8 Fundamentals of Fluid Flow

Types of fluid flow

1- Steady and unsteady flow

a- Steady flow

It occurs when velocity, acceleration,.. etc doesn't change with time

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

b- Unsteady flow

It occurs when velocity or acceleration,.. etc changes with time

e.g. flow in a pipe whose valve is opening or closing

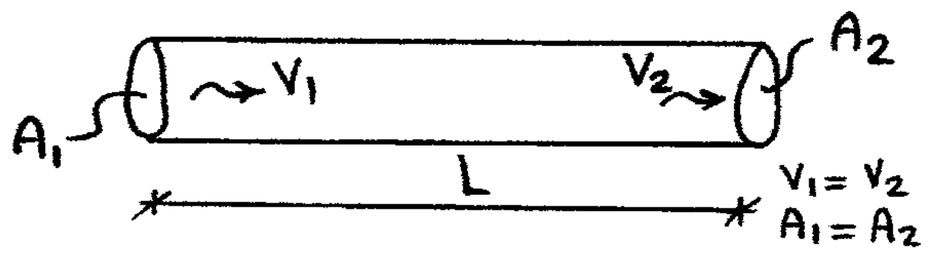
$$\frac{dV}{dt} \neq 0$$

2-Uniform and Non-uniform flow

a- Uniform flow

It occurs when velocity and cross-section remains constant over a given length

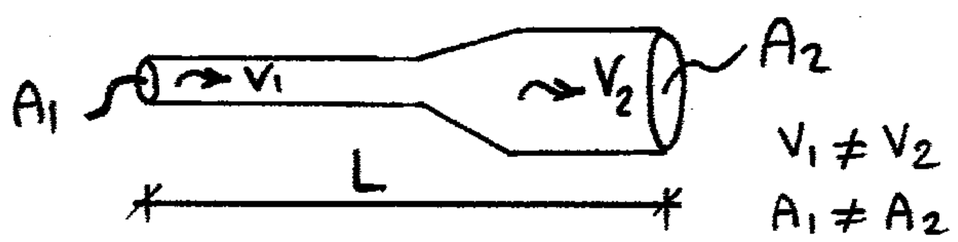
$$\frac{\partial V}{\partial L} = 0 \quad , \quad \frac{\partial A}{\partial L} = 0$$



b- Non-uniform flow

It occurs when velocity or cross-section changes over a given length

$$\frac{dV}{dL} \neq 0 \quad , \quad \frac{dA}{dL} \neq 0$$

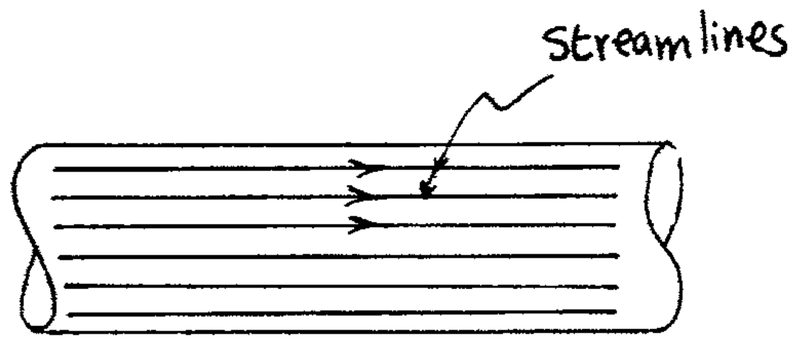


3- Laminar and turbulent flow

a- Laminar flow

It occurs when fluid particles in parallel paths and do not intersect

e.g. flow through capillary tubes, ground water, and blood in veins.

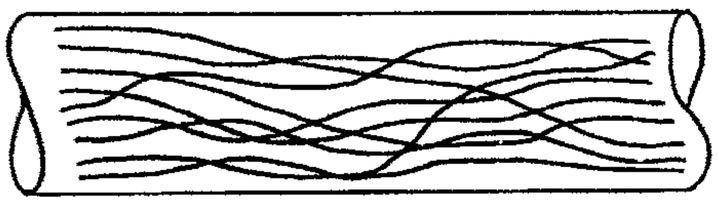


$R_n < 2000$

b- Turblent flow

It occurs when fluid particles move in random motion

e.g. Nearly in all flow in pipes

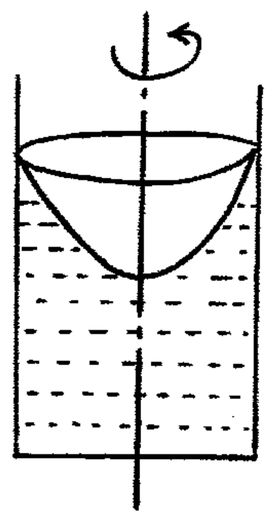


$R_n > 4000$

4- Rotational and Irrotational flow

a- Rotational flow

It occurs when fluid particles have a rotation about an axis



b- Irrotational flow

It occurs when fluid particles don't have a rotation about an axis

5- Compressible and incompressible flow

a- Compressible flow

It occurs when the density of the fluid changes from point to point

e.g. Flow of gases through orifices and nozzles

b- Incompressible flow

It occurs when the density is constant for fluid flow

e.g. Liquid are generally considered flowing incompressibly

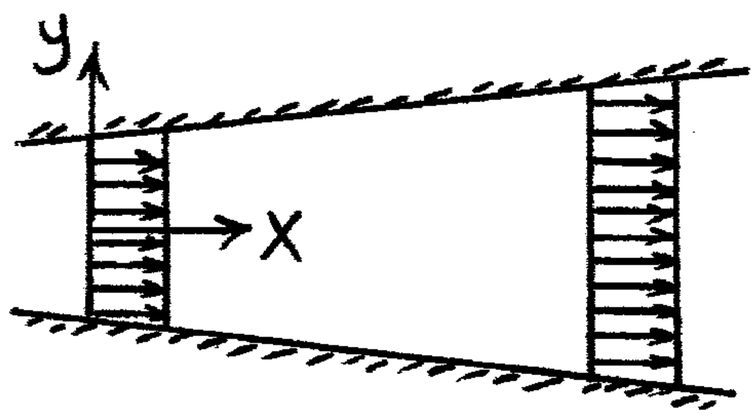
6- One, two three dimensional flow

a- One dimensional flow

It occurs when the velocity is a function of time and one co-ordinate.

$v = f(x, t)$

e.g. Flow through a straight uniform diameter pipe



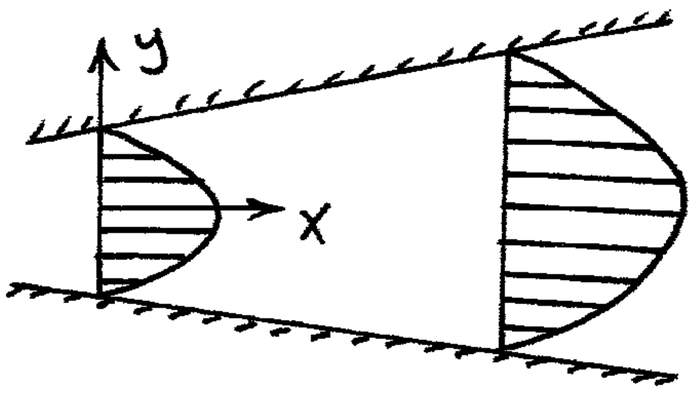
The flow is never truly 1 dimensional, because viscosity causes the fluid velocity to be zero at the boundaries.

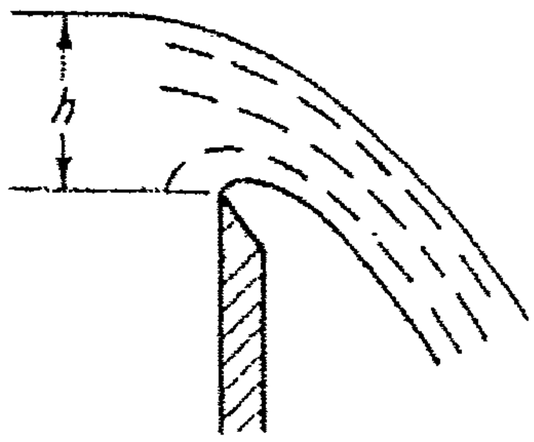
b- Two dimensional flow

It occurs when the velocity is a function of time and two co-ordinates

$v = f(x, y, t)$

e.g. Flow in the main stream of a wide river



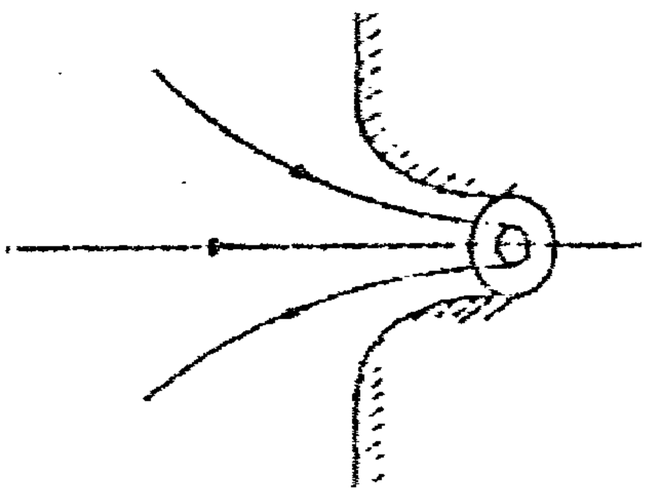


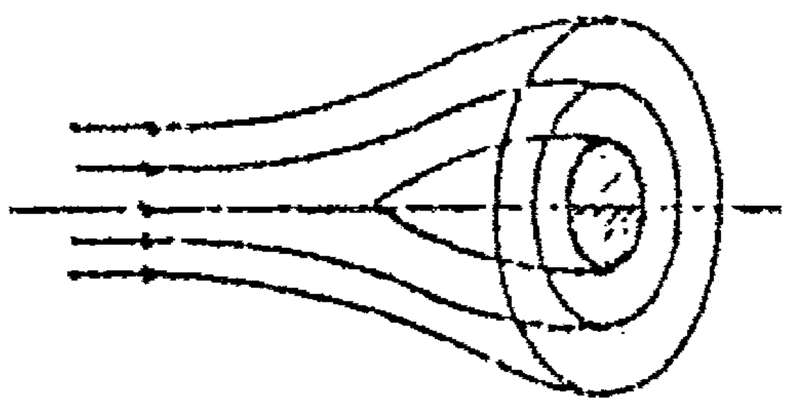
c- Three dimensional flow

It occurs when the velocity is a function of time and three co-ordinates

$v = f(x, y, z, t)$

e.g. Flow in a converging or diverging pipe

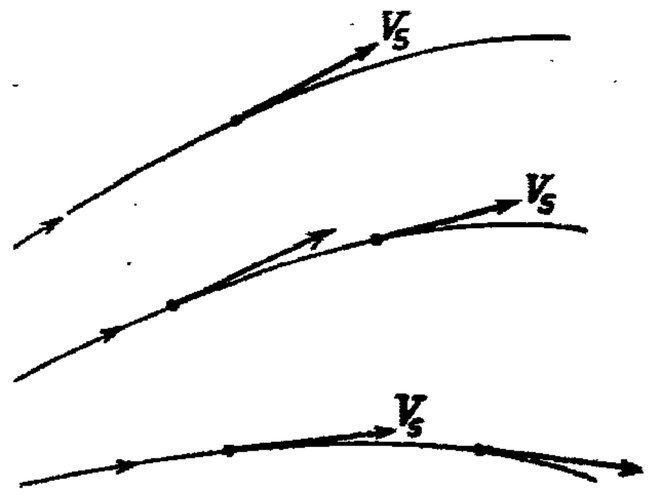




7- Stream lines and streamtubes

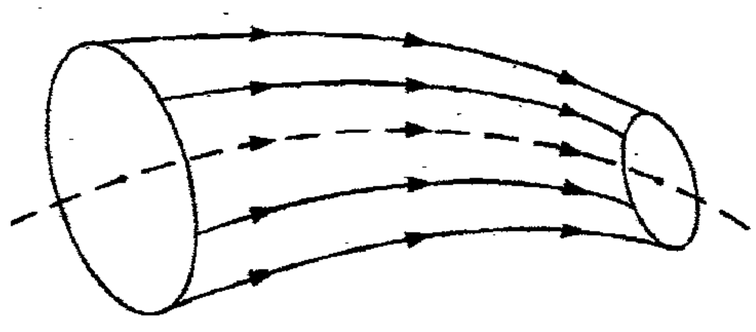
a- Streamlines

- Streamlines are imaginary curves drawn to show the direction of fluid flow
- The tangent at any point gives the velocity direction



b- Streamtubes

- A stream tube is a fluid mass bounded by a group of streamlines



8- Ideal and Real Fluids

a- Ideal Fluids

- It is a fluid that has no viscosity, and incompressible
- Shear resistance is considered zero
- Ideal fluid does not exist in nature

e.g. Water and air are assumed ideal

b- Real Fluids

- It is a fluid that has viscosity, and compressible
- It offers resistance to its flow

e.g. All fluids in nature

9- Viscous and inviscid flow

a- Viscous flow

- It occurs for fluids that have viscosity which offers shear resistance to the flow
- A part of the total energy is lost in flow

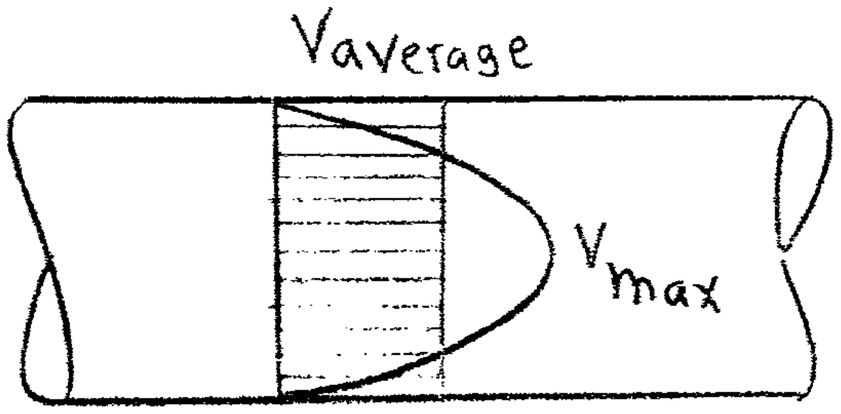
b- Inviscid flow

- It occurs for fluids that have no viscosity
- No shear resistance to the flow
- The total energy remains constant.

10- Mean velocity and Discharge

a- Mean velocity

It is the average velocity passing a given section



$$V_{mean} = \frac{Q}{A}$$

b- Discharge

It is the rate of Volume of liquid passing a given cross-section

$$Q = \frac{\forall}{t} = A.V$$