

Case Study - 5

Most of the fluids are not ideal ones and offer some resistance to motion. This resistance to fluid motion is like an internal friction analogous to friction when a solid moves on a surface. It is called viscosity. This force exists when there is relative motion between layers of the liquid.

The coefficient of viscosity (pronounced 'eta') for a fluid is defined as the ratio of shearing stress to the strain rate.

$$\eta = \frac{F/A}{v/l} = \frac{Fl}{vA}$$

The SI unit of viscosity is poiseuille (Poise). Its other units are N-s- m⁻² or Pa s. The dimensions of viscosity are [ML⁻¹ T⁻¹]. Generally, thin liquids, like water, alcohol, etc., are less viscous than thick liquids, like coal tar, blood, glycerine, etc. The viscosity of liquids decreases with temperature, while it increases in the case of gases.

Stokes law:

When a body falls through a fluid it drags the layer of the fluid in contact with it. A relative motion between the different layers of the fluid is set and, as a result, the body experiences a retarding force. Falling of a raindrop and swinging of a pendulum bob are some common examples of such motion. It is seen that the viscous force is proportional to the velocity of the object and is opposite to the direction of motion. The other quantities on which the force F depends are viscosity η of the fluid and radius a of the sphere. Sir George G. Stokes (1819–1903), an English scientist enunciated clearly the viscous drag force F as

$$F = 6\pi\eta av$$

This is known as Stokes' law. We shall not derive Stokes' law. This law is an interesting example of retarding force, which is proportional to velocity. Answer the following.

1. Unit if viscosity is
 - a. Poise
 - b. N-s- m⁻²
 - c. Pa s
 - d. All of these\

2. Dimensions of Viscosity are
 - a. $[ML^{-2} T^{-2}]$.
 - b. $[ML^{-1} T^{-1}]$.
 - c. $[ML^1 T]$.
 - d. None of these
3. Define viscosity.
4. State stokes law
5. Give numerical formula of coefficient of viscosity with SI unit and Dimensions.

Answer key - 5

1. D
2. B
3. It is the resistance to fluid motion likes friction when a solid moves on a surface. It is called viscosity.
4. When a body falls through a fluid it drags the layer of the fluid in contact with it. A relative motion between the different layers of the fluid generates viscous force which is proportional to the velocity of the object and is opposite to the direction of motion. The other quantities on which the force F depends are viscosity η of the fluid and radius a of the sphere. The viscous drag force F as $F = 6\pi\eta av$. This is known as Stokes' law.
5. The coefficient of viscosity for a fluid is defined as the ratio of shearing stress to the strain rate.

$$\eta = \frac{F/A}{v/l} = \frac{Fl}{vA}$$

The SI unit of viscosity is poiseuille (Poise). Its other units are N-s- m^{-2} or Pa s.
The dimensions of viscosity are $[ML^{-1} T^{-1}]$.