— University of Mosul —
College of Petroleum & Mining Engineering

Fluid Flow II

Lecture (1)
Fluid Dynamic

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LECTURE CONTENTS

Fluid Dynamic

Type of Fluid

Fluid Dynamics

It deals with the relations between velocities, accelerations of fluid with the forces or energy causing them.

Fluid Kinematics

Is a branch of **Fluid Mechanics** which deals with the study of velocity and acceleration of the particles of fluids in motion and their distribution in space without considering any force or energy involved

Types of Fluid Flow

1. **Steady and Unsteady Flows**
2. **Uniform and non-uniform Flows**
3. **One-, two- and three-dimensional Flows**
4. **Rotational and irrotational Flows**
5. **Laminar and Turbulent Flows**
6. **Compressible and incompressible**

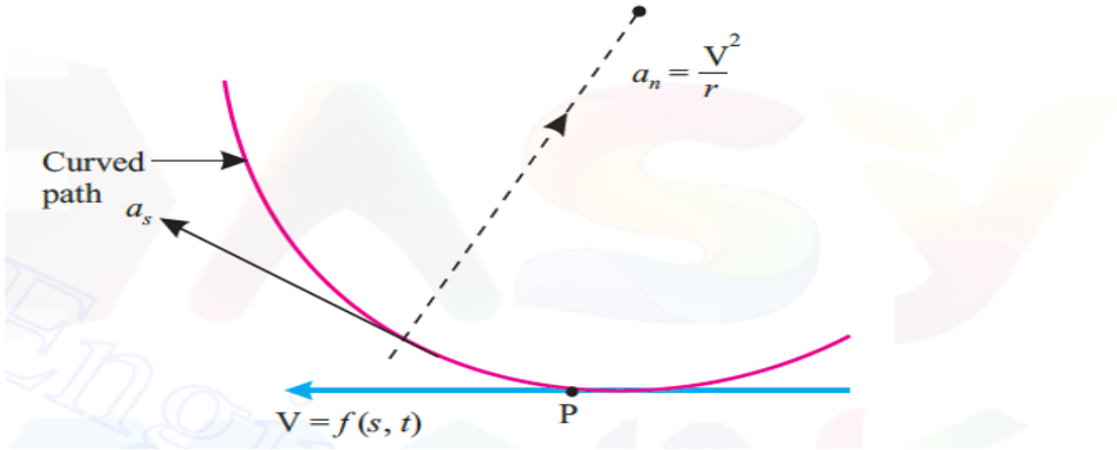


Fig. 1. Tangential and normal acceleration

1.Steady and Unsteady Flows

Steady Flow

The fluid characteristics like velocity, pressure, density, etc, at a point do not change with time is called steady flow. Mathematically, we have:

$$\left(\frac{\partial u}{\partial t}\right)_{x_o y_o z_o} = 0 \quad , \quad \left(\frac{\partial v}{\partial t}\right)_{x_o y_o z_o} = 0 \quad , \quad \left(\frac{\partial w}{\partial t}\right)_{x_o y_o z_o} = 0$$

$$\left(\frac{\partial p}{\partial t}\right)_{x_o y_o z_o} = 0 \quad , \quad \left(\frac{\partial \rho}{\partial t}\right)_{x_o y_o z_o} = 0 \quad ,$$

And so on where (x_o, y_o, z_o) is affixed point a fluid field where these variables are being measured w.r.t. time.

Example; Flow through a prismatic or non – prismatic conduit at a constant flow rate Q m^3/s is steady.

Unsteady Flow

It is that type of flow in which the velocity, pressure or density at a point change w.r.t. time. Mathematically, we have:

$$\left(\frac{\partial u}{\partial t}\right)_{x_o y_o z_o} \neq 0 \quad , \quad \left(\frac{\partial v}{\partial t}\right)_{x_o y_o z_o} \neq 0 \quad , \quad \left(\frac{\partial w}{\partial t}\right)_{x_o y_o z_o} \neq 0$$

$$\left(\frac{\partial p}{\partial t}\right)_{x_o y_o z_o} \neq 0 \quad , \quad \left(\frac{\partial \rho}{\partial t}\right)_{x_o y_o z_o} \neq 0 \quad ,$$

Example: The flow in a pipe whose valve is being opened or closed gradually

2.Uniform and non-uniform Flows

Uniform Flow

The type of flow, in which the velocity at any given time does not change with respect to space is called uniform flow. Mathematically, we have:

$$\left(\frac{\partial V}{\partial s}\right)_{t=constant} = 0$$

Where, ∂V = Change in velocity

∂s = Displacement in any direction

Example: Flow through a straight prismatic conduit (i. e. flow through a straight pipe of constant diameter)

Non-uniform Flow

It is that type of flow, in which the velocity at any given time changes with respect to space. Mathematically,

$$\left(\frac{\partial V}{\partial s}\right)_{t=constant} \neq 0$$

Example:

1. Flow through a non – prismatic conduit
2. Flow a round a uniform diameter pipe – bend or a canal bend.

3.One-two- and three-dimensional Flows

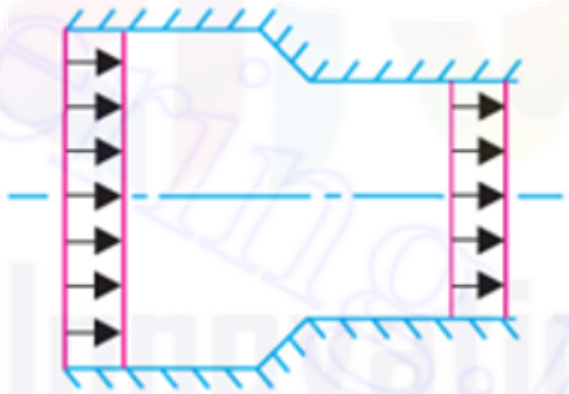
One dimensional Flow

It is that type of flow in which the flow parameter such as velocity is a function of time and one space co – ordinate only. Mathematically:

$$u = f(x), v = 0 \; and \; w = 0$$

Where u,v and w are velocity components in x, y and z directions respectively.

Example: Flow in a pipe where average flow parameters are considered for analysis.



Tow dimensional Flow

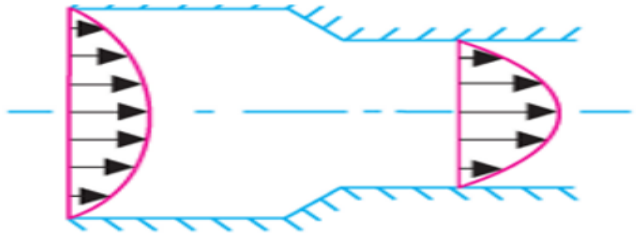
The flow in which the velocity is a function of time and two rectangular space coordinates is called two-dimensional flow. Mathematically:

$$u = f_1(x, y)$$

$$v = f_2(x, y) \quad , \quad w = 0$$

Example:

1. Flow between parallel plates of infinite extent
2. Flow in the main stream of a wide river.



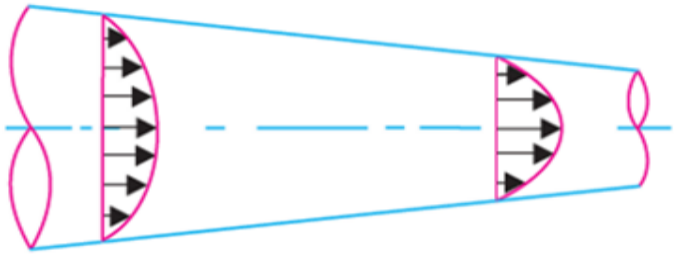
Three-dimensional Flow

It is that type of flow in which the velocity is a function of time and three mutually perpendicular direction. Mathematically:

$$u = f_1(x, y, z)$$

$$v = f_2(x, y, z)$$

$$w = f_3(x, y, z)$$



Example:

1. Flow in a converging or diverging pipe or channel
2. Flow in a prismatic open channel in which the width and the water depth are of the same order of magnitude