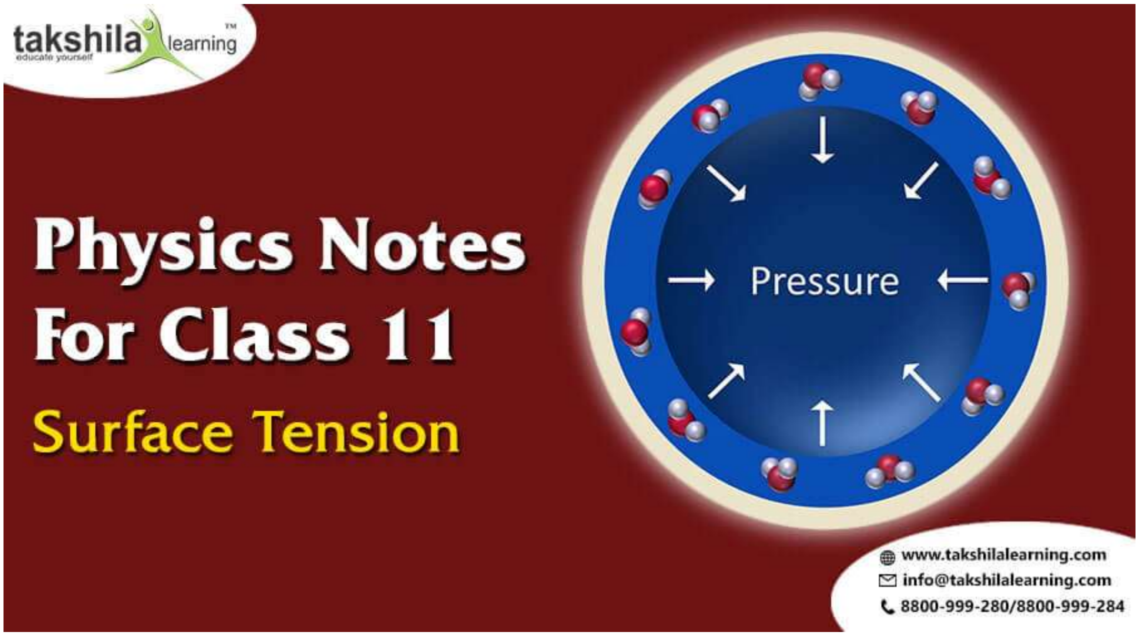

Physics Notes for Class 11 Surface Tension

Surface tension is the property of a liquid by virtue of which it tries to minimize its surface area.

Surface tension of the liquid is measured as the force acting per length on an imaginary line drawn tangentially on the free liquid surface the liquid.

Surface tension = force / length

= F/L

= work done / change in area

Its SI unit is Nm^{-1} or Jm^{-1} and its dimensional formula is $[MT^{-2}]$.

It is a scalar quantity. Surface tension is a molecular phenomenon which due to cohesive force and the root cause of the force is electrical in nature. Surface tension of the liquid depends upon the nature of the liquid and independent of the surface area of the film or length of the line. Small liquid drops are spherical due to the property of surface tension.

- What is the surface tension of a bubble?

The tendency to minimize that wall tension pulls the bubbles into spherical shapes. Even though the soap film has less surface tension than pure water, which would pull itself into tiny droplets, it is nevertheless strong to be able to maintain the bubble with such a small thickness.

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Mechanical concept of surface tension

Figure 4.3 shows an infinitesimal section of a surface so that the radii of curvature R1 and R2, which are perpendicular to each other are constant. Assuming that the pressure is varied from Δp 'in the z-direction and, consequently, the sectional area is increased from `dA`.

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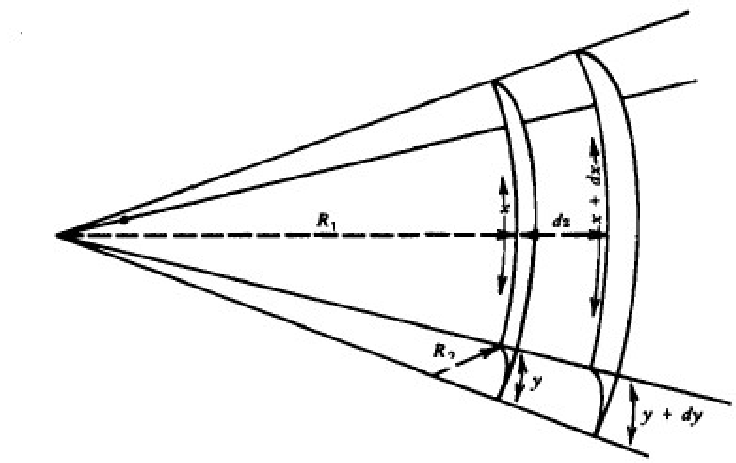
Figure 4.3 - Condition for mechanical equilibrium of a surface arbitrary curve



Mathematically, the infinitesimal increase in area is given by

dA= (x+dx). (y + dy) = x.dy + y.dx

The work performed to expand the surface (S) is given by:

W =γ.dA=γ.(x.dy+y.dx)

As the expansion was caused by an increase in pressure, the work surface is given by:

W =Δp.x.y.dz

In figure 4.3 for similarity of triangles we have:

axis x:

$$\frac{x+dx}{R1+dz} = \frac{x}{R1}$$

R1.x + R1.dx = R1.x + x.dz

dx= $\frac{x.dz}{R1}$

axis y:

$\frac{y+d}{R2+dz} = \frac{y}{R2}$

R2.y + R2.dy = R2.y + y.dz

dy= $\frac{y.dz}{R2}$

As the system is in mechanical equilibrium, the two expressions of the work can be matched:

Δp.x.y.dz =γ.(xdy+ydx)

Substituting expressions for `dx` and `dy` in the above equation we have:

Δp.x.y.dz= γ.(x$\frac{y.dz}{R2}$ + y$\frac{x.dz}{R1}$dx)

After simplifications, we obtain the Laplace equation:

Δp = γ.(1/R2 + 1/R1)

The mathematical expressions for radii of curvature are:

$\frac{1}{R1} = \frac{\frac{(d2y)}{dx2})}{\left(1+\left(\frac{dy}{dx}\right)2\right)3/2}$

Example 1:

Find the pressure inside a water droplet having diameter of 0.5 mm at 20 0 C if the outside pressure is 1.03N/cm 2and the surface tension of water at that temperature is 0.0736 N/m.

Solution :

Given Data: -

$$\sigma = 0.0736 N/m.$$

$$r = d/2 = 0.5/2 = 0.025mm.$$

Pressure inside the droplet $p = \frac{2\sigma}{r}.$

Answer:- $1.62\ \text{N/cm}^3.$

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