

Answer on Question#38713, Physics, Mechanics | Kinematics | Dynamics

Deduce an expression for height of a liquid in capillary tube. Also write practical applications of capillary action.

Answer

T is the surface tension acting along the tangent to the meniscus. The angle of contact α is the angle between this tangent and the solid surface namely the tube inside the liquid. So we can get α as the angle between T and the outer surface. Now resolving T as $T \sin \alpha$ perpendicular to the cylindrical surface and $T \cos \alpha$ along the surface upward. Now as T is defined as force per unit length, for the circumference $2\pi r$ we get $2\pi r T \cos \alpha$ as the force which is responsible to lift the liquid up as capillary rise. Now this force will get balanced by the weight of the rise itself. Let h be the height. Then volume is $\pi r^2 h$. So $\pi r^2 h \rho$ gives mass (ρ is density). And $\pi r^2 h \rho g$ will be the weight (g – acceleration of gravity). So we get

$$2\pi r T \cos \alpha = \pi r^2 h \rho g.$$

Simplifying we get

$$T = \frac{hr\rho g}{2 \cos \alpha}.$$

So

$$h = \frac{2T \cos \alpha}{r\rho g}.$$

Applications:

1. Paper towels absorb liquid through capillary action, allowing a fluid to be transferred from a surface to the towel.
2. A technique called thin layer chromatography uses capillary action in which a layer of liquid is used to separate mixtures from substances.
3. Capillary action helps us naturally by pumping out tear fluid in the eye. This process cleanses the eye and clears all of the dust and particles that are around the ducts of the eye.
4. Cotton dresses are preferred in summer because cotton dresses have fine pores which act as capillaries for sweat.
5. The supply of water to the leaves at the top of even a tall tree is through capillary rise.