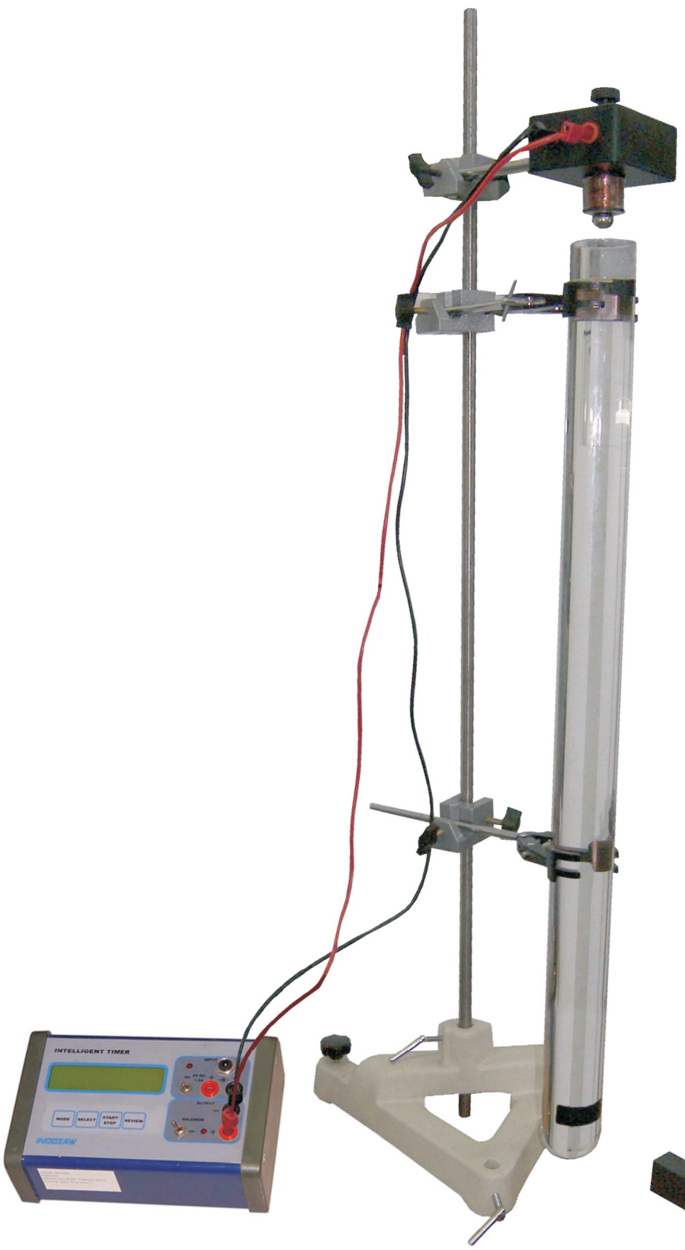
INSTRUCTION MANUAL FOR

VISCOSITY OF GLYCERINE (SK049)



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Experiment: To determine the viscosity of glycerine.

Introduction: This laboratory investigation involves determining the viscosity of glycerine using Stokes' Law. Viscosity is a fluid property that provides an indication of the resistance to shear within a fluid. Specifically, a fluid column will be used as a viscometer. Time taken by the steel ball to travel a distance in the fluid will be measured using the Intelligent Timer.

Theory:

George Gabriel Stokes, an Irish-born mathematician, worked most of his professional life describing fluid properties. Perhaps his most significant accomplishment was the work describing the motion of a sphere in a viscous fluid. This work lead to the development of Stokes' Law, a mathematical description of the force required to move a sphere through a quiescent, viscous fluid at specific velocity.

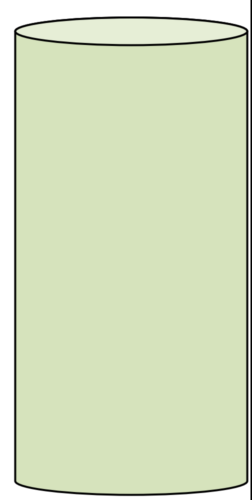
A body moving in a fluid is acted upon by a frictional force in the opposite direction to its direction of travel. The magnitude of this force depends on the geometry of the body, velocity of the body, and the internal friction of the fluid. A measure for the internal friction is given by the dynamic viscosity η. For a sphere of radius *r* moving at velocity *v* in an infinitely extended fluid of dynamic viscosity η, the frictional force according to Stokes' law is given as:

$$F_1 = 6.\pi.\eta.r.v \qquad (1)$$

If the sphere is allowed to fall vertically in the fluid, after a time, it will move at a constant velocity *v*, and all the forces which are acting on the sphere will be in equilibrium: the frictional force F_1 which acts upwards, the buoyancy force F_2 which also acts upwards and the downward acting gravitational force F_3, shown in free body diagram. The latter two forces are given by:

$$F_2 = \frac{4\pi r^3 \rho_1 g}{3} \qquad (2)$$

$$F_3 = \frac{4\pi r^3 \rho_2 g}{3} \qquad (3)$$



Where, ρ_1 is the density of the fluid

ρ_2 is the density of the sphere

g is the acceleration due to gravity

And the equilibrium between these three forces can be described by:

$$F_1 + F_2 = F_3 \qquad (4)$$

The viscosity can, therefore, be determined by measuring the rate of fall v:

$$\eta = \frac{2}{9} \cdot r^2 \cdot \frac{(\rho_2 - \rho_1) \cdot g}{v} \qquad (5)$$

Where, v can be determined by measuring the fall time t over a given distance s. The equation 5 can be written as

$$\eta = \frac{2}{9} \cdot r^2 \cdot \frac{(\rho_2 - \rho_1) \cdot g \cdot t}{s} \qquad (6)$$

In practice, equation 1 has to be corrected since the assumption that the fluid extends infinitely in all directions is unrealistic and the velocity distribution of the fluid particles relative to the surface of the sphere is affected by the finite dimensions of the fluid. For a sphere moving along the axis of a cylinder of fluid of radius R, the frictional force is:

$$F_1 = 6\pi\eta v r \left(1 + 2.4.\frac{r}{R}\right) \qquad (7)$$

$$\eta = \frac{2}{9} \cdot r^2 \cdot \frac{(\rho_2 - \rho_1) \cdot g \cdot t}{s} \cdot \frac{1}{\left(1 + 2.4.\frac{r}{R}\right)} \qquad (8)$$

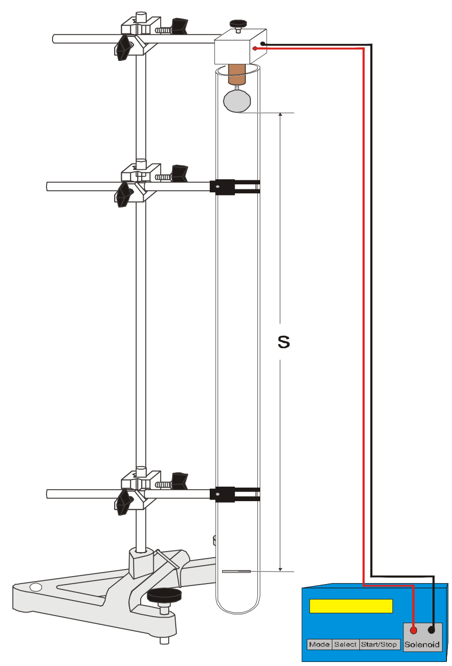
If the finite length L of the fluid cylinder is taken into account, a further correction of the order r/L is necessary.

$$\eta = \frac{2}{9} \cdot r^2 \cdot \frac{(\rho_2 - \rho_1) \cdot g \cdot t}{s} \cdot \frac{1}{\left(1 + 2.4.\frac{r}{R}\right)\left(1+3.3\,\frac{r}{L}\right)} \qquad (9)$$

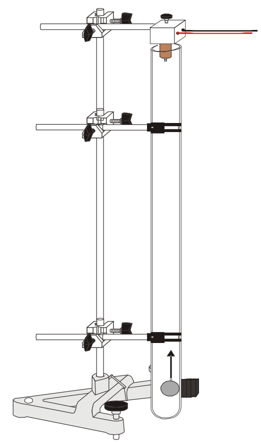
Procedure

Set up

1. Clamp the stand rod on the 'A' shaped Base and then clamp the Glass tube using Bosshead and Universal finger clamp such that the tube is held vertical. Level the apparatus with the help of leveling screws of the 'A' shaped Base.
2. Clamp the Electromagnet assembly on the stand rod using Bosshead such that the core of the electromagnet lies along the axis of the tube.



3. Fill the glass tube with glycerine such that about 2cm of the tube is empty.
4. Connect the electromagnet to the 4mm sockets provided on the Intelligent Timer *(Marked as solenoid)* using flexible plug leads and switch on the electromagnet.
5. Hold the steel ball with the electromagnet and make a trial to ensure that when the Start Switch is pressed the electromagnet release the ball immediately, if it doesn't then turn the iron core a bit upward.
6. Position the holding magnet with the steel ball above the fluid column in a way that the steel ball is on concenters with the cylinder axis and completely dipped in.
7. Mark the position of the steel ball on the tube itself and from that position, mark another position at 80 cm (say).
8. Press the Start/Stop switch to release the ball and again press the Start/Stop switch when the ball reaches the marked position.
9. Note down the time.
10. Using three ferrite magnet combination return the steel ball to the electromagnet as shown in the adjacent figure.
11. Repeat the experiment several times and take out the mean value to find out the speed and hence, the coefficient of viscosity for glycerine at that temperature.



Observations:

$\rho_1 = 1260$ kgm^{-3} Density of Glycerine

$\rho_2 = 7790$ kgm^{-3} Density of Iron Bal

R=0.023 m r=0.0095m

S.No	Time(s)
1	2.0184
2	2.1507
3	2.0515
4	2.0515

Mean t=2.0680 s

Using equation 9, the coefficient of viscosity η=1.55 kg m^{-1} s^{-1}

The value quoted in the literature is (θ = 20 ºC): η = 1.480 kg m^{-1} s^{-1}