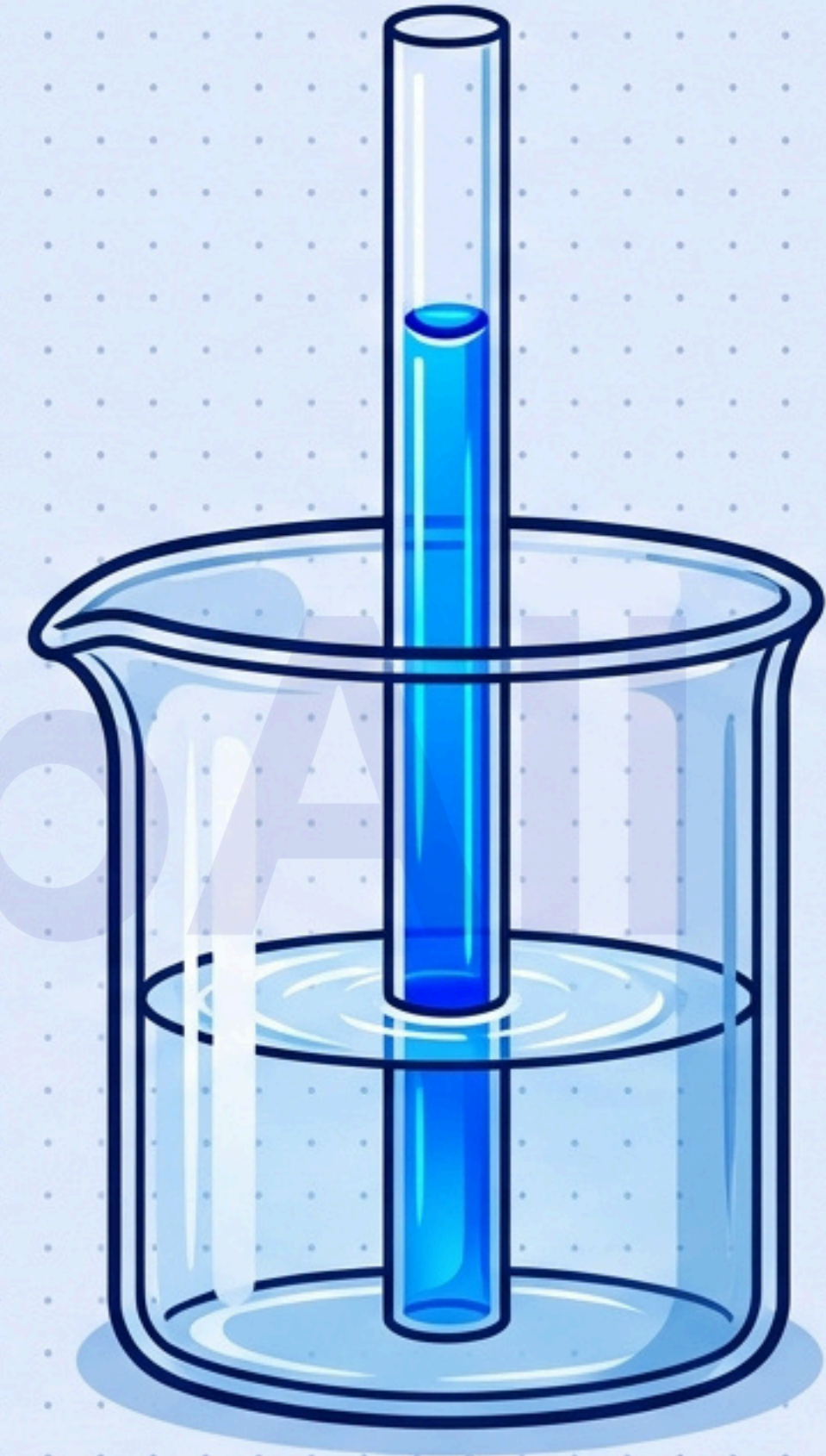


CLASS 11 PHYSICS • SECTION 9.6.5

Capillary Rise

How Surface Tension and Pressure Drive Fluids Upward

Master the mechanics of the meniscus, pressure differences, and the fundamental equations for NEET/JEE.

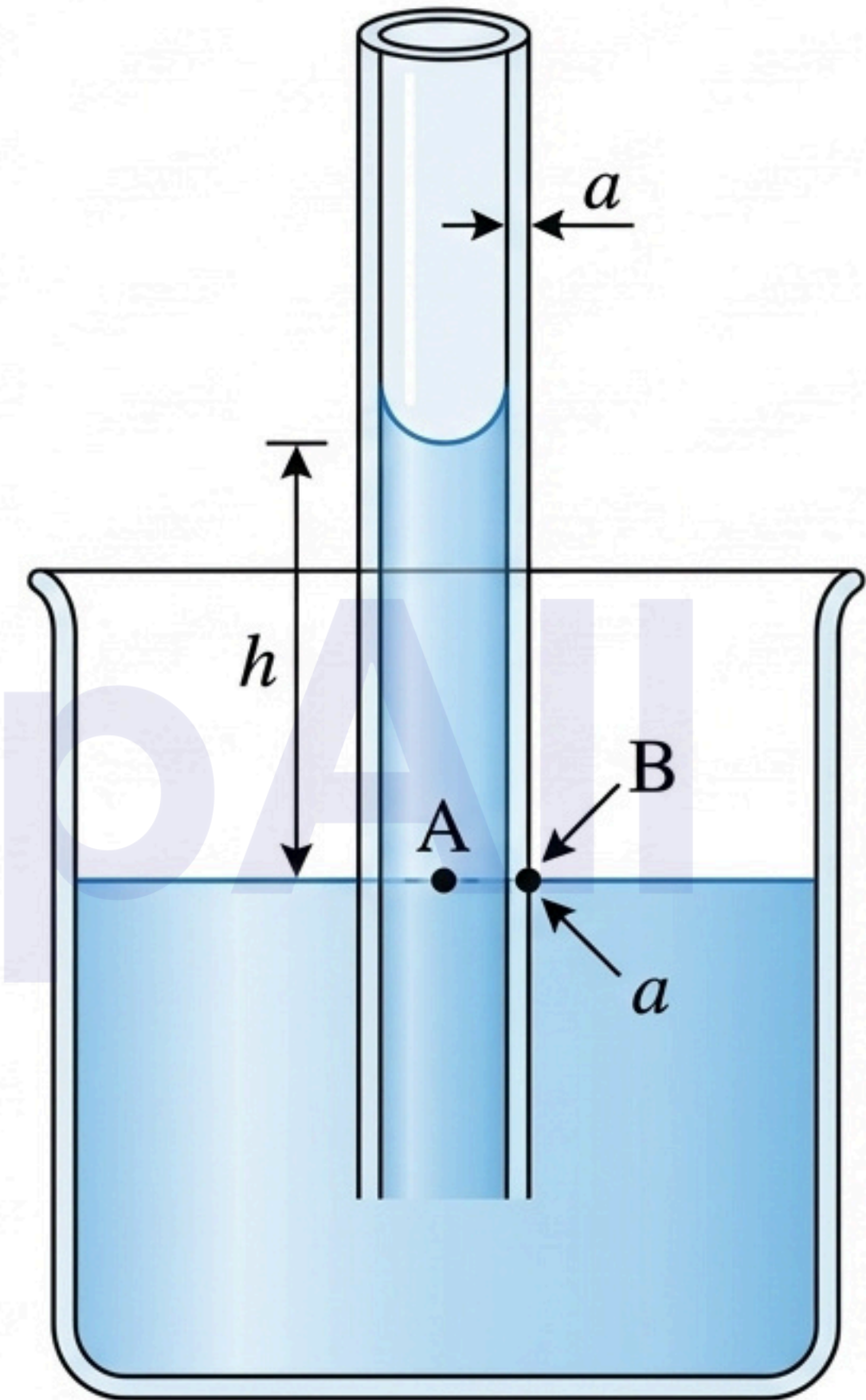


MACROSCOPIC VIEW

Defying Gravity in Narrow Tubes

When a narrow tube (a capillary) is inserted into water, the liquid spontaneously rises inside, settling at a height h above the outside surface.

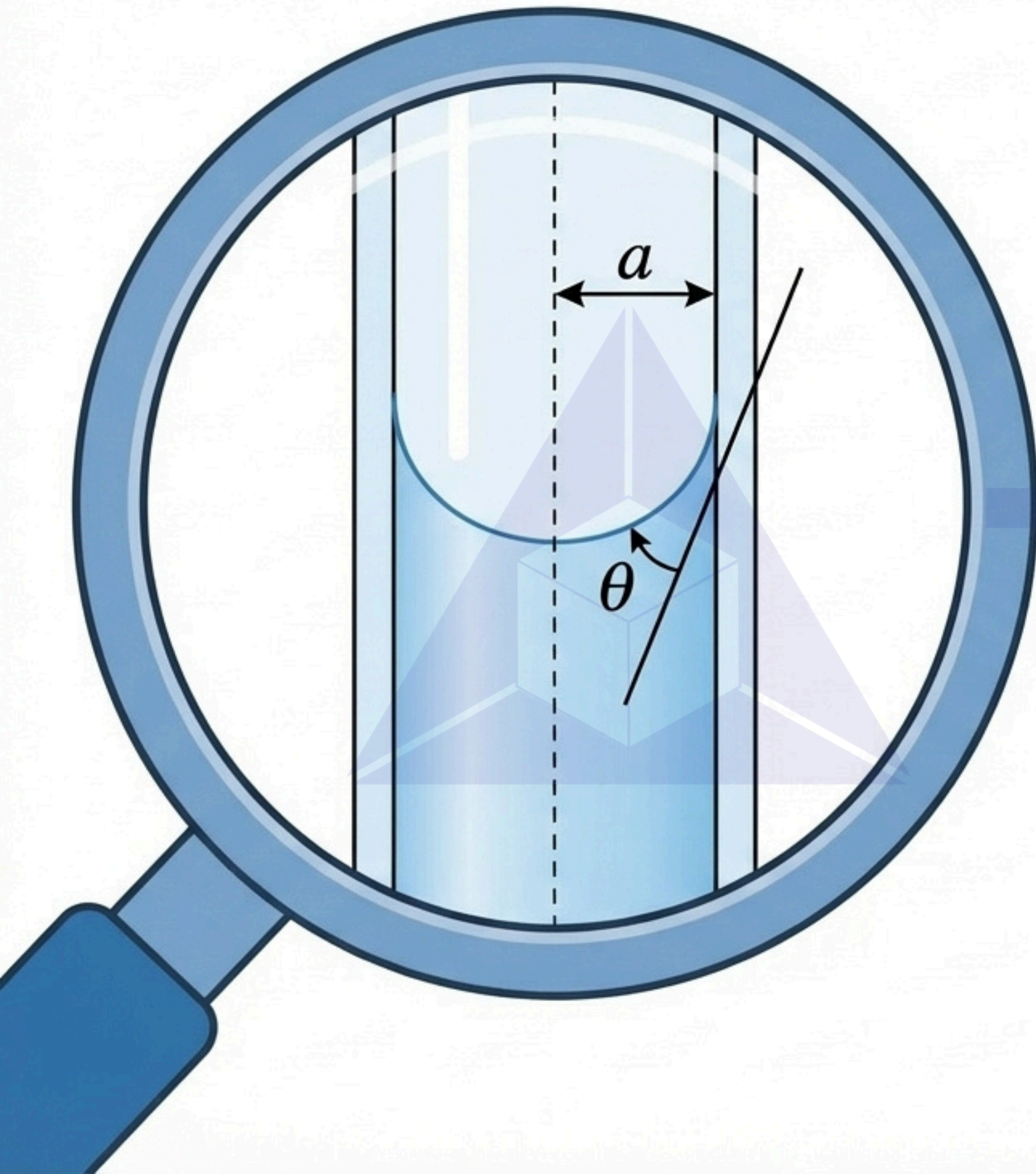
- ▶ **Gravity pulls down:** But a hidden force pulls the water up.
- ▶ **The requirement:** The tube must be extremely narrow (hair-thin).
- ▶ **The secret:** It all begins at the very top of the water column—the surface interface.



MICROSCOPIC VIEW

The Shape of the Surface

Water and glass have a high affinity for each other, creating an acute contact angle.



- ▶ **Acute Angle:** The contact angle (θ) between water and glass is less than 90° .
- ▶ **Concave Shape:** The surface of the water in the capillary curves downward, forming a concave meniscus.
- ▶ **Geometry:** The curved surface behaves like part of a sphere within tube radius a .



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$$E=mc^2$$



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Key Highlights

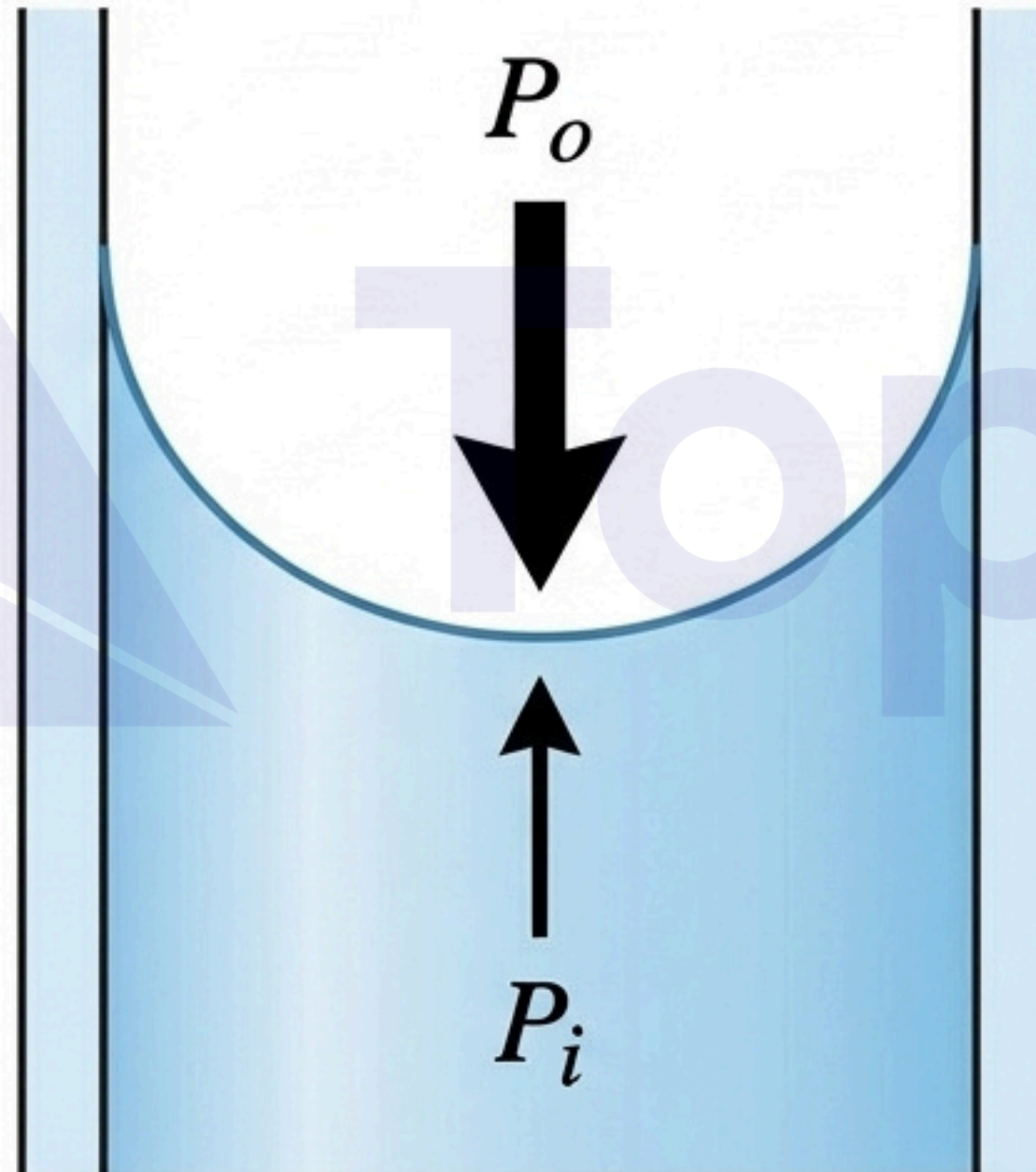
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Pressure Across a Curve

Surface tension across a curved interface always creates a pressure difference.

The concave side (outside/air) has a higher pressure than the convex side (inside/water).



$$P_o - P_i = \frac{2S \cos \theta}{a}$$

- ▶ P_o : Atmospheric pressure pushing down.
- ▶ P_i : Pressure just below the meniscus.
- ▶ **The Result:** P_i is less than atmospheric pressure. This creates a vacuum-like effect, pulling water up to restore balance.

FORMULA FOCUS

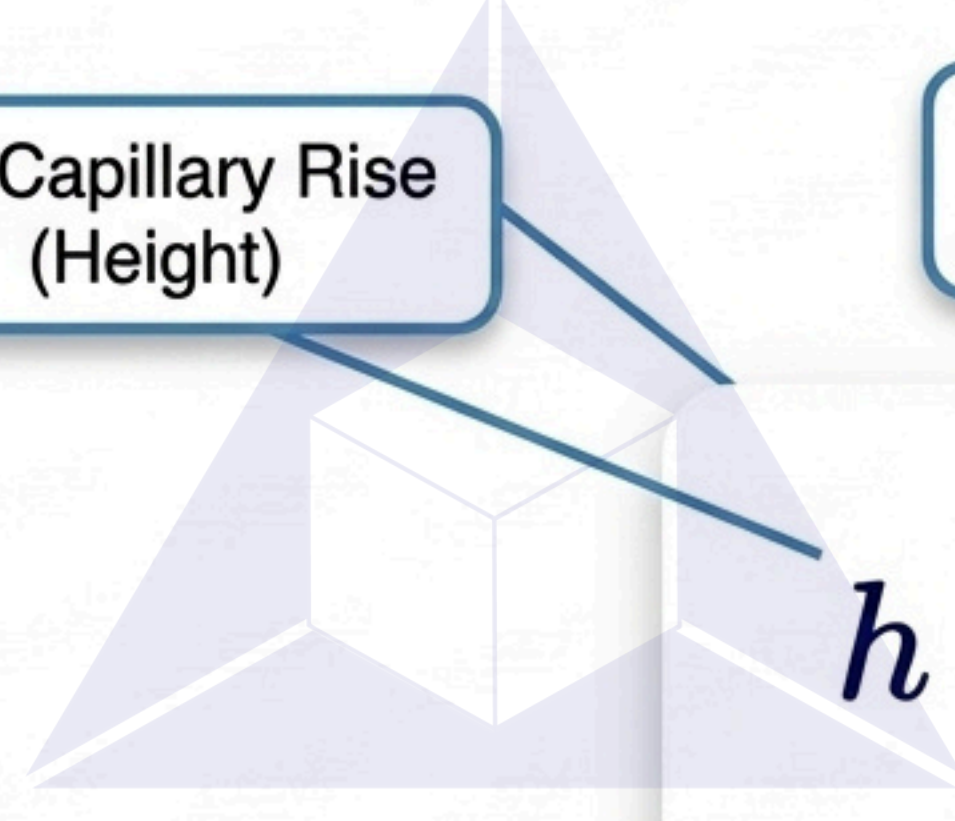
The Equilibrium Equation

The water rises until the hydrostatic pressure of the column ($h\rho g$) perfectly balances the pressure deficit at the meniscus.

h = Capillary Rise
(Height)

S = Surface Tension
of the liquid

θ = Angle of
Contact


$$h = \frac{2S \cos \theta}{\rho g a}$$

ρ = Density of
the liquid

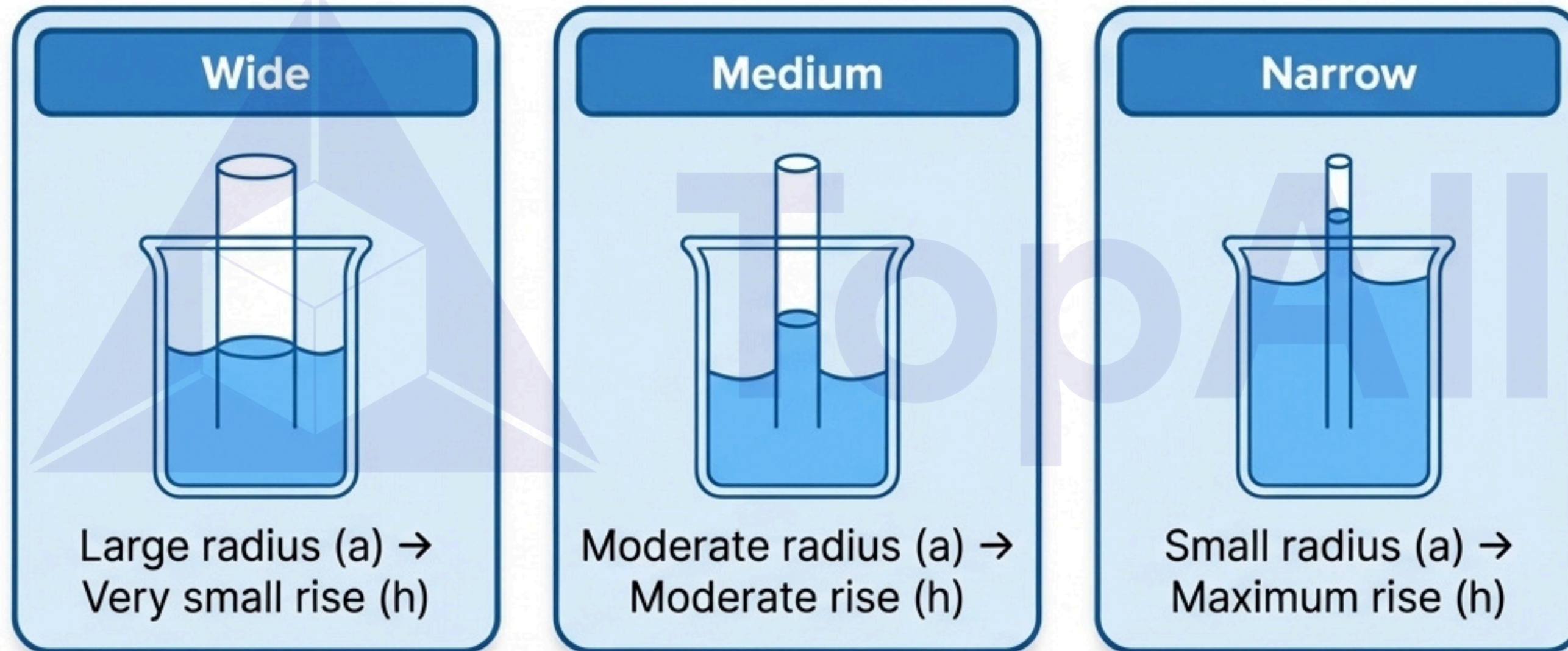
g = Acceleration
due to gravity

a = Radius of
the tube

H1. Narrower Tube = Larger Rise

Looking at our formula, height (h) and tube radius (a) have an inverse relationship.

$$h \propto \frac{1}{a}$$



EXAM TIP: For fine capillaries (e.g., $a = 0.05$ cm), water can rise several centimeters!

Key Takeaways

- ✓ **The Cause:** Capillary rise is driven by surface tension creating a pressure difference across a curved liquid-air interface (meniscus).
- ✓ **The Geometry:** An acute contact angle (θ) creates a concave meniscus, lowering pressure inside the liquid just beneath the surface.
- ✓ **The Rule:** The height of the rise (h) is inversely proportional to the radius of the tube (a).



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