DAVANGERE UNIVERSITY GRADUATE PROGRAMME

Bachelor of Science (B.Sc.) Semester Scheme Syllabus (From 2016-17)(CBCS)

Subject: PHYSICS :SEMESTER – I :

Paper 1: Mechanics and Properties of Matter :Total-52 hours Module-3 : 13 Hours

Session-10: Viscosity

Viscosity

In a fluid motion, if the velocity at a point remains same, then fluid motion is called streamline flow.

Example: slowly and quickly river, wind blowing smoothly across a surface, slowly flowing water in a pipe.

Streamline:

The path along which a particle moves in a streamline flow is called a streamline. The tangent to a streamline at a point gives the direction of motion of all particles passing that point.

Tube of flow:

A bundle of streamlines is called a tube of flow.

Turbulent flow:

When the velocity of flow of a liquid is greater than a certain value, the flow becomes turbulent.

In a fluid motion, if the velocity at a point does not remain same, then fluid motion is called turbulent flow.

Example: The motion of water in a high water fall, hurricane, a fast moving river.

Difference between Streamline and Turbulent flow:

Streamline flow	**Turbulent flow**
Velocity at a point is constant	Velocity at a point changes
Liquid particles follow regular paths	Liquid particles follow irregular paths
Liquid flows in layers in ordered manner	Disordered flow (Eddies and vortices are observed)
Velocity of flow is less than a critical value	Velocity of flow is greater than a critical value

Viscosity

In streamlines (slow and steady) motion, the motion of liquid can be treated as flow of layers of liquid. The bottom layer of the liquid which is in contact with the surface remains at rest. As we move upward, speed of the layers increases. The top most layer moves with highest speed. Thus different layers move one above the other or there is a relative motion between different layers (such a flow of the liquid is called laminar flow). The layer above (faster layer) tends to accelerate the layer below (slower layer) and the layer below tends to retard the layer above. Thus, there are internal frictional forces between adjacent layers, which destroy the relative motion between layers. To maintain the motion, an external force is needed.

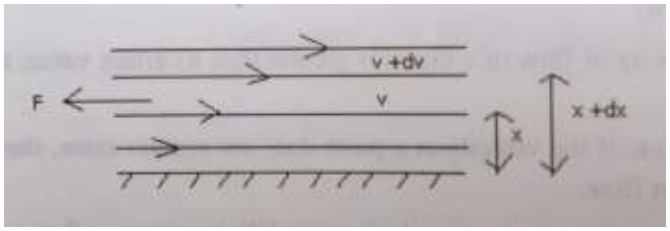
The retarding forces between the layers of the moving liquid are called viscous forces. The property of a liquid due to which liquid opposes relative motion between its different layers is called viscosity.

The viscous forces (backward dragging forces) are similar to friction between two solid surfaces in relative motion and viscosity is sometimes called internal friction.

Example: When water in a container is stirred, it is brought to rest after some time due to the internal friction between the layers of the water. Oil offers more resistance to relative motion and is said to be more viscous.

Velocity gradient

In the case of streamline motion of a liquid on a horizontal surface, the velocity of different layers increases with the distance from the fixed surface.



The rate of change of velocity with distance, measured (from the fixed surface) normal to the direction of flow is called velocity gradient.

Consider two adjacent layers A and B of a liquid in streamline motion on a horizontal surface.

Let x and x+ dx are the perpendicular distances of the layers from the fixed surface, and v and v+ dv, are their velocities respectively.

Then dv is the change in velocity for a small distance dx normal to flow.

The ratio dv/dx represents, rate of change of velocity with distance and is called velocity gradient.

Coefficient of viscosity (η)

According to Newton, the viscous force F between any two adjacent layers is directly proportional to,

1. The area A of the layer, and
2. The velocity gradient dv/dx

That is, $F \alpha A\, dv/dx$

$$F = -\eta A\frac{d_v}{d_x}$$

Where η is called coefficient of viscosity

The negative sign shows that the viscous force acts in a direction opposite to the flow of liquid.

If A = 1 and dv/dx = 1, then F = η

Coefficient of viscosity is defined as the tangential force per unit area required to maintain unit velocity gradient.

SI unit of viscosity is, Ns/m^2 and is called decapoise. $[\eta] = [M^1L^{-1}T^{-1}]$

- Two mark questions:
  1. What is Viscisity? Explain.
  2. Difference between Streamline and Turbulent flow. (2 mark)
  3. Define Coefficient of Viscosity.
  4. Define terminal Velocity, and Velocity Gradient

Reference Books:

- 1. Elements of Properties of Matter – By D.S.Mathur
- 2. Physics for Degree Students - B.Sc First Year - By C.L.Arora , P.S. Hemne
- 3. College Physics-Vol-1 By N .Sundar Rajan and others