SUBJECT – APPLIED PHYSICS (LAB)

EXPERIMENT No.– ------

AIM –To determine the surface tension of water by capillary rise method.

Materials required:-

- A clean and dry capillary tube
- A tipped pointer
- A beaker containing water
- A travelling microscope
- Adjustable wooden stand
- Clamps and stand

Theory:-

Surface tension has been well- explained by the molecular theory of matter. According to this theory, cohesive forces among liquid molecules are responsible for the phenomenon of surface tension. The molecules well inside the liquid are attracted equally in all directions by other molecules. The molecules on the surface experience an inward pull. So, a network is formed against the inward pull, in order to move a molecule to the liquid surface. It results in a greater potential energy on surface molecules. In order to attain minimum potential energy and hence stable equilibrium, the free surface of the liquid tends to have the minimum surface area and thereby it behaves like a stretched membrane. Surface tension is measured as the force acting normally per unit length on an imaginary line drawn on the free liquid surface at rest. It is represented by the symbol T (or S). It's S.I. The unit is Nm^{-1} and dimensional formula is $M^1L^0T^{-2}$.

When a capillary tube is dipped in a liquid, the liquid level either rises or falls in the capillary tube. The phenomena of rise or fall of a liquid level in a capillary tube is called capillarity or capillary action.

When a liquid rises in a capillary tube, the weight of the column of the liquid of density ρ inside the tube is supported by the upward force of surface tension acting around the circumference of the points of contact. Thus, surface tension; $T = \frac{r(h + \frac{r}{3})\rho g}{2cos\theta}$ Where, h - height of the liquid column above the liquid meniscus ρ - Density of the liquid r - Inner radius of the capillary tube θ - Angle of contact

Diagram:-

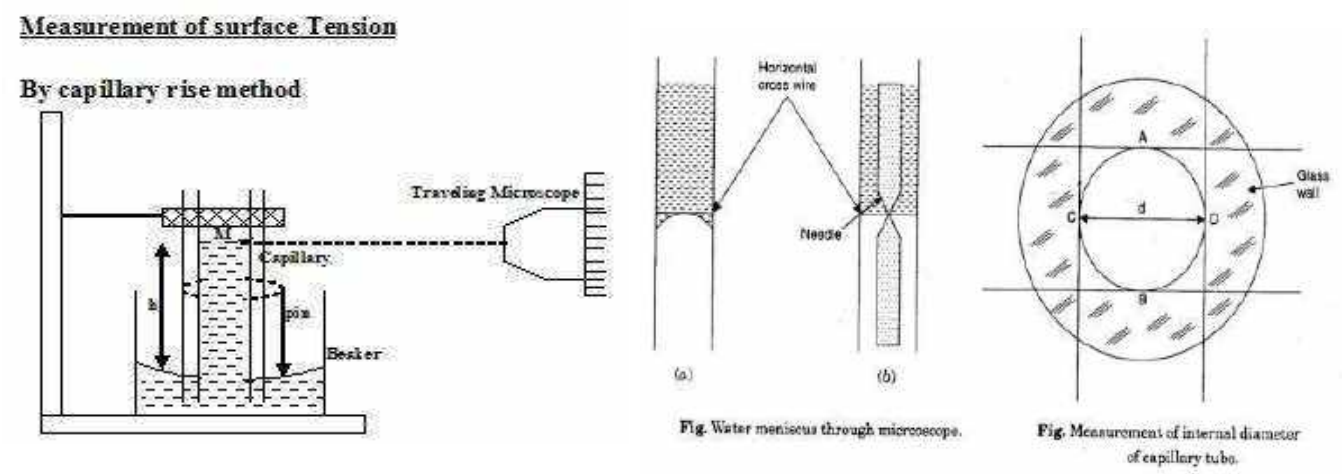

Fig - Rise of water in capillary tube is observed under microscope

Procedure

To set up the apparatus:

- Place the adjustable height stand on the table and make its base horizontal by leveling the screws.
- Fix the capillary tube and the pointer in a cork, and clamp it in a rigid stand so that the capillary tubes and the pointer become vertical.
- Adjust the height of the vertical stand, so that the capillary tubes dip in the water in an open beaker.
- Adjust the position of the pointer, such that its tip just touches the water surface.

To find the capillary rise:

- Find the least count of the travelling microscope for the horizontal and the vertical scale.
- Make the axis of the microscope horizontal.
- Adjust the height of the microscope using the height adjusting screw.
- Bring the microscope in front of the capillary tube and clamp it when the capillary rise becomes visible.

- Make the horizontal cross wire just touch the central part of the concave meniscus.
- Note the reading of the position of the microscope on the vertical scale.

- Now, carefully remove the beaker containing water
- Move the microscope horizontally and bring it in front of the pointer.
- Lower the microscope and make the horizontal cross wire touch the tip of the pointer.
- Corresponding vertical scale readings are noted.
- The difference in the two readings (i.e., height of water meniscus and height of the tip of pointer) will give the capillary rise of the given liquid.
- We can repeat the experiment by changing the height of the wooden stand.

To find the internal diameter of the capillary tube:

- Place the capillary tube horizontally on the adjustable stand.
- Focus the microscope on the end dipped in water.
- Make the horizontal cross- wire touch the inner circle at A (fig i). Note microscope reading on the vertical scale.
- Raise the microscope to make the horizontal cross wire touch the circle at B (fig ii). Note the vertical scale reading.
- The difference between the two readings will give the vertical internal diameter (AB) of the tube.
- Move the microscope on the horizontal scale and make the vertical cross wire touch the inner circle at C (fig iii). Note microscope reading on the horizontal scale.
- Move the microscope to the right to make the vertical cross wire touch the circle at D (fig iv). Note the horizontal scale reading.
- The difference between the two readings will give the horizontal internal diameter (CD) of the tube.
- We can calculate the diameter of the tube by calculating the mean of the vertical and horizontal internal diameters. Half of the diameter will give the radius of the capillary tube.

<u>OBSERVATIONS</u> –

Room temperature =_____®C

Value of one main scale division of travelling microscope, x =_____cm

Total number of division of Vernier scale, n = _____cm

Least count = x/n = _____ cm

(A) For the height of water column "h" in capillary tube.

S.NO.	Reading for the upper surface Of water in the beaker			Reading for the meniscus of Water in capillary			Height of Water Meniscus In capillary h=(b-a) cm
	M.S. Reading (in cm)	V.S. Reading (in cm)	Total Reading (a) cm	M.S. Reading (in cm)	V.S. Reading (in cm)	Total Readings (b) cm	
1.							
2.							
3.							

Mean value of "h" = _____ cm

(B) For the radius "r" of capillary tube.

S.NO.	Left edge of Capillary tube			Right edge of Capillary tube			diameter d=(b-a) cm	Radius r=d/2 cm	Mean r cm
	M.S. cm	V.S. cm	Total(a)	M.S. cm	V.S. cm	Total(b)			
1.									
2.									

CALCULATION:

In the relation T = $\frac{r\left(h+\frac{r}{3}\right)\rho.g}{2}$

r= _____cm, g= _____cm/sec ², h= _____cm

RESULT: Surface tension of water at _____®C = _____ dynes/ cm

PRECAUTIONS:

1. The surface of water in the beaker should be free from dirt and grease. To ensure this, beaker should be carefully washed.
2. The capillary should be set vertically.
3. The radius of the capillary tubes should be measured by breaking it at the point up to which water rises.
4. Diameter should be measured in two perpendicular directions.
5. The microscope should be horizontal so as to ensure a perfect vertical movement of the tube.
6. The cross wire should be tangential to the lower meniscus.