## 1/ Introduction:

Kinematics is the branch of mechanics that deals with quantities involving space and time only. It treats variables such as displacement, velocity, acceleration, deformation, and rotation of fluid elements without referring to the forces responsible for such a motion. Kinematics therefore essentially describes the "appearance" or a motion. Some important kinematical concepts are described in this chapter. The forces are considered when one deals with the dynamics of the motion, which will be discussed in later chapters.

## 2/ Lagrangian and Eulerian Specifications:

There are two ways of describing a fluid motion. In the Lagrangian description, one essentially follows the history of individual fluid particles (Figure 01). Consequently, the two independent variables are taken as time and a label for fluid particles. The label can be conveniently taken as the position vector $x_0$ of the particle at some reference time t = 0. In this description, then, any flow variable F is expressed as $F(x_0, t)$. In particular, the particle position is written as $x(x_0, t)$, which represents the location at t of a particle whose position was $x_0$ at t = 0.

The velocity and acceleration of a fluid Particle in the Lagrangian description are simply the partial time derivatives:

$$v_i = \frac{\partial x_i}{\partial t},\ a_i = \frac{\partial v_i}{\partial t} = \frac{\partial^2 x_i}{\partial t^2}$$

as the particle identity is kept constant during the differentiation.

The Lagrangian description is used occasionally when we are interested in finding particle paths of fixed identity.

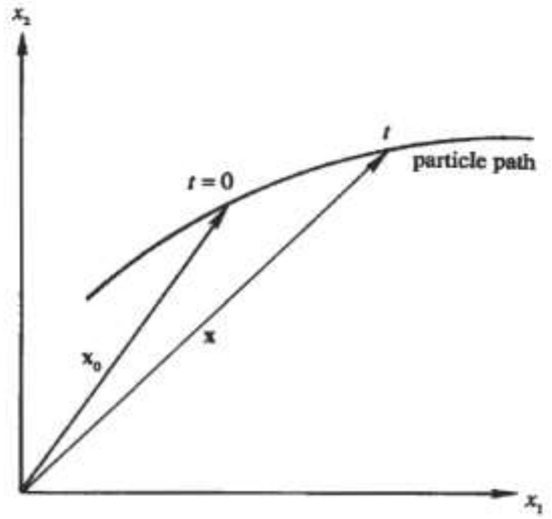
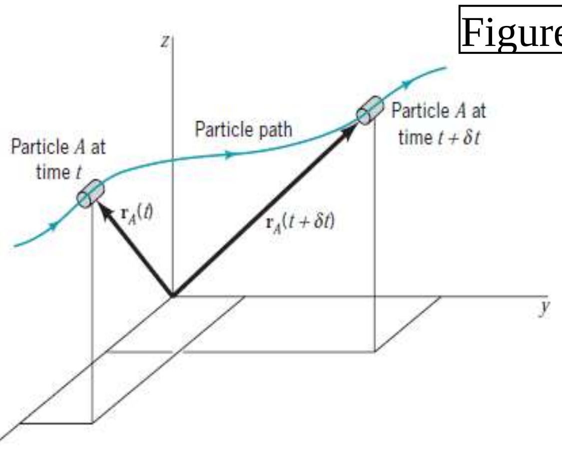


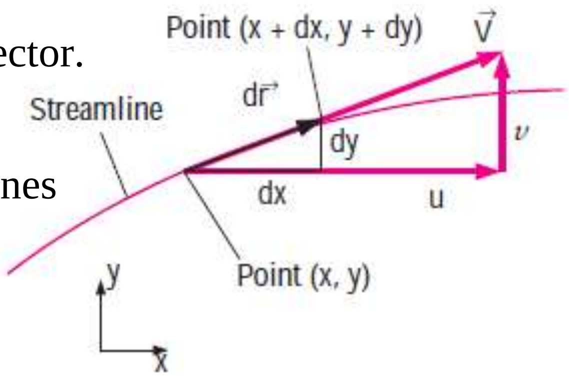

Figure 01 Lagrangian description of fluid motion.



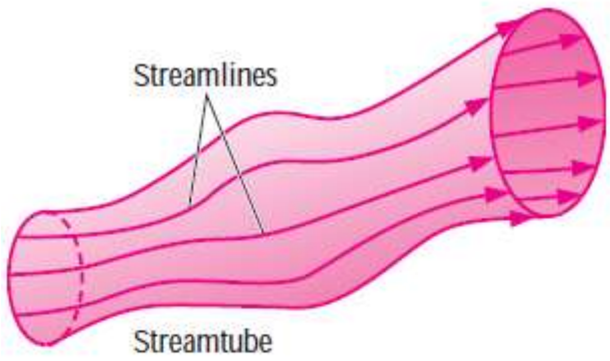
In the Eulerian description, one concentrates on what happens at a spatial point x, so that the independent variables are taken as x and t.
The fluid motion is given by completely prescribing the necessary properties (pressure, density, velocity, etc.) as functions of space and time.
That is, a flow variable is written as F(x, t).
In the Eulerian description, however, the partial derivative $\frac{\partial}{\partial t}$ gives only the local rate of change at a point x, and is not the total rate of change seen by a fluid particle. Additional terms are needed to form derivatives following a particle in the Eulerian description. The Eulerian specification is used in most problems of fluid flows.
From this method we obtain information about the flow in terms of what happens at fixed points in space as the fluid flows through those points.

### 3/ Streamlines, Streamtubes, and Pathlines:

A streamline is a curve that is everywhere tangent to the instantaneous local velocity vector.




A streamtube consists of a bundle of streamlines




A pathline is the actual path traveled by an individual fluid particle over some time period.