FLUID MECHANICS

Fluid kinematics: Fluid kinematics is the study of fluid motion regardless of the cause of motion. The fluid flow is analysed by using Lagrangian approach and Eulerian approach.

In Lagrangian approach, in this approach each fluid particles is observed with respect to time, whereas, in Eulerian approach, define a frame of reference and whole flow field is described with space coordinate and then the fluid flow is analysed at that point. Because of its simplicity Eulerian technique is mostly used.

Types of Fluid flow:

1. Steady and Unsteady flow
2. Uniform and Non-uniform flow
3. Laminar and Turbulent flow
4. Rotational and Irrotational flow
5. Compressible and Incompressible flow

1. Steady and Unsteady flow:

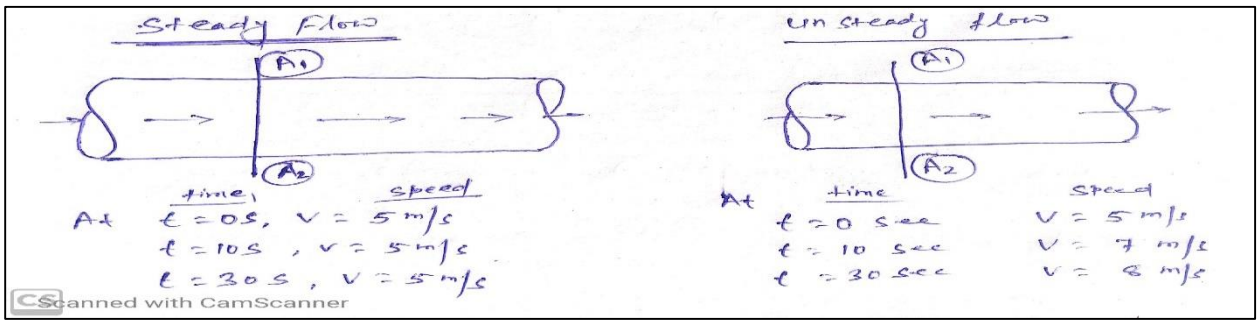
Steady flow: A flow is called a steady flow if fluid velocity and fluid properties invariant with respect to time at any given section.

For steady flow, $\frac{dv}{dt} = 0 \quad \& \quad \frac{dX}{dt} = 0$

Where v is the velocity of fluid particles & X is the set of fluid properties

Unsteady flow: A flow is called an unsteady flow if fluid velocity and fluid properties varies with respect to time at any given section.

For unsteady flow, $\frac{dv}{dt} \neq 0 \quad \& \quad \frac{dX}{dt} \neq 0$



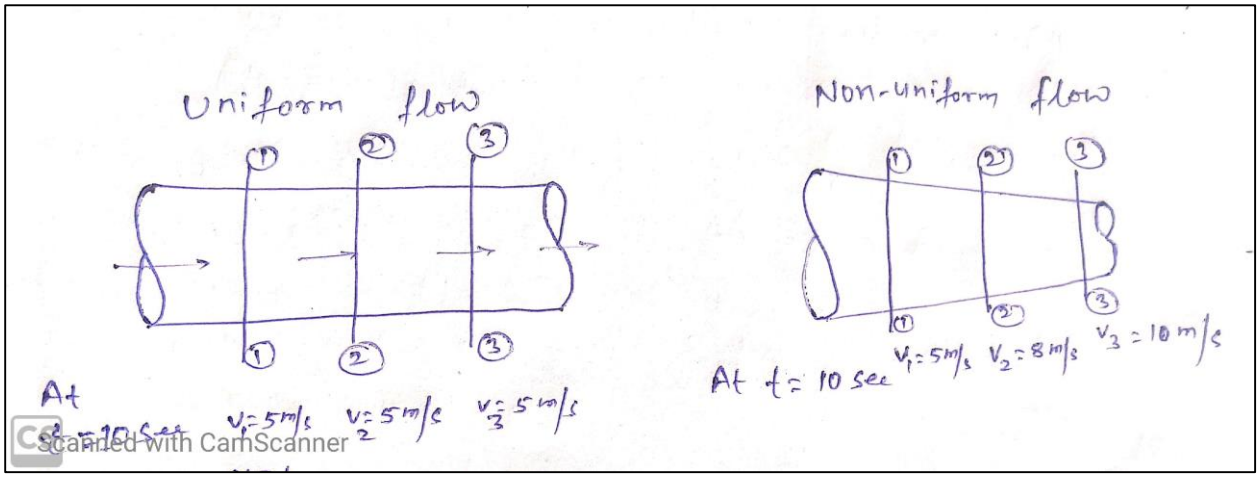
2. Uniform and Non-uniform flow:

Uniform flow: A flow is called a uniform flow if the fluid velocity and fluid properties is invariant with respect to space at any given instantaneous time.

For a uniform flow, $\frac{dv}{ds} = 0$ & $\frac{dX}{ds} = 0$

Non-uniform flow: A flow is called a non-uniform flow if the fluid velocity and fluid properties does not remains constant with respect to space at any instantaneous time.

For a uniform flow, $\frac{dv}{ds} \neq 0$ & $\frac{dX}{ds} \neq 0$



3. Laminar and Turbulent flow:

Laminar flow: When liquid particles moves in forms of layer with one layer sliding over another adjacent layer in parallel manner then such a flow is called laminar flow. Laminar flow generally occurs at low velocity.

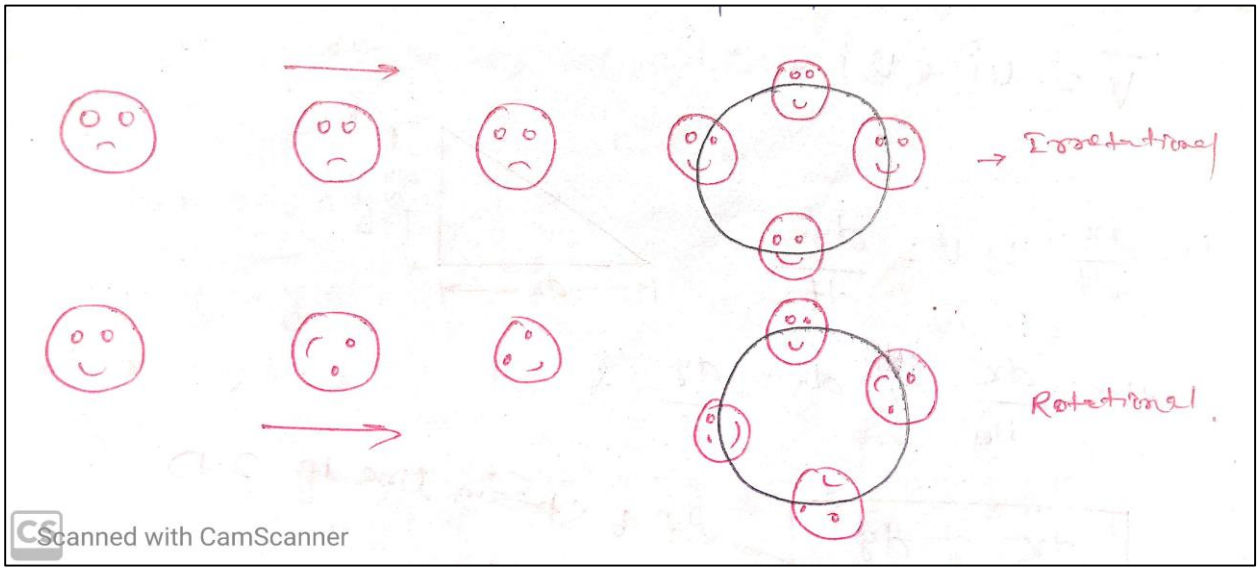
Turbulent flow: In turbulent flow, liquid particles moves in zig-zag manner leading to very fast mixing of particles. Turbulent flow usually occurs at very high velocity.

4. Rotational and Irrotational flow:

Rotational flow: A flow is called a rotational flow when fluid particles rotate about their centre of mass in the flow field.

Irrotational flow: A flow is called an irrotational flow when fluid particles does not rotate about their centre of mass in the flow field.

In case of irrotational flow there is no torque i.e there is no tangential force and this is generally associated with non-viscous fluid.



5. Compressible and Incompressible flow:

Incompressible flow: If the density of fluid does not changes with respect to the pressure. Such a flow is called as incompressible flow.

Here density is constant and invariant with respect to change in pressure.

$$\frac{d\rho}{dp} = 0$$

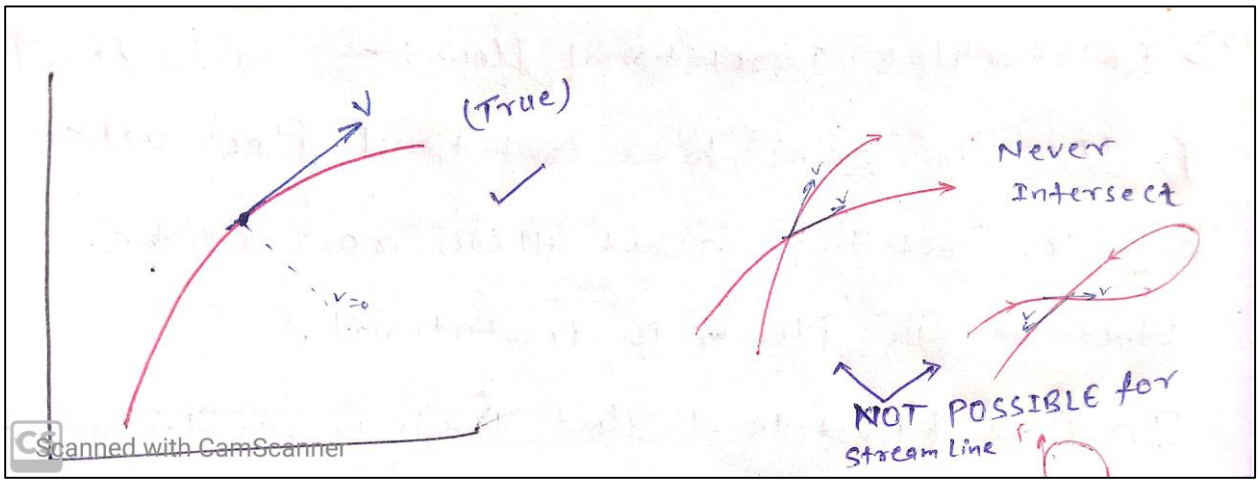
Compressible flow: If the density of fluid changes with respect to the pressure. Such a flow is called as compressible flow.

$$\frac{d\rho}{dp} \neq 0$$

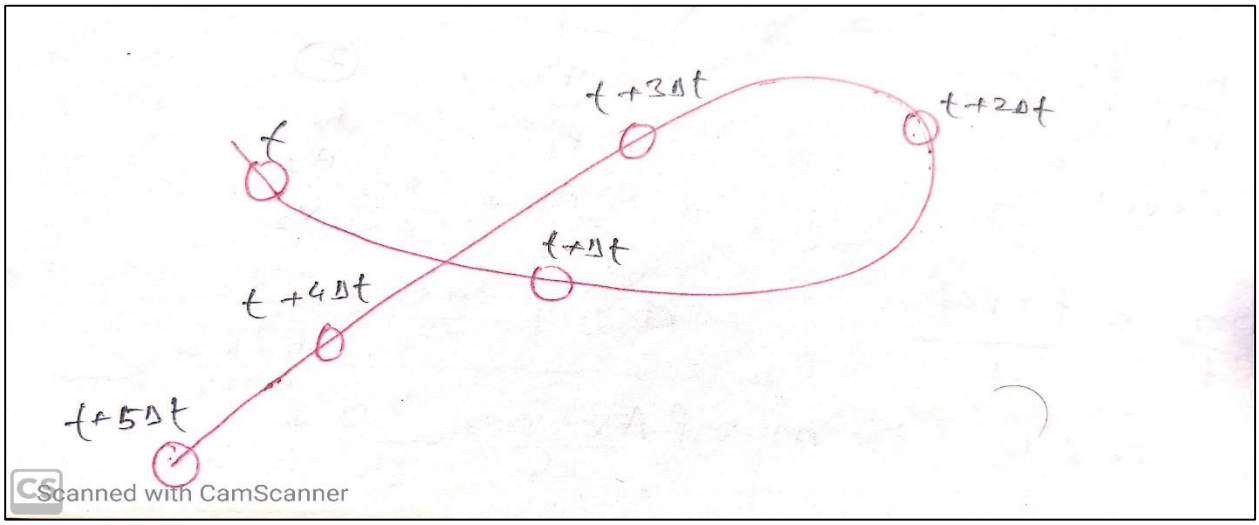
Different types of line:

1. Stream line: It is an imaginary curve or line drawn in flow field in such a way that the tangent drawn at any point on this line gives the direction of flow. Stream line is drawn for a particular instant as there is no component of velocity in that particular direction, therefore there is no flow across a stream line. Therefore the flow is always along a stream line.

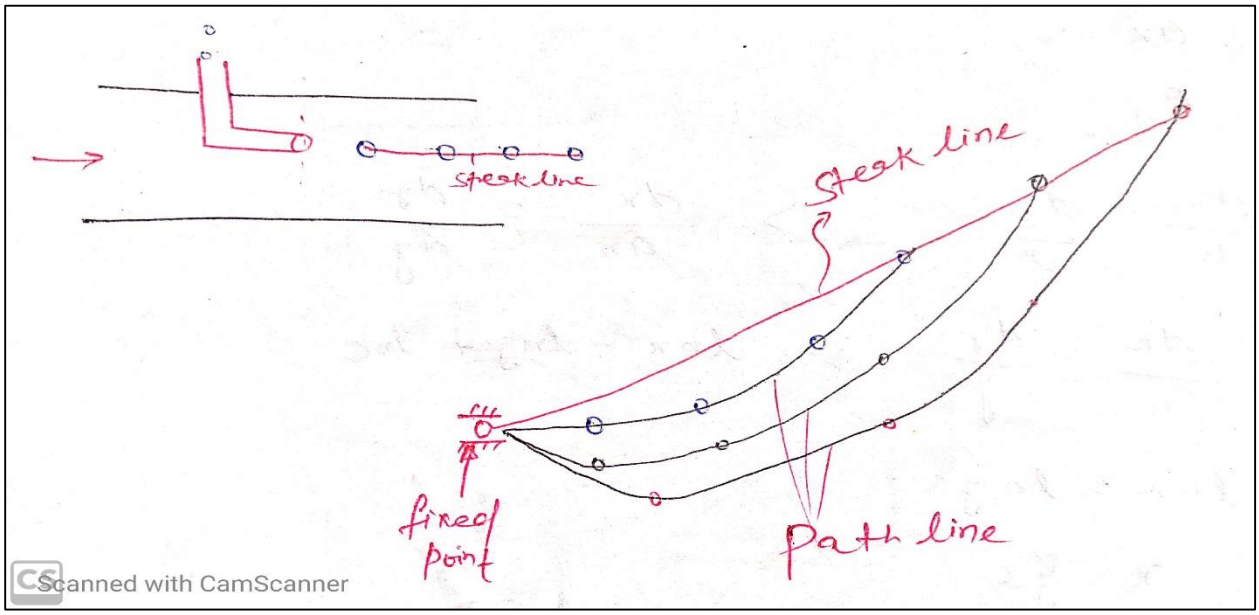
No two stream line intersect or a single stream line can never intersect with itself, because at any given point and at any given instant the velocity is unique.



2. Path line: It is the path trace by a single fluid particle at different instant of time.



3. Streak line: It is an imaginary line which is passing through the points which have passed through a same point after a given time interval.



If the flow is steady, then stream line, path line and streak line will coincide.

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