Experimental No. (10)
THE VISCOSITY

Objective:

- **To show that a small sphere falls with constant terminal velocity (v).**
- **To determine the viscosity coefficient η of glycerin.**

Apparatus: Viscosity is determined using the falling sphere viscometer which is composed of:

- **Glass cylinder : one meter Length, 0.1m inner diameter,**
- **Glycerin, shamboo and honey.**
- **Ball bearings of 3-8 mm diameter (density 7.8 gm/cm^3)**
- **Small magnet; Acetone ; Two rubber bands;**
- **Meter stick; Micrometer; Caliper; Stop watch.**

INTRODUCTION:

The resistance to the fluid flow due to the internal friction between adjacent fluid layers is called viscosity. If a sphere of diameter d and density ρ is allowed to fall from rest (Fig.20) through a liquid of density ρ_o , it will accelerate by the gravitational force F_G opposed by viscous force F_D, and the buoyant force of the fluid, F_B, until it reaches a constant terminal velocity, v_t. At this point, F_G is balanced by the F_D and F_B :

$$F_D + F_B = F_G \tag{52}$$

$$Gravitational force \qquad F_G = mg \tag{53}$$

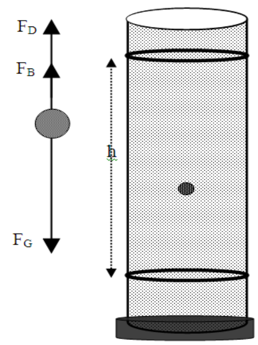

Figure 20:

$$\mathit{Buoyant force} \qquad F_B = \frac{1}{6}\pi d^3 \rho_o g \tag{54}$$

$$\mathit{The}\ \textbf{viscous force} \qquad \mathbf{F_D = 3\pi\eta d\nu} \tag{55}$$

Where: η is the coefficient of viscosity of the fluid. Using this balance, the student can show that the coefficient of viscosity η is given by:

$$\eta = \frac{1}{18}(\rho - \rho_o)g\frac{d^2}{v} \tag{56}$$

Experimental Procedure:

Measure the liquid temperature

- **To show that a small sphere falls with constant terminal velocity (v).**

  1. **Select a number of ball bearings of the same diameter. Adjust the distance between the two rubber bands, so that they are separated by a distance, h, of about 80 cm and record this distance. Start with the upper rubber band at about 10 cm below the surface of the fluid in the cylinder.**
  2. **Drop one ball bearing sphere down the central part of the cylinder. Use the stop watch to find the time, t, it takes**

the sphere to traverse the distance between the two rubber bands.

3. Keeping the lower band fixed, lower the upper rubber band by 10 cm at a time. For each new distance, obtain the value for the time it takes the sphere to transverse the distance h. Tabulate your data in a table similar to Table-1

- Determination of the viscosity coefficient η of liquid.

  1. Place the two rubber bands on the oil filled cylinder so that one is located 10 cm below the oil surface and the other is at 15 cm above the bottom of the cylinder.
  2. Select five spheres of different diameters, and measure their diameter using a micrometer. Clean the spheres with acetone and dry them. Hold each sphere carefully with a tweezers and drop it in the oil. Measure the time of fall between the two rubber bands t. Tabulate your data in Table-2

Name: **Grade:**

Students No.: **Date:**

Data and Data Analysis

- **To show that a small sphere falls with a constant terminal velocity**

Distance h(cm)	Time of Fall t(s)	Terminal Velocity $v = \frac{h}{t}$

Plot a graph between the distance h (cm) and the time t (s). Discuss your results and observations.

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- **Determination of the coefficient of viscosity.**

Sphere density (steel) $\rho =$ **7.85** gm/cm^3**; Liquid of density** $\rho_o =$ $...gm/cm^3$**;**

h= cm.

Diameter d(cm)	d^2	t	v	η

The average value of $\eta =$ **...........poise**

Plot a graph between the values of d^2 **against, v. Determine the slope of the graph.; Slope= ....** η**=............**