Lab-…The fall of a body through a viscous medium

Viscosity is measure of a fluid's resistance to flow **or** is a measure of the resistance of a fluid to deformation under shear stress.

Viscosity describes the internal friction of a moving fluid. A fluid with large viscosity resists motion because its molecular makeup gives it a lot of internal friction. A fluid with low viscosity flows easily because its molecular makeup results in very little friction when it is in motion.

Defined informally: -

The quantity that describes a fluid's resistance to flow.

Defined mathematically: -

The ratio of the shearing stress (***F/A***) to the velocity gradient in a fluid.

Units

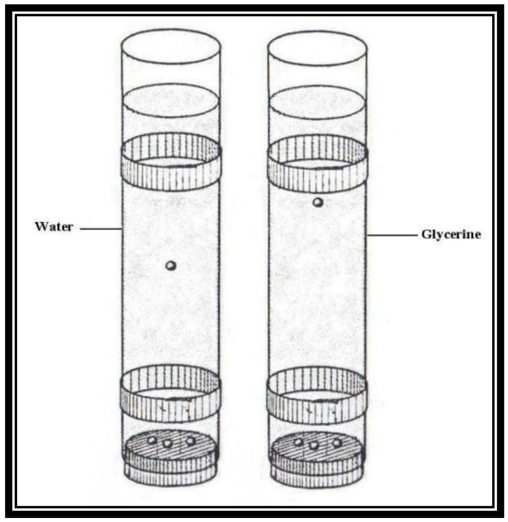
The **SI physical unit** of dynamic viscosity (**Greek symbol: η ((eta))**) is the **pascal.second** (**Pas.s**).

The **cgs physical unit** for dynamic viscosity is the **poise** (**P**) named after **Jean Louis Marie Poiseuille**.

1 pascal.second = 10 poise.

Stokes' Law

Let us consider first sedimentation of small spherical objects of density ρ in a solution of density σ in a gravitational field g. We know that falling objects reach a maximum (**terminal**) velocity due to viscosity effects.



We treated the entire situation as a race. Once the race was over we asked why the marble dropped fastest in the water and slowest in the glycerol. We explained that it was due to the different viscosities of the fluid.

Stokes has shown that for a spherical object of radius r, the retarding force F and the terminal velocity v are related by: -

$$F = 6 \pi \eta r v$$

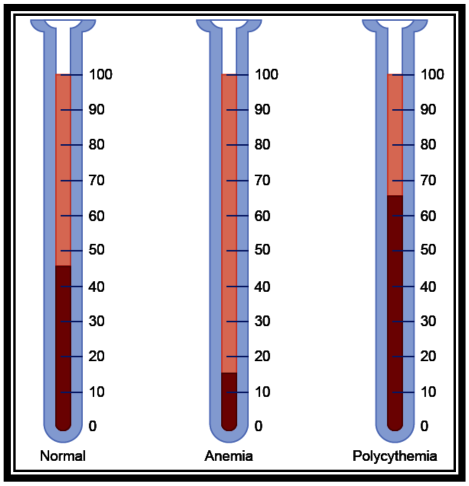
When the particle is moving at a constant speed, the retarding force F_d is in equilibrium with the difference between the downward gravitational force F_g and the upward buoyant force F_b (**the weight of the liquid the particle displaces**).

If we consider F_g acts downward and F_b acts upward, and the difference is equal to F_d from (F_g-F_b=F_d) we obtain the expression for the terminal velocity (**sedimentation velocity**).

$$\upsilon = \frac{2 r^2 g (\rho - \sigma)}{9 \eta}$$

Hematocrit

The percentage of the blood that is cells is called the **hematocrit**. Thus, if a person has a **hematocrit** of 40, 40 percent of the blood volume is cells and the remainder is plasma. The **hematocrit** of men averages about **42**, whereas that of women averages about **38**.



Effect of Hematocrit on Blood Viscosity

The greater the percentage of cells in the blood-that is, the greater the **hematocrit**-the more friction there is between successive layers of blood and this friction determines viscosity. Therefore, the viscosity of blood increases drastically as the **hematocrit** increases.

When the **hematocrit** rises to **60** or **70**, which it often does in **polycythemia**, the blood viscosity can become as great as **10** times that of water and its flow through blood vessels is greatly retarded.

What Makes the Blood so Viscous?

It is mainly the large numbers of suspended red cells in the blood, each of which exerts frictional drag against adjacent cells and against the wall of the blood vessel.

The Medical Applications of Viscosity

1. By measuring the viscosity of blood we can state whether the calculated viscosity of blood is normal or not (**anaemia** or **polycythemia**).
2. To compare between the viscosity of two different fluids.
3. To measure the density of any liquid materials.
4. By knowing the blood viscosity we can know the velocity of blood in the blood vessels which is indirectly proportional to the blood viscosity.
5. By knowing the blood viscosity we can know the temperature of blood in the blood vessels which is indirectly proportional to the blood viscosity.

Exp-

The Name: - The fall of a body through a viscous medium

The Aim: -

1. To show that a small sphere falls with a constant terminal velocity.
2. To find viscosity of the medium.

The Apparatus: -

1-A Long Glass Tube or Jar closed at one end.

2-Glycerine.

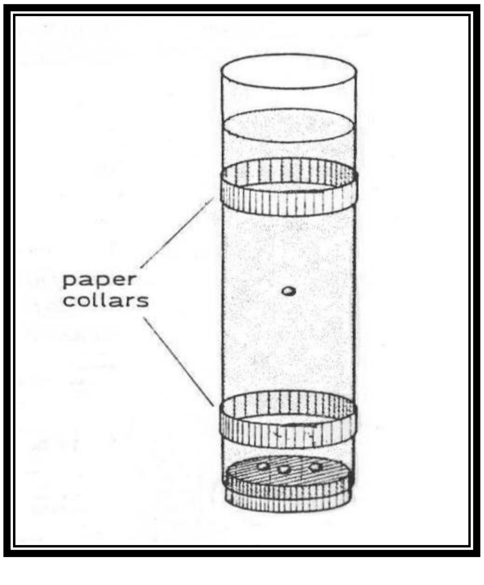
3- Metre Scale or Ruler.

4-Steel Balls.

5- Two Paper Collars or Rubber Bands.

6-Magnet.

7- Stop-Watch.



Put the jar or tube vertically and fill it with glycerine.

To show that a small sphere falls with a constant terminal velocity.

-Select ten balls of the same diameter.

-Adjust the distance between the rubber bands *h* and record this distance.

-Now drop a ball centrally down the jar and with the stop-watch find the time it takes to transverse the distance between the edges of the rubber bands.

- Obtain a confirmatory reading with a second ball.

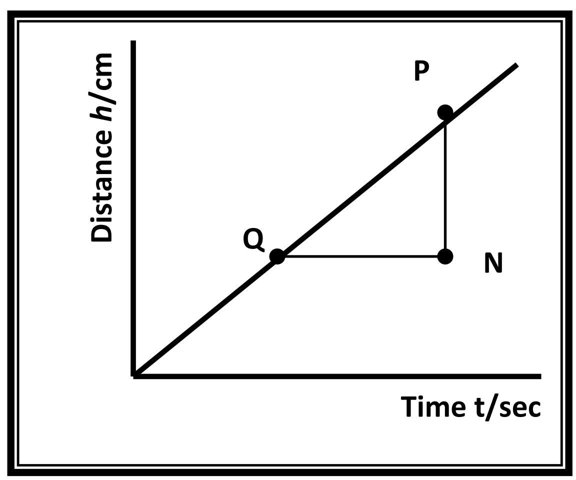
-Repeat the process with other ball and increase the distance between the rubber bands.

Tabulate the readings: -

Distance between rubber bands *h*/cm	Time of fall		
	t_1/sec	t_2/sec	Mean t/sec

To show that the balls fall with constant terminal velocity through the glycerine, plot a graph with values of distance *h*/cm as ordinates against the corresponding values of time t/sec as abscissae, and from the graph calculate the terminal velocity.

$$\textit{Terminal velocity} = \textit{slope} = \frac{\Delta h(cm)}{\Delta t(sec)}$$



To Find viscosity η of glycerin.

By Stokes' law, the viscous force F acting on a sphere(ball) of radius r falling with constant terminal velocity *v* through a medium of viscosity η is given by: -

$$F = 6 \pi \eta r v$$

Since the ball is falling steadily this viscous force is exactly balanced by the net downward force on the sphere due to its weight, allowance being made for the up Thrust due to displacement.

Hence: -

$$F = 6 \pi \eta r v = 4/3 \pi r^3 g (\rho - \sigma)$$

From which: -

$$\eta = \frac{2r^2 g(\rho - \sigma)}{9\upsilon}$$

Putting: -

r = d/2 and rearranging

$$\eta = \frac{g(\rho - \sigma)}{18} . \frac{d^2}{\upsilon}$$

η = is the viscosity of glycerine.

g = is the gravity (980 cm/sec^2).

ρ = is the density of sphere (7.8 gm/cm^3).

σ = is the density of glycerine (1.2 gm/cm^3).

d = is the diameter of sphere. v = is the velocity (slope).