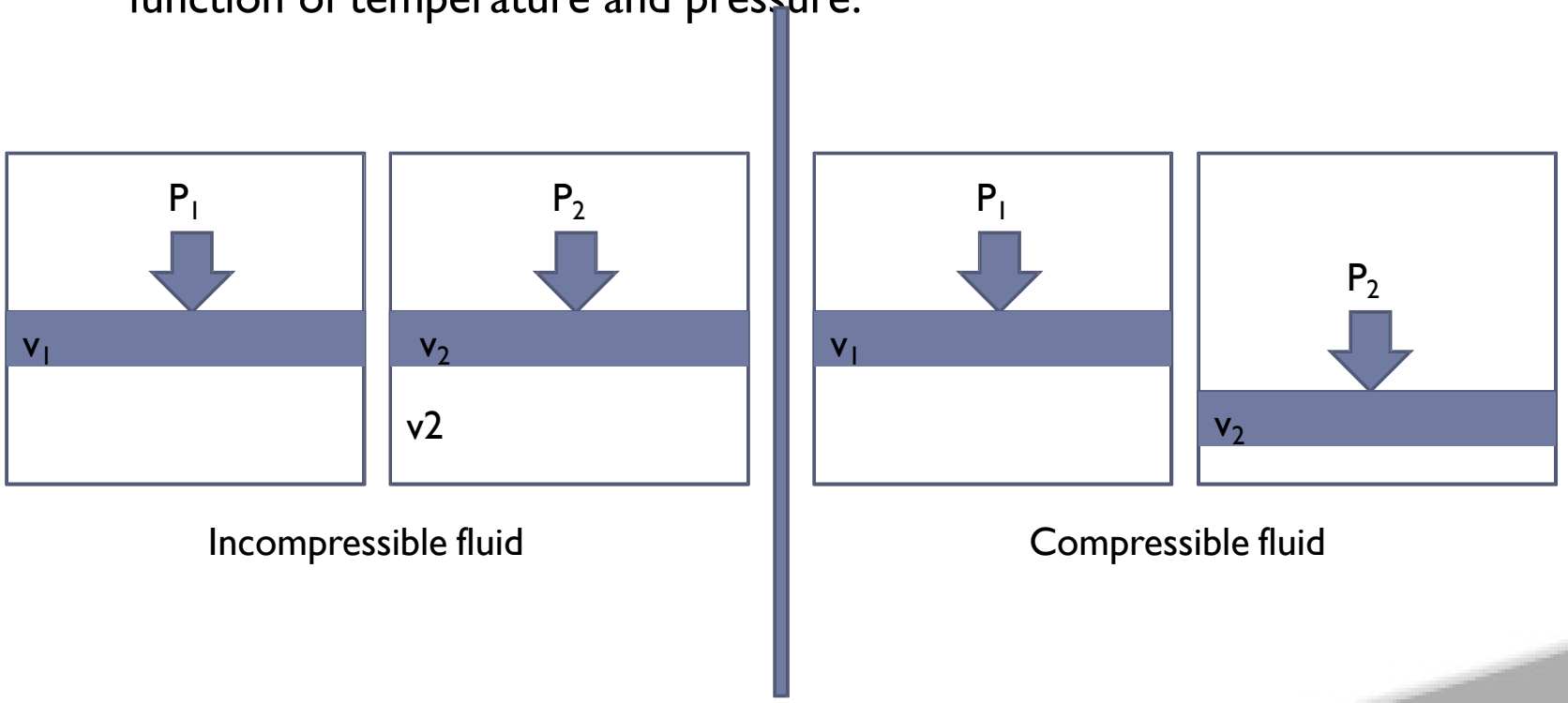
- Real fluid flows implies friction effects. Ideal fluid flow is hypothetical; it assumes no friction.




Velocity distribution of pipe flow

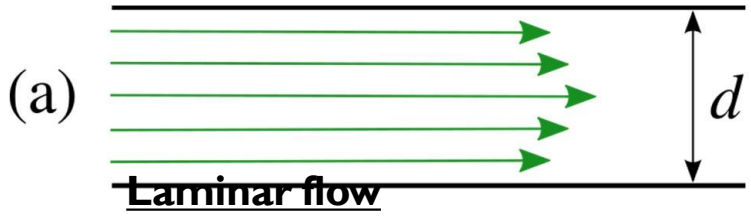
# Compressible and incompressible flows

- Incompressible fluid flows assumes the fluid have constant density while in compressible fluid flows density is variable and becomes function of temperature and pressure.

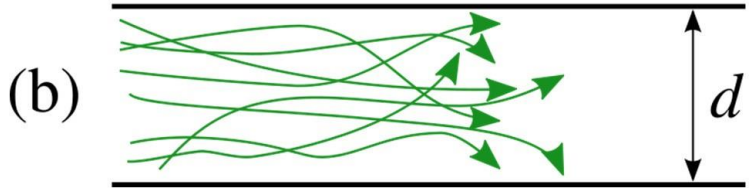


# Laminar and turbulent flow

- The flow in laminations (layers) is termed as laminar flow while the case when fluid flow layers intermix with each other is termed as turbulent flow.

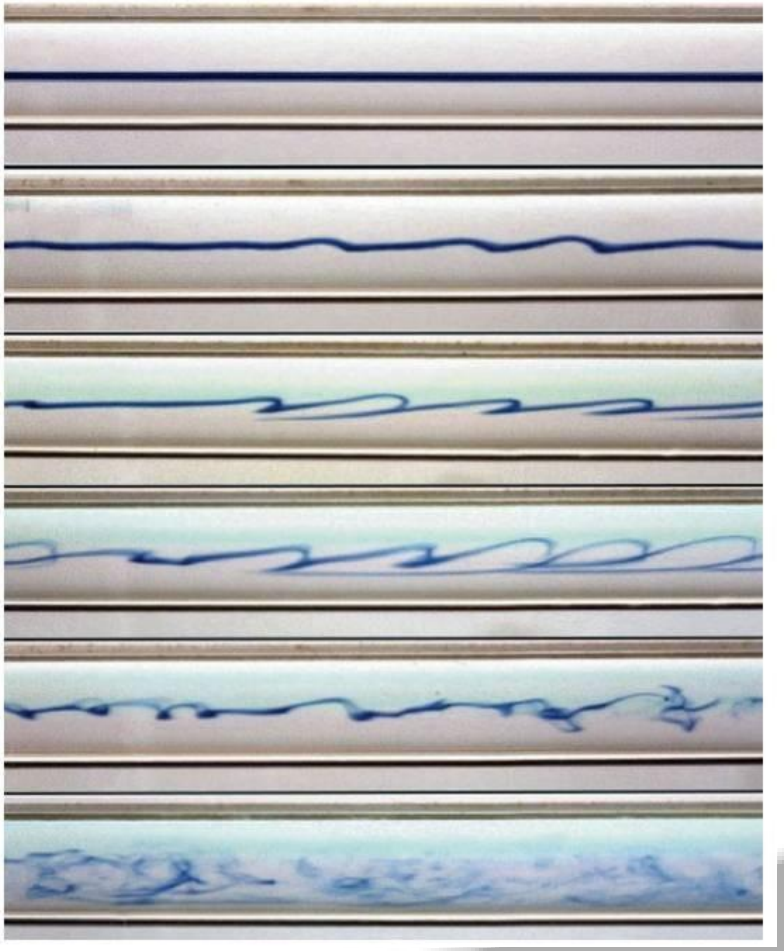



**Laminar flow**




**Turbulent flow**

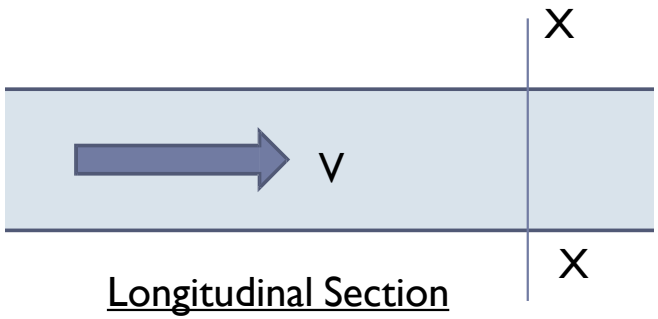
- Reynold's number is used to differentiate between laminar and turbulent flows.



**Transition of flow from Laminar to turbulent**

# Steady and Unsteady flows

- **Steady flow:** It is the flow in which conditions of flow remains constant w.r.t. time at a particular section but the condition may be different at different sections.
- Flow conditions: velocity, pressure, density or cross-sectional area etc.
- e.g., A constant discharge through a pipe.



Longitudinal Section

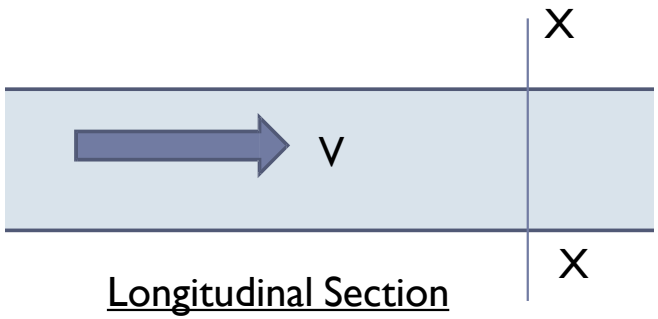
$$\frac{\partial V}{\partial t} = 0; \Rightarrow V = contt$$

- **Unsteady flow:** It is the flow in which conditions of flow changes w.r.t. time at a particular section.
- e.g.,A variable discharge through a pipe

$$\frac{\partial V}{\partial t} \neq 0; \Rightarrow V = \text{variable}$$

# Uniform and Non-uniform flow

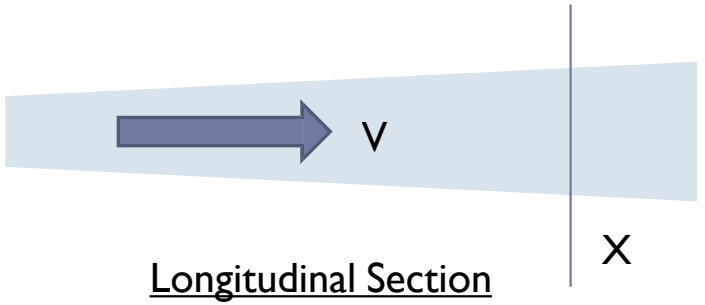
- **Uniform flow:** It is the flow in which conditions of flow remains constant from section to section.
- e.g., Constant discharge though a constant diameter pipe




Longitudinal Section

$$\frac{\partial V}{\partial x} = 0; \Rightarrow V = contt$$

- **Non-uniform flow:** It is the flow in which conditions of flow does not remain constant from section to section.
- e.g., Constant discharge through variable diameter pipe

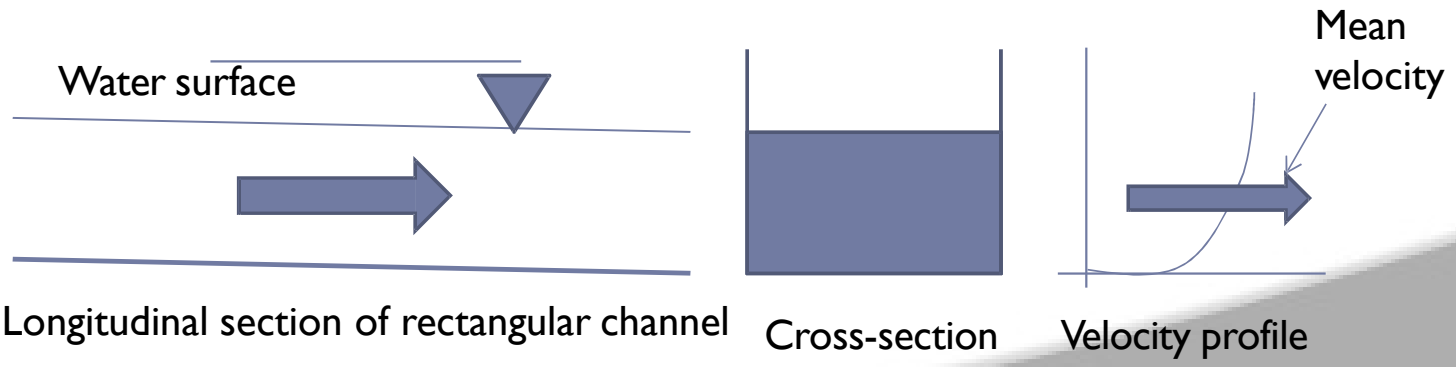



Longitudinal Section

$$\frac{\partial V}{\partial x} \neq 0; \Rightarrow V = \text{variable}$$

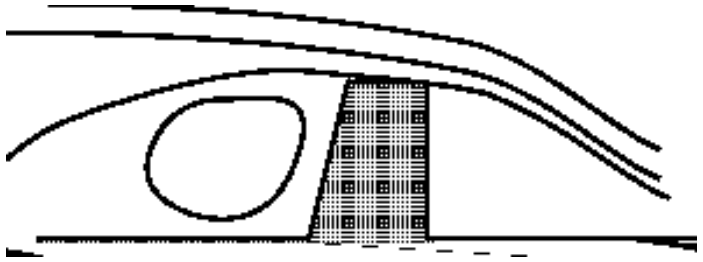
# One, Two and Three Dimensional Flows

- Although in general all fluids flow three-dimensionally, with pressures and velocities and other flow properties varying in all directions, in many cases the greatest changes only occur in two directions or even only in one. In these cases changes in the other direction can be effectively ignored making analysis much more simple.
- Flow is *one dimensional* *if the flow parameters (such as velocity, pressure, depth etc.) at a given instant in* time only vary in the direction of flow and not across the cross-section



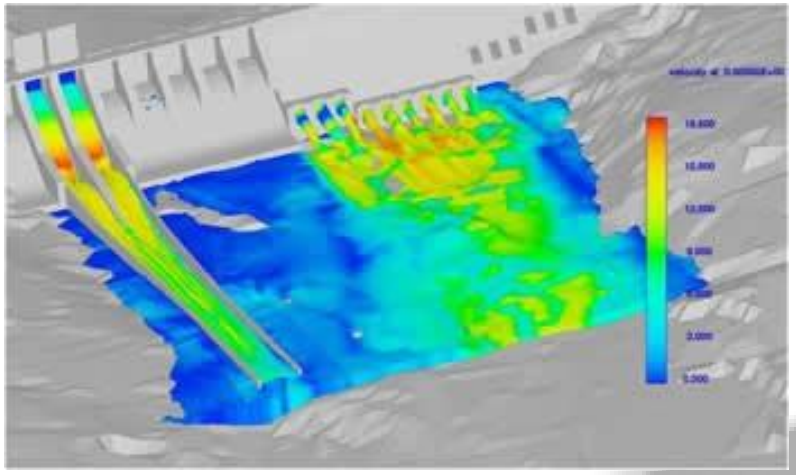
# One, Two and Three Dimensional Flows

- Flow is *two-dimensional* *if it can be assumed that the flow parameters vary in the direction of flow and in* one direction at right angles to this direction



Two-dimensional flow over a weir

- Flow is *three-dimensional* *if the flow parameters vary in all three directions of flow*



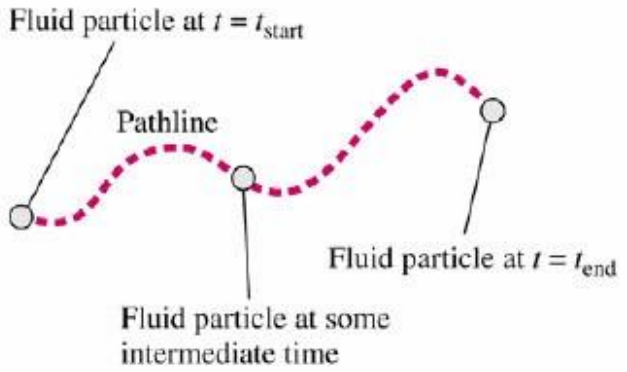
Three-dimensional flow in stilling basin

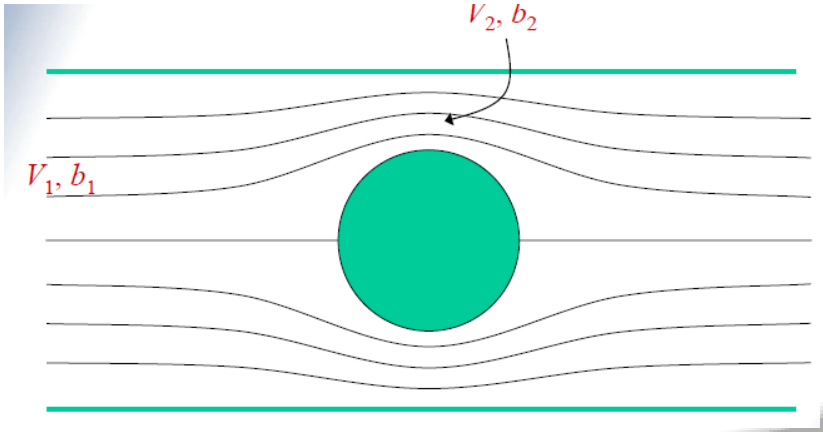
# Path line and stream line

- **Pathline:** It is trace made by single particle over a period of time.
- **Streamline** show the mean direction of a number of particles at the same instance of time.

- **Character of Streamline**

1. Streamlines can not cross each other. (otherwise, the cross point will have two tangential lines.)
2. Streamline can't be a folding line, but a smooth curve.
3. Streamline cluster density reflects the magnitude of velocity. (Dense streamlines mean large velocity; while sparse streamlines mean small velocity.

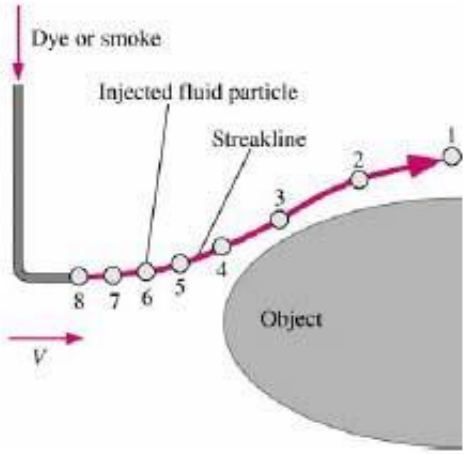



Flow around cylindrical object

# Streakline and streamtubes

- A **Streakline** is the locus of fluid particles that have passed sequentially through a prescribed point in the flow.
- It is an instantaneous picture of the position of all particles in flow that have passed through a given point.




- **Streamtube** is an imaginary tube whose boundary consists of streamlines.
- The volume flow rate must be the same for all cross sections of the stream tube.