Lecture-Two

Introduction and Fundamental Concepts

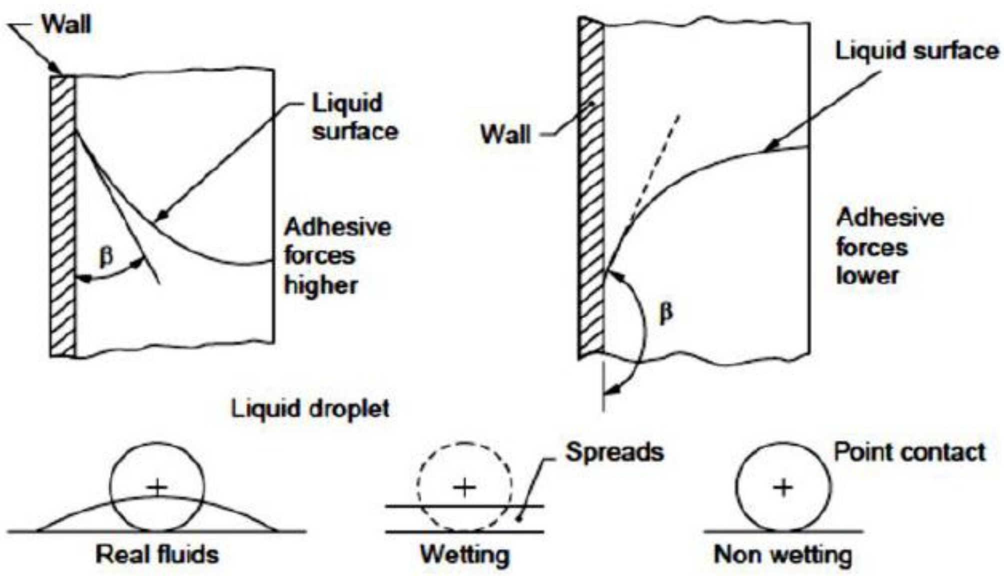
1- ***Surface Tension of Liquids.***

The phenomenon of surface tension arises due to the two kinds intermolecular forces.

I. *Cohesion Force*:- the force of attraction between the molecules of a liquid due to, they are bound to each other to remain as one assemblage of particles is known as the force of cohesion.

II. *Adhesion Force:*- The force of attraction between unlike molecules, i.e, between the molecules of different liquids or between the molecules of a liquid and those of solid body when they are in contact with each other.

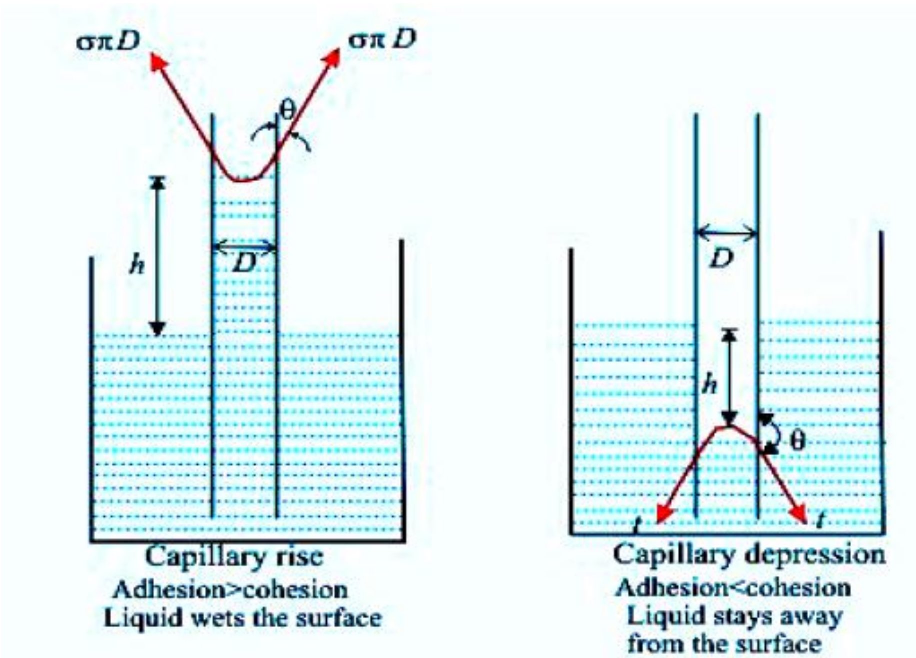
Surface tension may also be defined as the work per unit area (N.m / m^2) or (N/m) required creating unit surface of the liquid. The work is actually required for pulling up the molecules with lower energy from below, to form the surface. In liquids cohesion forces between molecules and the effect on solid-liquid interface are lead to surface tension.



Surface tension effect at solid-liquid interface

2- Capillarity.

When a liquid is in contact with a solid, if the forces of adhesion between the molecules of the liquid and the solid are greater than the forces of cohesion among the liquid molecules themselves, the liquid molecules crowd towards the solid surface. The area of contact between the liquid and solid increases and the liquid thus wets the solid surface



Phenomenon of Capillarity

3- Example

(a) Derive an expression for the change in high (h) in a circular tube of a liquid with surface tension *(σ)* and contact angle *(θ)*. As in below figure.

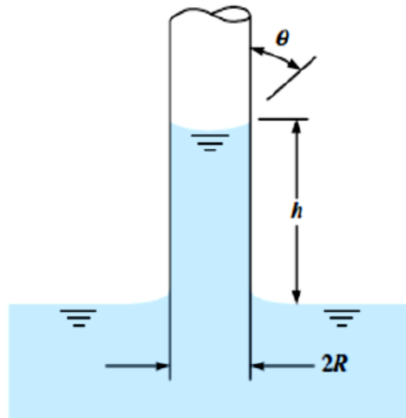
(b) Suppose that, the fluid is water having $\sigma = 0.073\ N/m$, $\theta = 0.0°$, ρ=1000 kg/m^3 and $R=1mm$, then find the capillary rise for the water-air-glass interface.

Sol. ***(a)*** The vertical component of the ring surface tension force at the interface in the tube must balance the weight of column of fluid of height *(h)*.

$$2\pi R\sigma\cos\theta = \rho g\pi R^2 h$$

Solving for *h*, we have the desired result

$$h = \frac{2\sigma\cos\theta}{\gamma R} = \frac{4\sigma\cos\theta}{\gamma d}.$$



(b)

$$h = \frac{2\sigma cos\theta}{\gamma R} = \frac{2(0.073)cos0}{1000 * 9.81 * 0.001} = 0.015\ m = 1.5\ cm$$

4- Dimensions and Units.

Dimensions:- is the measure by which a physical variable is expressed quantitatively.

Unit:- is a particular way of attaching a number to the quantitive dimension.

There are three widely used systems of units in the word. These are

I. British or English system (it's not in official use now in Briton)
II. Metric system.
III. SI system (System International of Unites or International System of Units).

Length: is a dimension →
- Distance
- Displacement
- Width
- Deflection

$$\left.\begin{array}{l}\text{Centimeter}\\ \text{Meter}\\ \text{Inch}\end{array}\right\}\ \text{Numerical values are the units}$$

In fluid mechanics there are only four primary dimensions from which all other dimensions can be derived: mass, length, time, temperature. These dimensions and their units in both systems are given in Table 1.1

Table 1.1: Primary dimensions in SI and BG system

Primary Dimension	SI Unit	BG Unit	Conversion Factor
Mass (M)	Kilogram(kg)	Slug	1 slug = 14.5939 kg
Length (L)	Meter (m)	Foot (ft)	1 ft = 0.3048 m
Time (T)	Second (s)	Second (s)	1 s = 1 s
Temperature (θ)	Kelvin (K)	Rankin (°R)	1K = 1.8 °R

The secondary dimensions, which is directly related to mass, length, time and temperature. As the force from Newton's second law

$F = m*a$

We define the Newton and pound is the dimension of force

1 Newton of force = 1N = 1 kg.m/s^2

1 pound of force = 1 lb_f = 1 slug. ft/s^2 = 4.4482 N