2.1 FLUID KINEMATICS

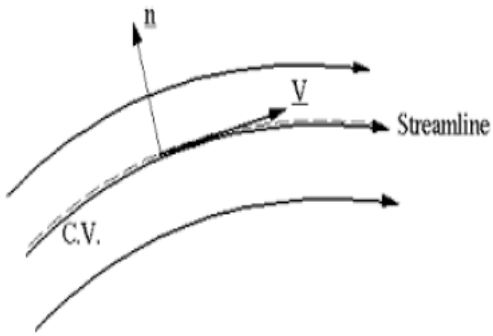
Kinematics is defined as a branch of science which deals with motion of particles without considering the forces causing the motion. The velocity at any point in a flow field at any time is studied in this. Once the velocity is known, then the pressure distribution and hence the forces acting on the fluid can be determined.

Stream line: A stream line is an imaginary line drawn in a flow field such that the tangent drawn at any point on this line represents the direction of velocity vector. From the definition it is clear that there can be no flow across stream line. Considering a particle moving along a stream line for a very short distance 'ds' having its components dx , dy and dz, along three mutually perpendicular co-ordinate axes. Let the components of velocity vector Vs along x, y and z directions be u, v and w respectively. The time taken by the fluid particle to move a distance 'ds' along the stream line with a velocity Vs is:

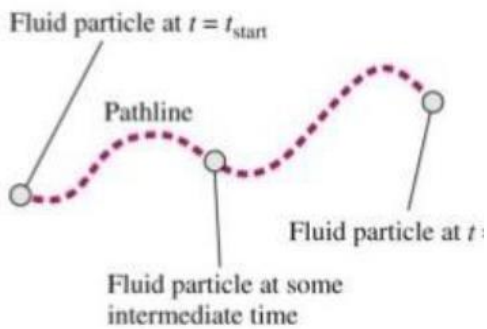
$$= \frac{ds}{Vs} \quad \text{Which is same as } t = \frac{dx}{u} = \frac{dy}{v} = \frac{ds}{w}$$

Hence the differential equation of the steam line may be written as:

$$\frac{dx}{u} = \frac{dy}{v} = \frac{ds}{w}$$



Path line: A path line is locus of a fluid particle as it moves along. In other words a path line is a curve traced by a single fluid particle during its motion. A stream line at time t1 indicating the velocity vectors for particles A and B. At times t2and t3 the particle A occupies the successive positions. The line containing these various positions of A represents its **Path line**



Streak line: When a dye is injected in a liquid or smc
subsequent motion of fluid particles passing a fixed point, the path followed by dye or smoke is called the **streak line**. Thus the streak line connects all particles passing through a given point.

In steady flow, the stream line remains fixed with respect to co-ordinate axes. Stream lines in steady flow also represent the path lines and streak lines. In unsteady flow, a fluid particle will not, in general, remain on the same stream line (except for unsteady uniform flow). Hence the stream lines and path lines do not coincide in unsteady non-uniform flow.

Instantaneous stream line: in a fluid motion which is independent of time, the position of stream line is fixed in space and a fluid particle fallowing a stream line will continue to do so. In case of time dependent flow, a fluid particle fallows a stream line for only a short interval of time, before changing over to another stream line. The stream lines in such cases are not fixed in space, but change with time. The position of a stream line at a given instant of time is known as **Instantaneous stream line.** For different instants of time, we shall have different Instantaneous stream lines in the same space. The Stream line, Path line and the streak line are one and the same, if the flow is steady.

Stream tube: If stream lines are drawn through a closed curve, they form a boundary surface across which fluid cannot penetrate. Such a surface bounded by stream lines is known as **Stream tube**.

From the definition of stream tube, it is evident that no fluid can cross the bounding surface of the stream tube. This implies that the quantity of fluid entering the stream tube at one end must be the same as the quantity leaving at the other end. The Stream tube is assumed to be a small cross-sectional area, so that the velocity over it could be considered uniform.