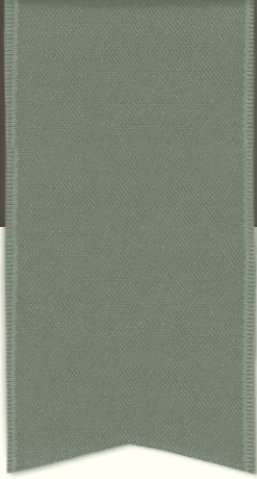




CE 261: Fluid Mechanics

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CHAPTER 3

KINEMATICS OF FLUID FLOW

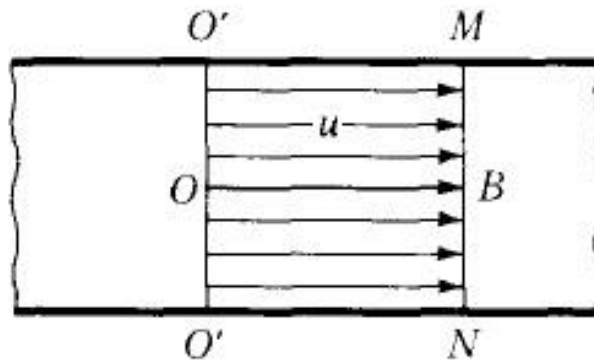
TYPES OF FLUID

- Ideal fluid
- Real fluid
- Compressible fluid
- Incompressible fluid
- Newtonian fluid
- Non-Newtonian fluid

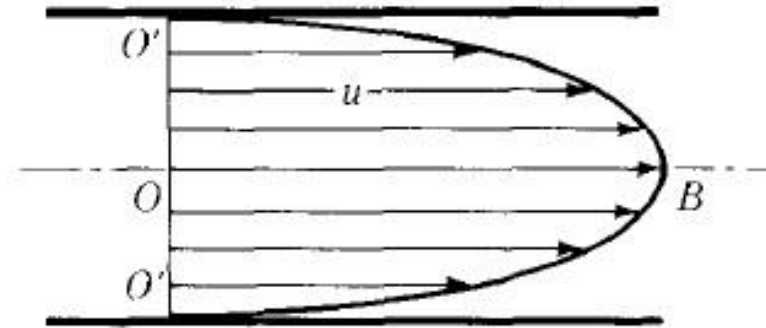
TYPES OF FLUID

Ideal Fluid: has no **Viscosity**

Real Fluid: Whenever **motion** takes places, **shearing forces** are developed



(a) Ideal fluid.



(b) Real fluid.

Figure 3.1. Typical velocity profiles. (a) Ideal fluid. (b) Real fluid.

TYPES OF FLUID

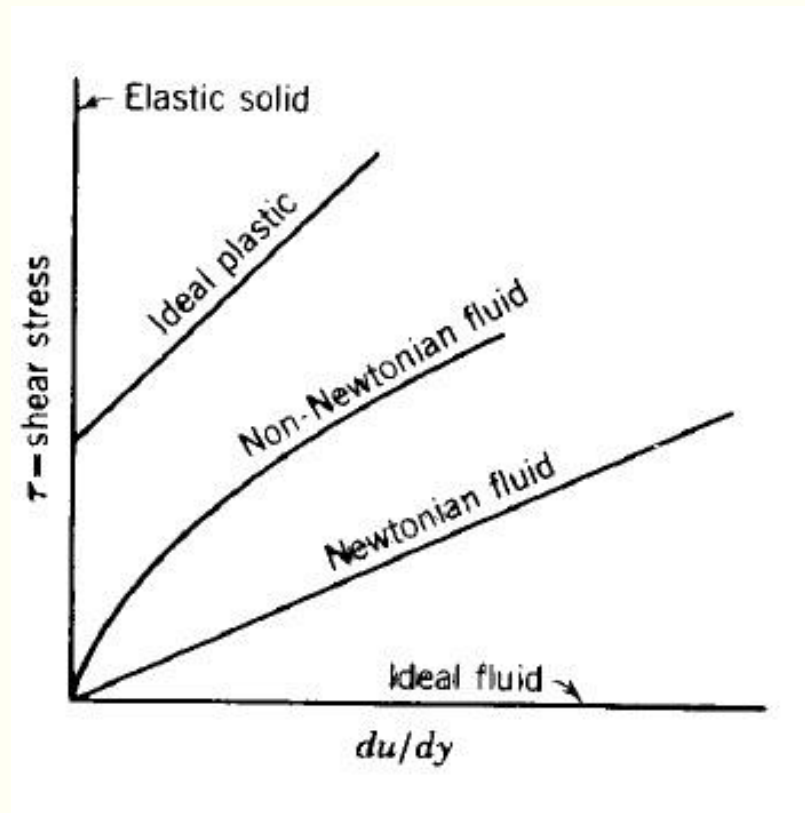
Incompressible fluid: Fluid with **constant density** with **change in pressure**

Compressible fluid: Fluid with **variable density**

TYPES OF FLUID

Newtonian fluid: A fluid for which **viscosity does not change** with **rate of deformation**

Non-Newtonian fluid: Under force it becomes more liquid or more solid.



TYPES OF FLOW

- Laminar flow and Turbulent flow
- Steady and Unsteady Flow
- Uniform and Non-Uniform Flow
- One, Two and Three Dimensional Flow

REYNOLD'S NUMBER

Reynold's experiment: <https://youtu.be/pae5WrmDzUU>

$$Re = \frac{\textit{Inertia Force}}{\textit{Viscous Force}}$$

$$Re = \frac{\rho V L}{\mu}$$

TYPES OF FLOW

Laminar flow: Type of fluid flow in which the fluid travels smoothly or in regular paths.

Turbulent flow: fluid undergoes irregular fluctuations and mixing

TYPES OF FLOW

Steady Flow: Flow properties remain **constant with respect to time**

Unsteady Flow: Flow properties **vary with respect to time.**

TYPES OF FLOW

Uniform Flow: If the flow velocity is assumed to have the same speed and direction at every point within the fluid, it is said to be uniform.

Non-Uniform Flow: If at a given instant, the velocity is not the same at every point, the flow is non-uniform.

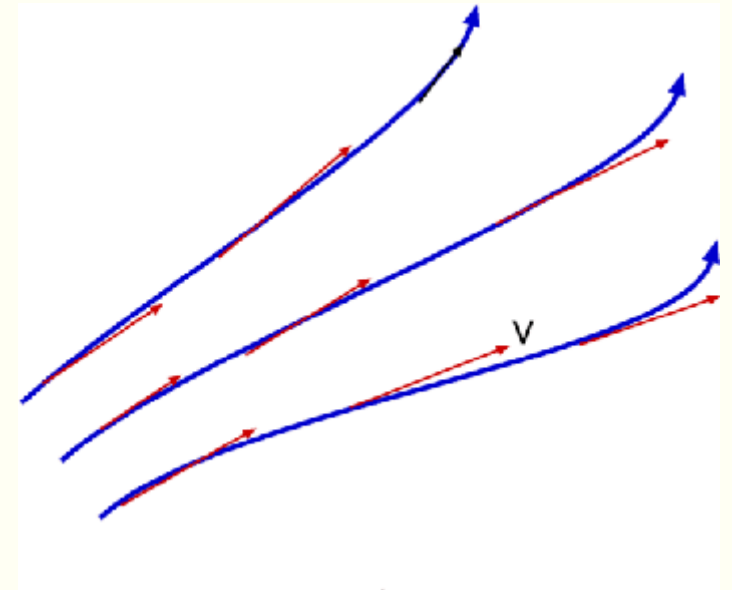
FLOW PATTERN

- Streamline
- Streamtube
- Pathline
- Streakline

FLOW PATTERN

Streamline

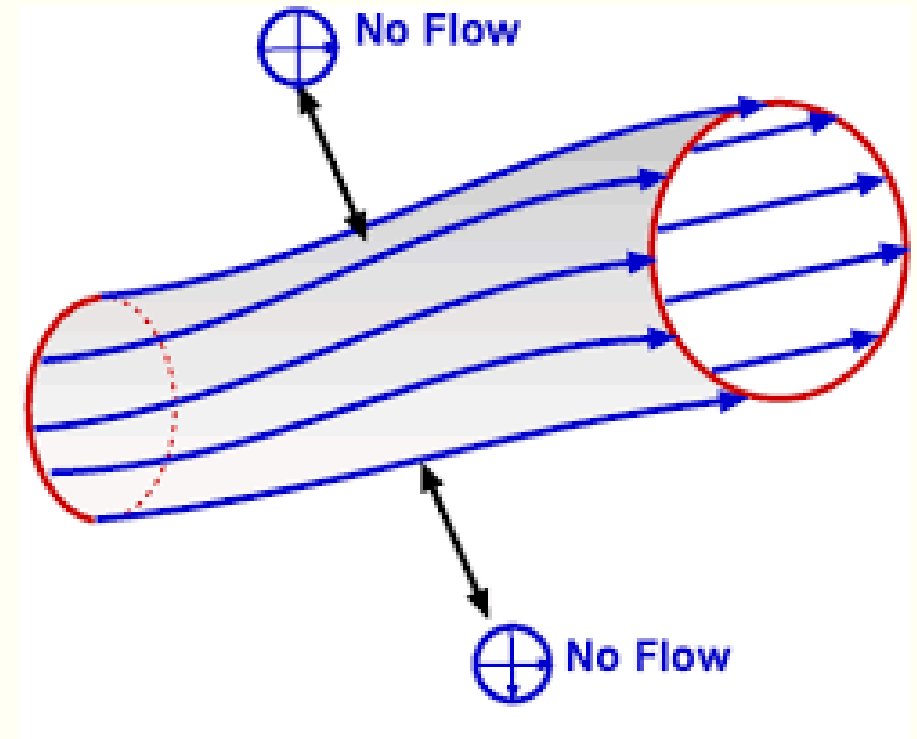
- A line which is everywhere **tangent to the velocity vector** at a given instant.
- It shows the mean direction of a number of particles at the same instant of time.



FLOW PATTERN

Streamtube:

- A bundle of streamline is called streamtube
- A streamtube is formed by a close collection of streamlines.
- Fluid can not flow in a direction perpendicular to the streamline
- Streamtube surface need not to be solid but may be fluid surface



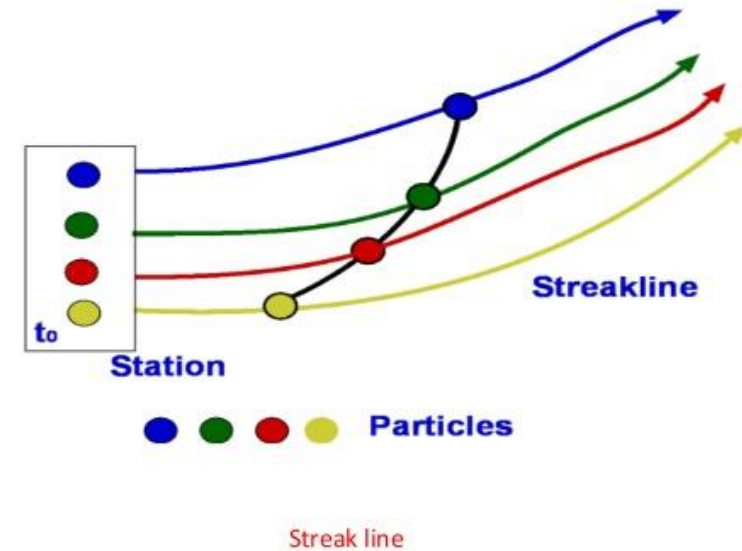
FLOW PATTERN

Pathline

- Is the trace made by a single particle over a period of time

Streakline:

Is the locus of a particle which earlier passed through a fixed point.



Continuity Equation

Expresses the conservation of Mass

M_t = mass of fluid contained in the control volume at time t

M_{t+dt} = mass of fluid contained in the control volume at time $t+dt$

Problems on Continuity Equation

A pipeline carries oil (relative density 0.86) at $v = 2$ m/s through 200mm cross-section. Find

- Mass flow rate
- Weight flow rate
- Volume flow rate
- Velocity in 60mm cross-section.