

[NEET/JEE FOCUS]

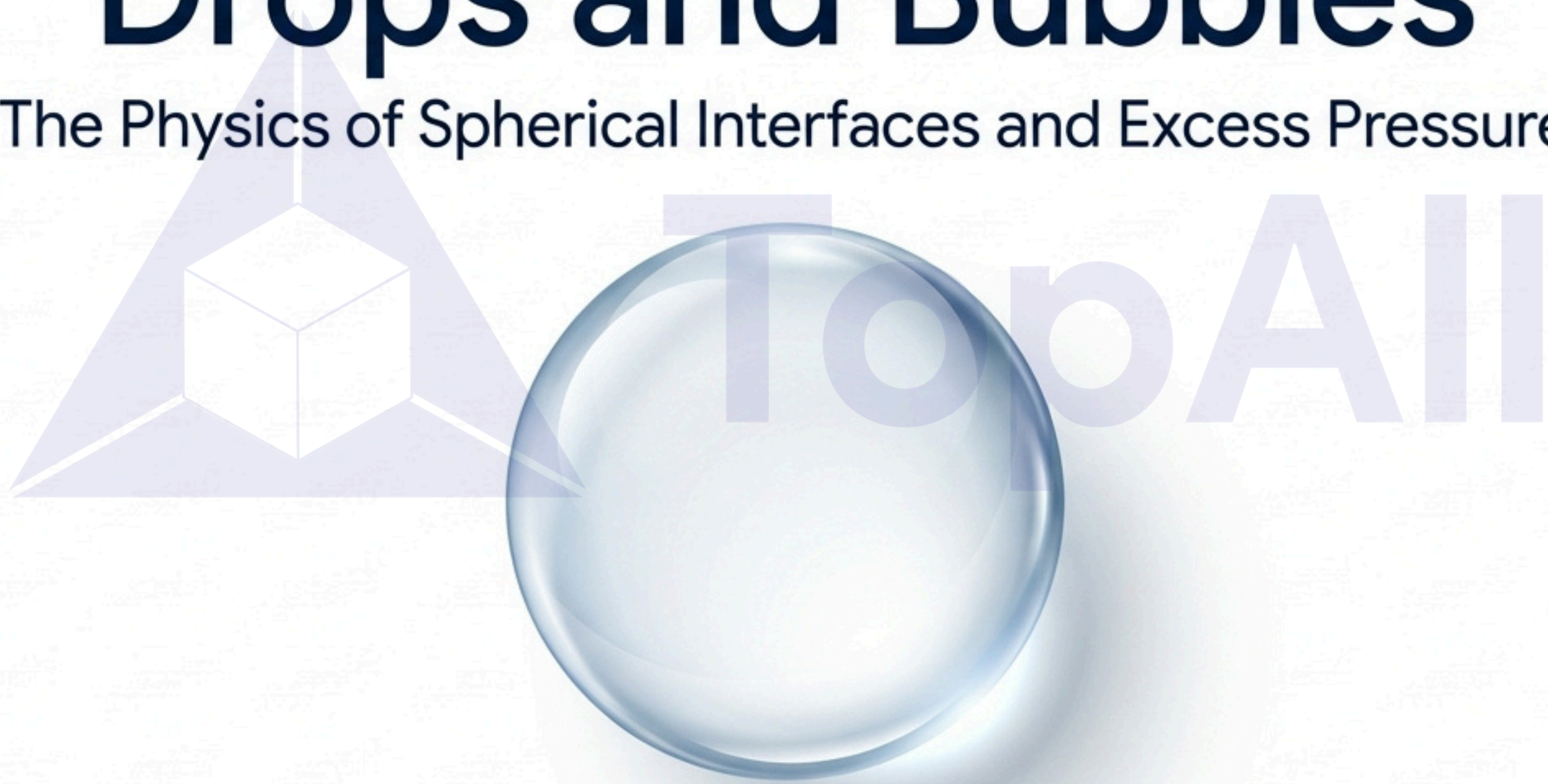
[SECTION 9.6.4]



CLASS 11 PHYSICS • CHAPTER 9: FLUIDS

Drops and Bubbles

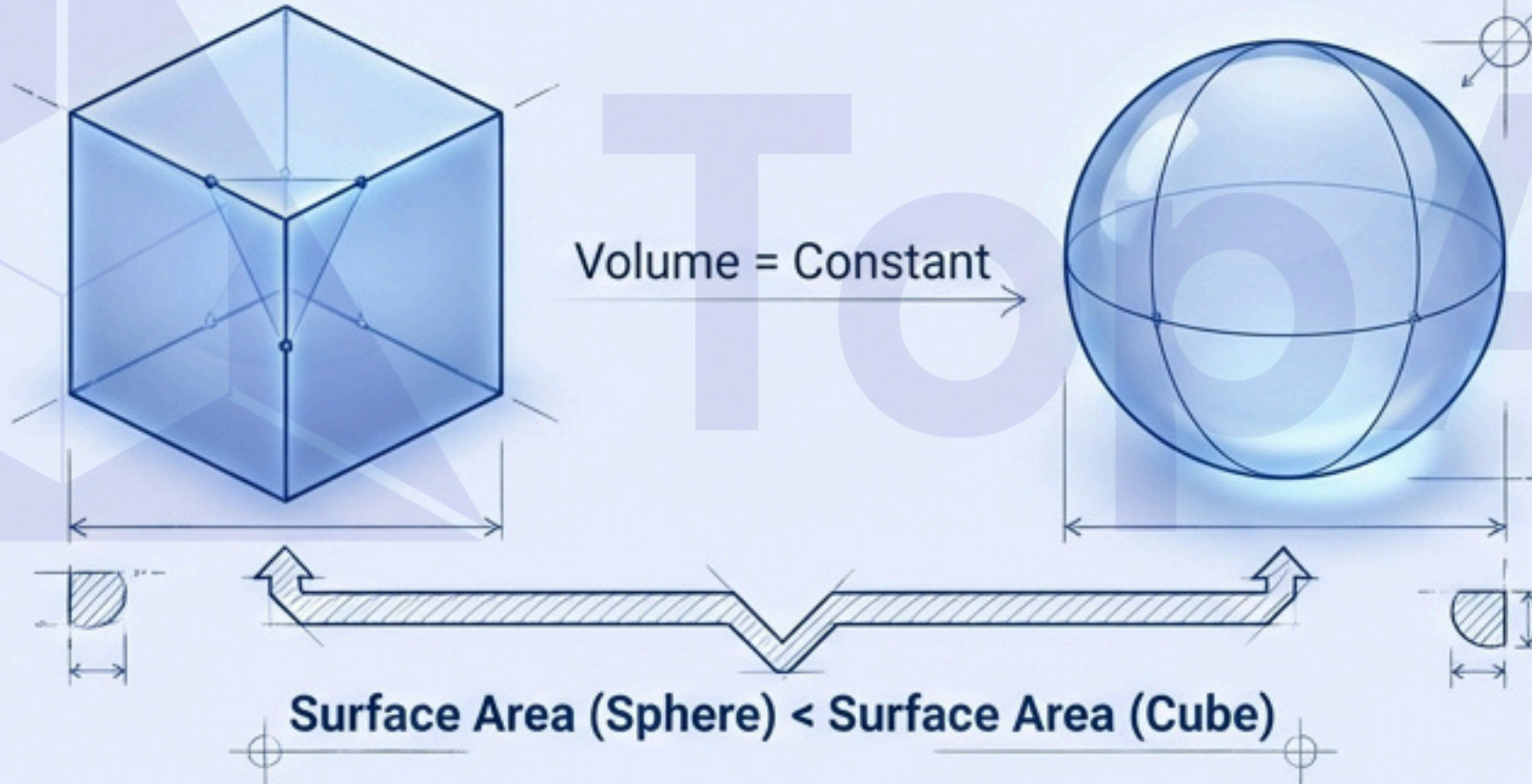
The Physics of Spherical Interfaces and Excess Pressure



Why Are Free Drops Spherical?

When the effects of gravity are neglected (like in a high-speed spray or falling rain), liquid drops and bubbles naturally form perfect spheres.

The Minimum Area Principle



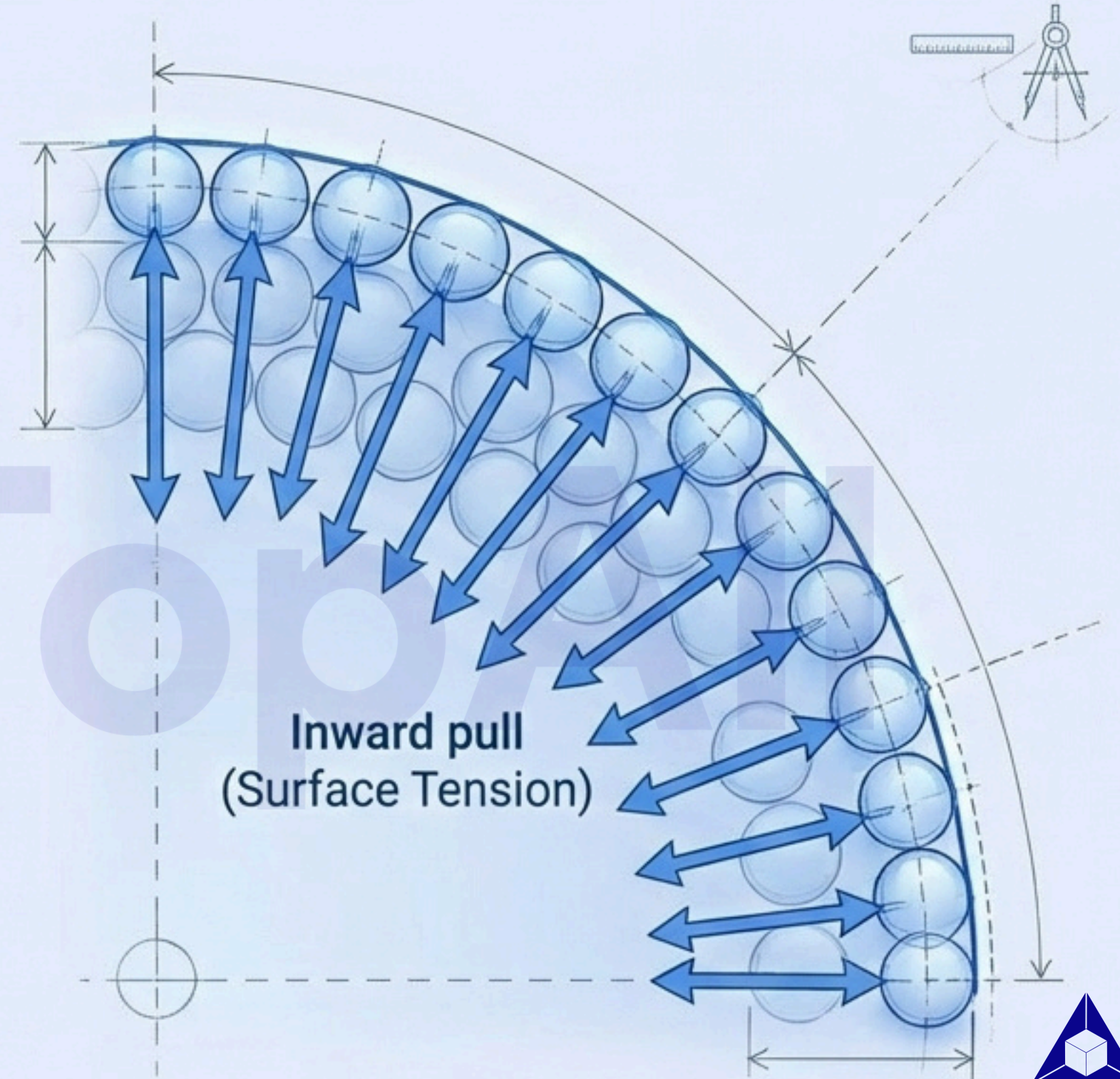
For any given fixed volume of liquid, a sphere offers the absolute minimum surface area compared to any other shape.

The Surface-Energy Argument



- A liquid-air interface inherently possesses surface energy.
- Nature always seeks the state of lowest possible energy.
- To minimize surface energy, the liquid minimizes its surface area.
- Because a sphere has the least area for a fixed volume, it represents the **most stable**, lowest-energy shape.

EXAM TIP: Less Area = Less Surface Energy = High Stability





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$$E=mc^2$$



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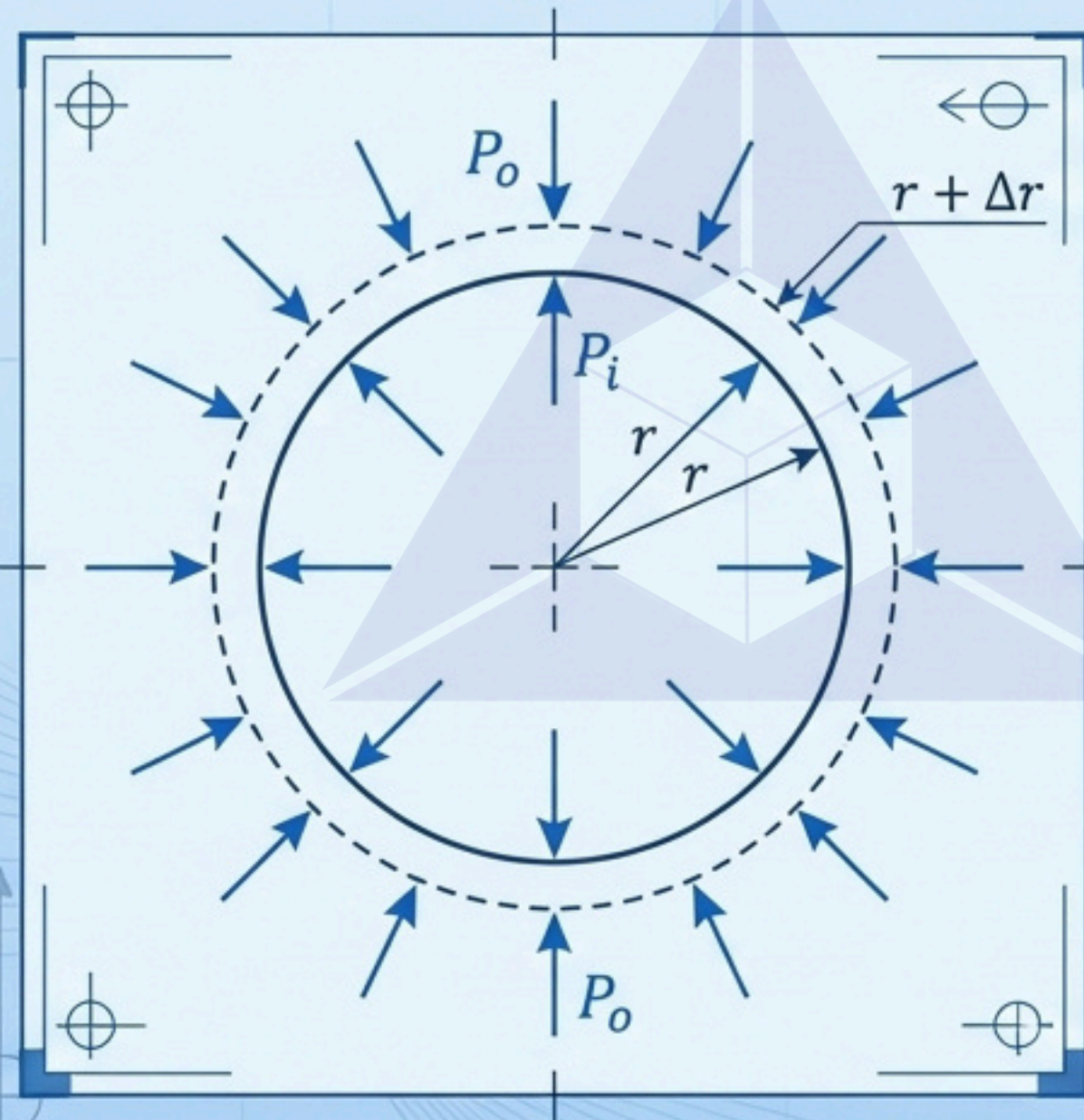


MATHEMATICAL DERIVATION



Balancing Pressure Inside a Drop

Surface tension pulls inward. To prevent the drop from collapsing, the pressure inside (P_i) must be greater than the pressure outside (P_o).



$$\text{Energy Gain: } \Delta E = 8\pi r \Delta r S_{la} \quad [\text{Eq. 9.23}]$$

$$\text{Work Done by Pressure: } W = (P_i - P_o) 4\pi r^2 \Delta r \quad [\text{Eq. 9.24}]$$

$$\text{Equilibrium: } W = \Delta E$$

$$P_i - P_o = \frac{2S_{la}}{r} \quad [\text{Eq. 9.25}]$$

S_{la} = liquid-air surface tension



FIG. 9.18 • CLASSIFICATION

Drop vs. Cavity vs. Bubble

Liquid Drop



Liquid inside, air outside.

1 Interface
(liquid-air)

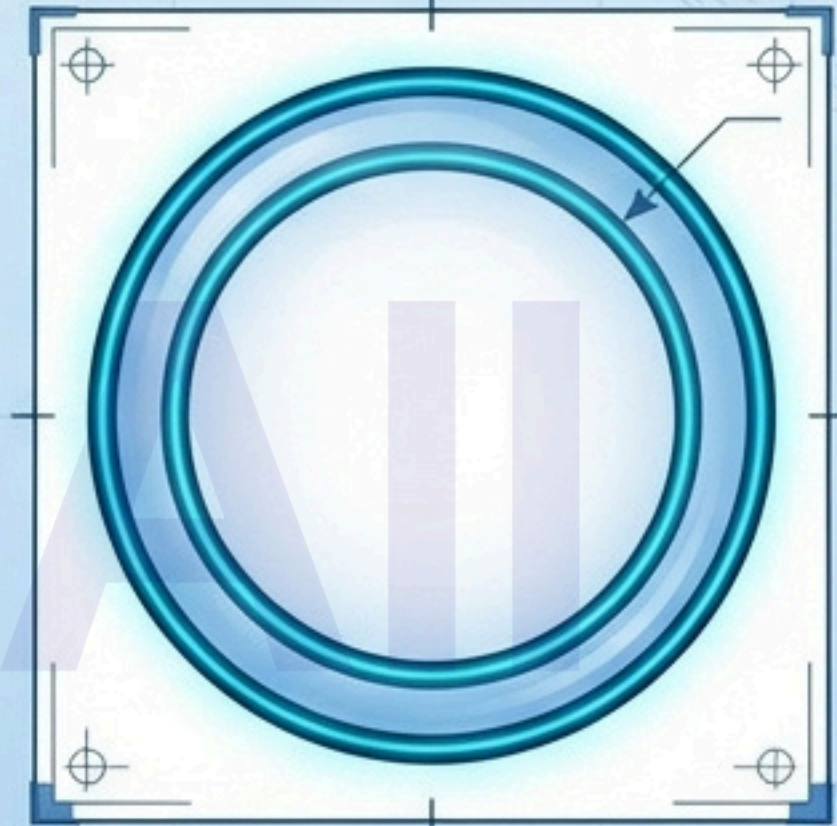
Cavity (Air Bubble)



Air inside, liquid outside.

1 Interface
(air-liquid)

Soap Bubble



Air inside, thin liquid film,
air outside.

2 Interfaces
(inner & outer)

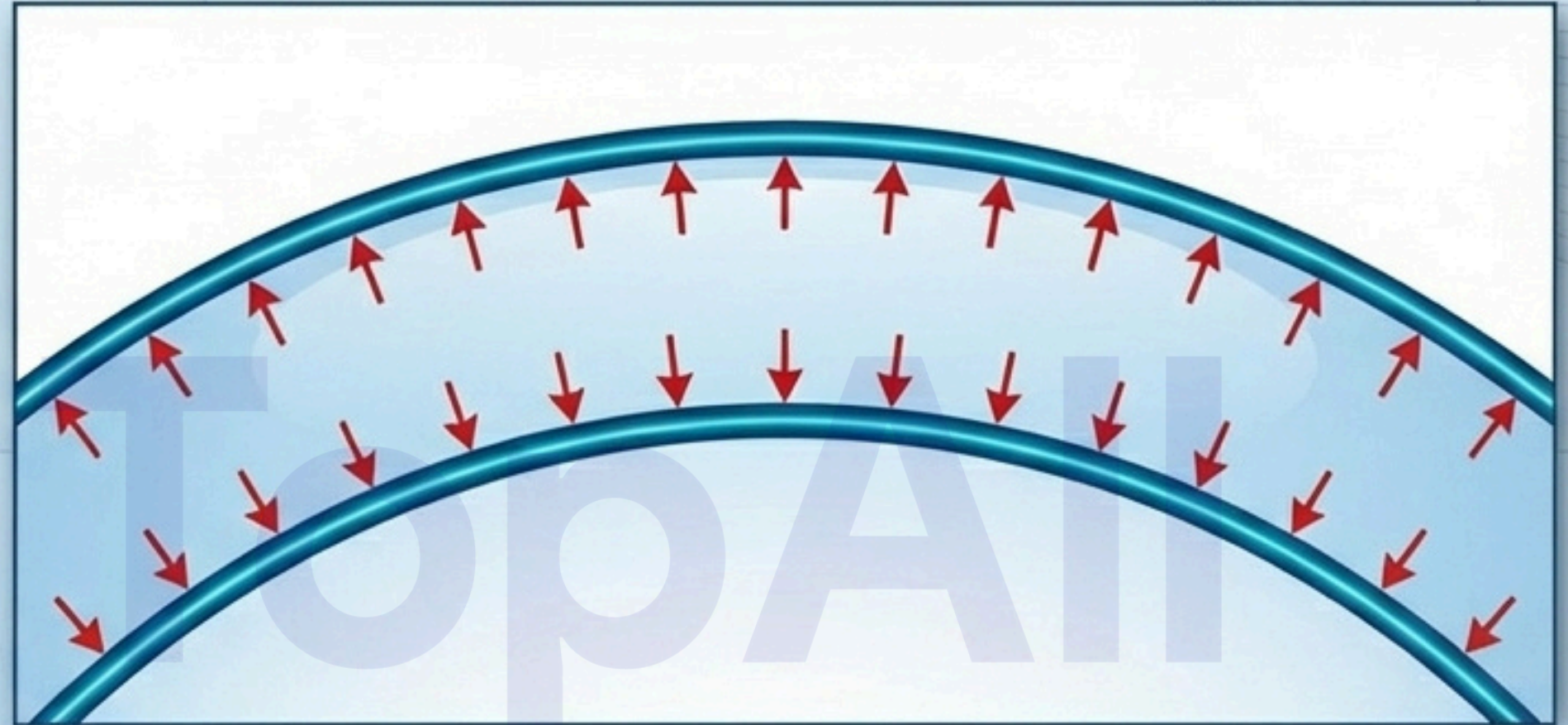


THE SOAP BUBBLE EXCEPTION



Why Bubbles Need More Pressure

- Unlike drops or cavities, a soap bubble has two distinct liquid-air interfaces (one inside, one outside the thin film).
- Both interfaces contribute to surface energy, doubling the inward surface tension force.
- This is why you must blow harder to form a soap bubble!



Navy Exam Chip

[2 Interfaces = Double
the Excess Pressure]

$$P_i - P_o = \frac{4S_{la}}{r}$$

[Eq. 9.26]



CHAPTER SUMMARY



Key Takeaways

- Free drops form spheres to minimize surface area and lower surface energy.
- Pressure inside a curved liquid surface is always higher on the concave side.

- Drops & Cavities (1 interface):

$$\text{Excess Pressure} = \frac{2S_{la}}{r}$$

- Bubbles (2 interfaces):

$$\text{Excess Pressure} = \frac{4S_{la}}{r}$$

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