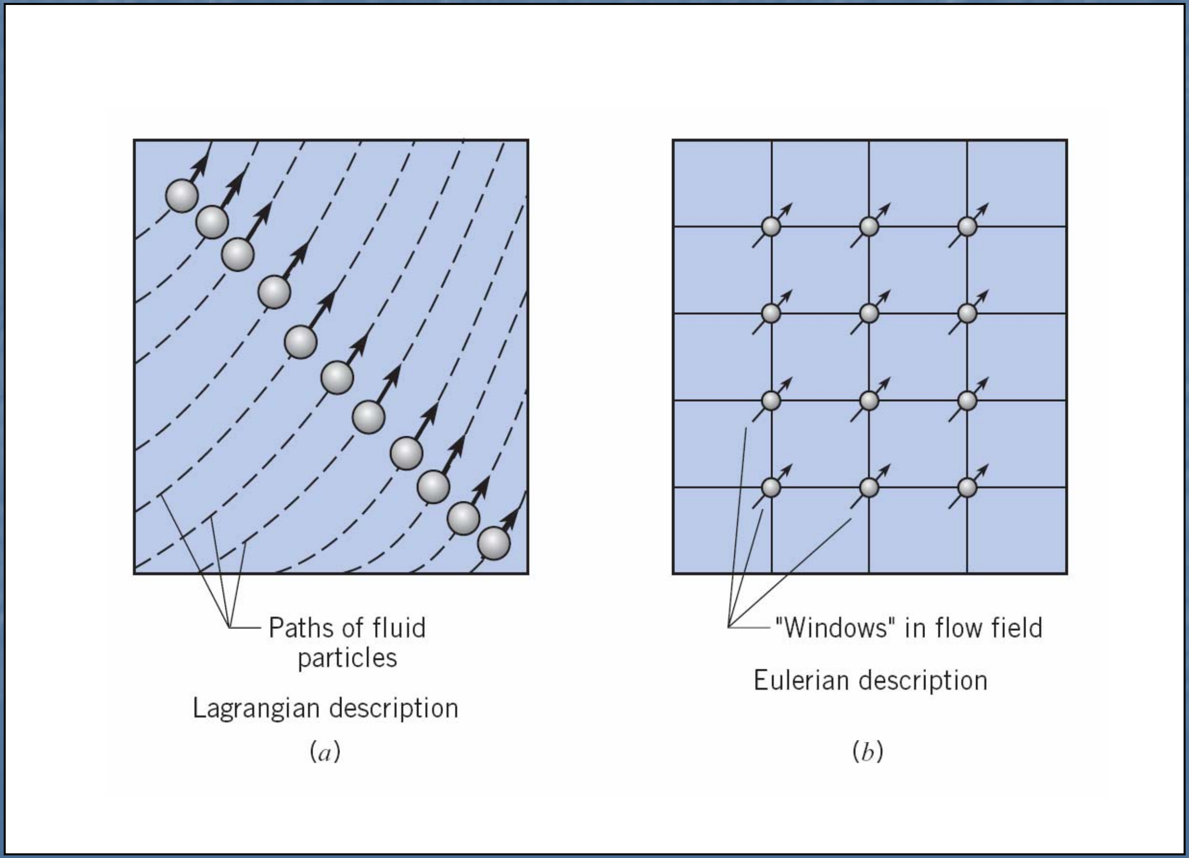
Fluid Motion

FLUID MOTION AND PRESSURE VARIATION

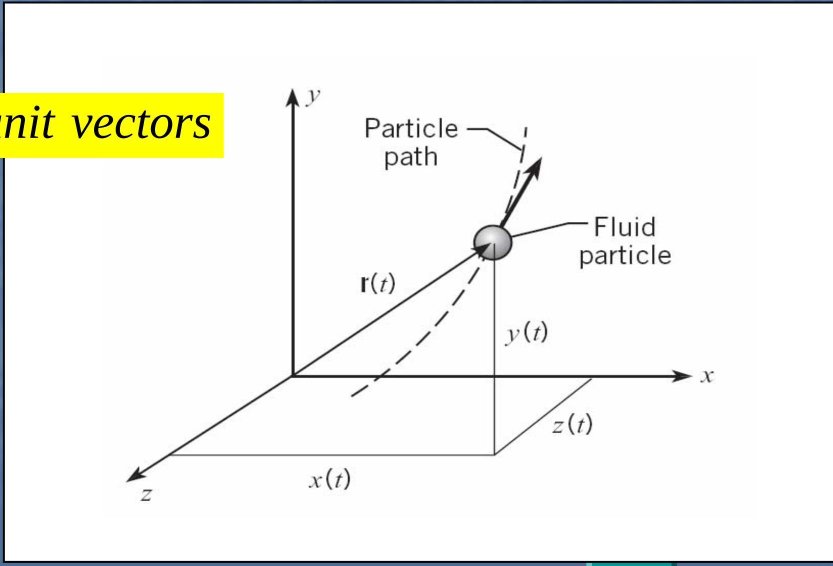
Lagrangian and Eulerian Description of Fluid Motion



Fluid Motion

1. Lagrangian Description of Fluid Motion

In the Lagrangian approach, one particle is chosen and is followed as it moves through space with time. The line traced out by that one particle is called a *particle pathline*.
To consider a fluid particle motion with time. The particle path can be expressed in Cartesian coordinates as follows:



$$r(t) = x(t)i + y(t)j + z(t)k \qquad where\ (i, j, k) \quad are\ unit\ vectors$$

The corresponding fluid particle velocity can be expressed as

$$V(t) = \frac{dr(t)}{dt} = \frac{dx}{dt}i + \frac{dy}{dt}j + \frac{dz}{dt}k$$

$$V(t) = u(i) + v(j) + w(k)$$

$$Where\ u, v, w \qquad are\ the\ component\ velocities$$

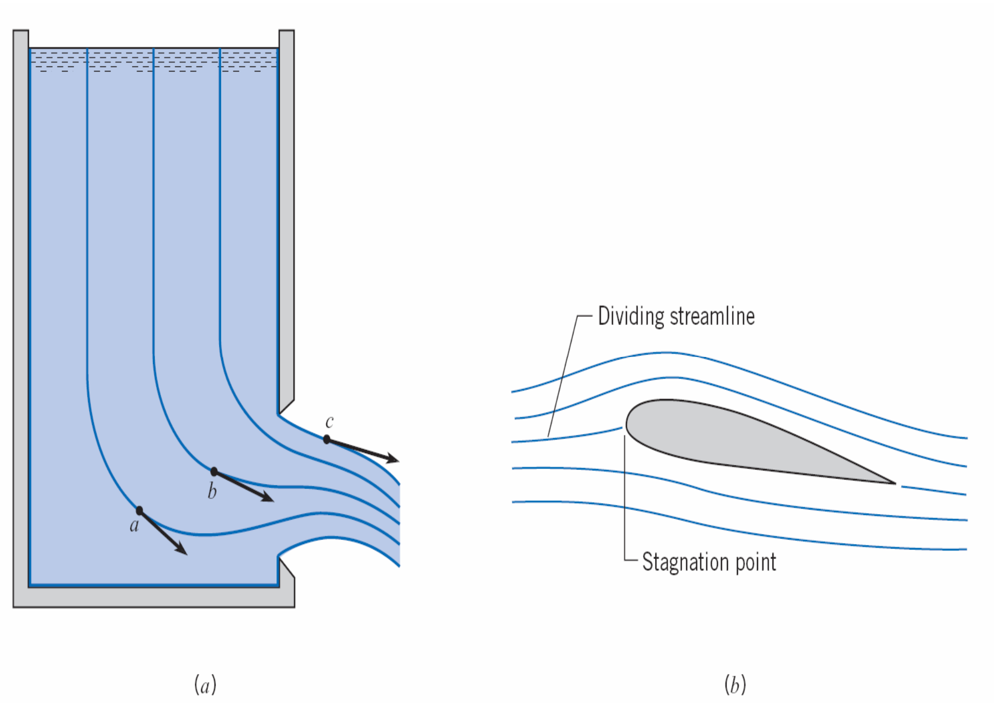
Fluid Statics

Eulerian approach (Swiss Mathematician)

consider an array of windows in the flow field as shown in Fig. 2b. In this case the velocity is a function of the window position (x,y,z) and time,

$$u = f(x, y, z, t) \quad v = f(x, y, z, t) \quad w = f(x, y, z, t)$$

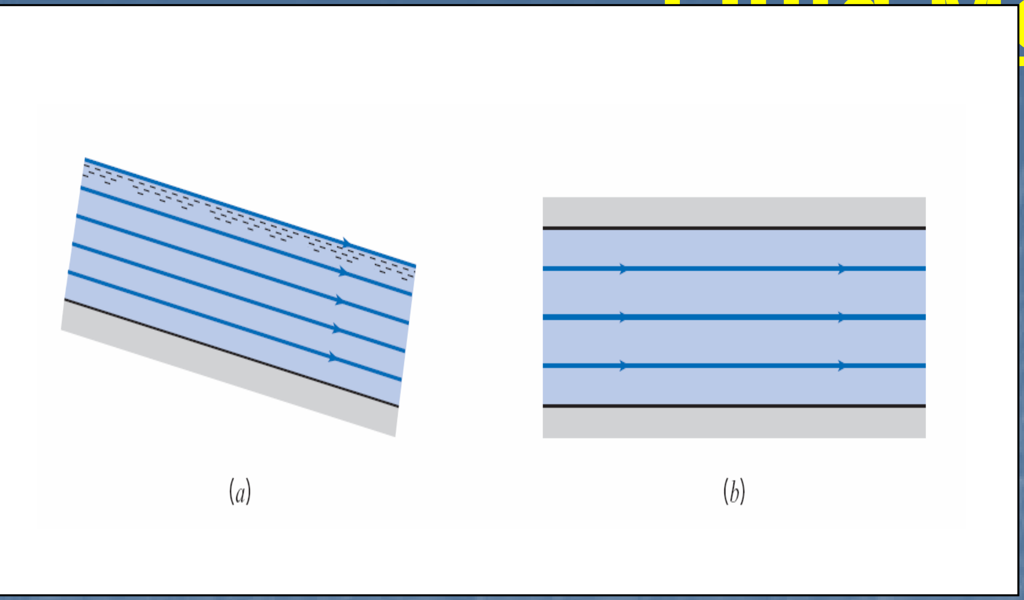
Thus, a pathline refers to the trace of a single particle in time and space whereas a streamline presents the line of motion of many particles at a fixed time.

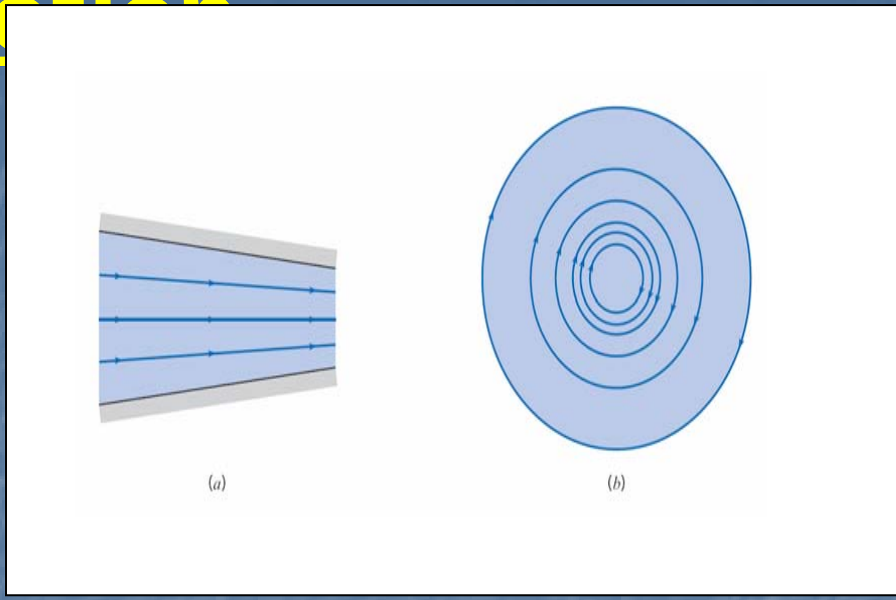


Flow pattern:
Can be defined as lines that are constructed to describe the flow direction.

Streamlines:
Can be defined as lines that are drawn through the flow field in such a manner that the local velocity vector is tangent to the streamline at every point along the line at that instant

Fluid Motion





Uniform Flow

$$\frac{\partial V}{\partial s} = 0$$

Non-Uniform Flow

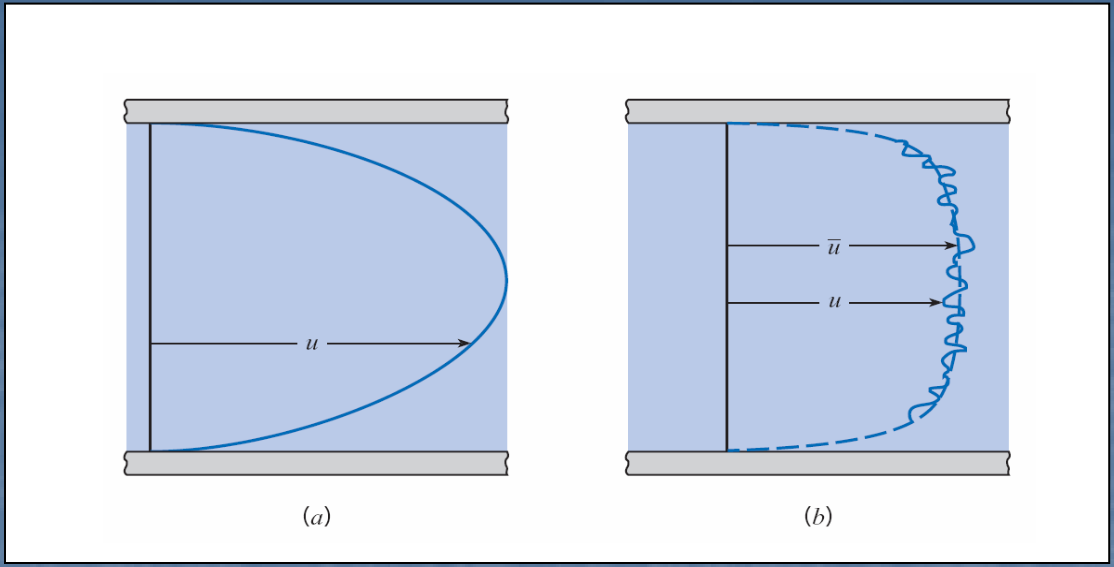
$$\frac{\partial V}{\partial s} \neq 0$$

Steady Flow

$$\frac{\partial V}{dt} = 0$$

Non-Steady Flow

$$\frac{\partial V}{dt} \neq 0$$



Laminar Flow: Low velocities and smooth appearance. (Ex. Flow in a pipe) as shown in Fig. 6a.

Turbulent Flow: High velocities and unsteady flow. (Ex. Smoke) as shown in Fig. 6b.

Reynolds number index is used to distinguish between laminar & turbulent flow.

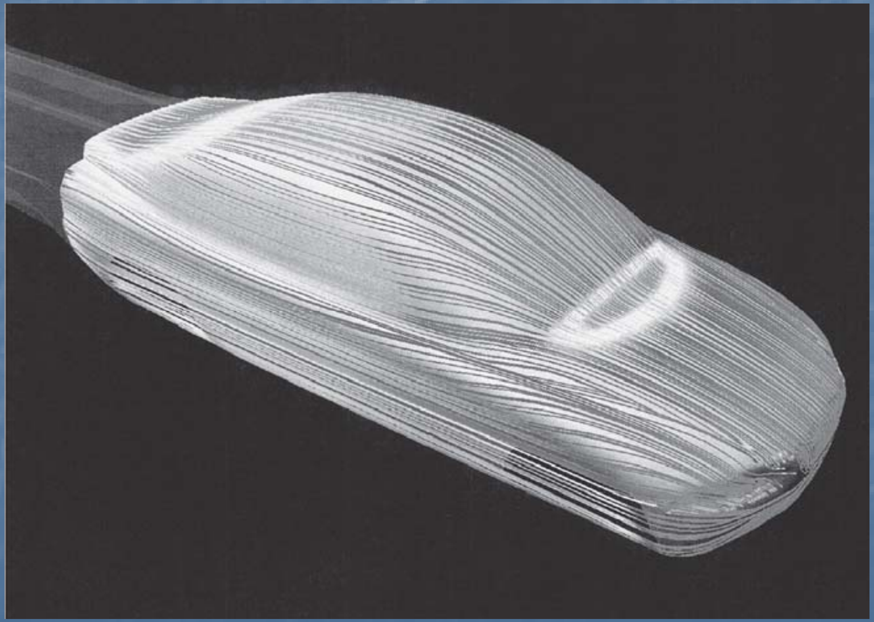
$(\mathrm{Re} < 2000) \quad \textit{Flow is laminar}$

$(\mathrm{Re} > 2000) \quad \textit{Flow is turbulent}$

Fluid Motion

Methods for Developing Flow Pattern

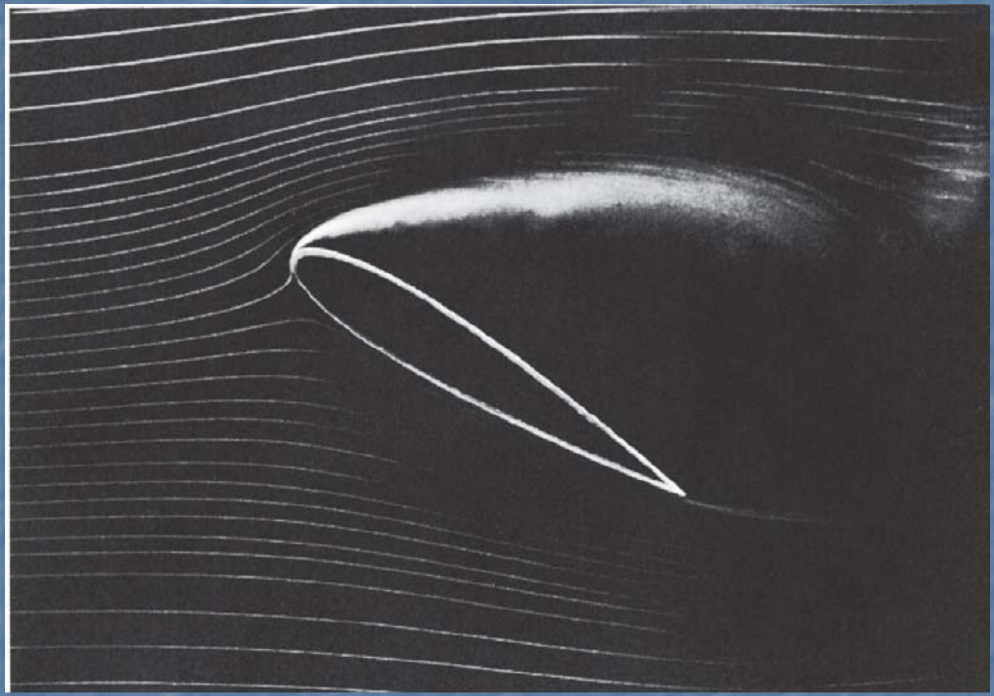
1. **Analytical Method:** The solution is mathematical
2. **Computational Method** The solution is done using the computer
3. **Experimental Method**



Predicted streamline pattern (Volvo prototype)

Predicted pathline pattern of flow particles

Predicted streakline pattern



END OF LECTURE (1)