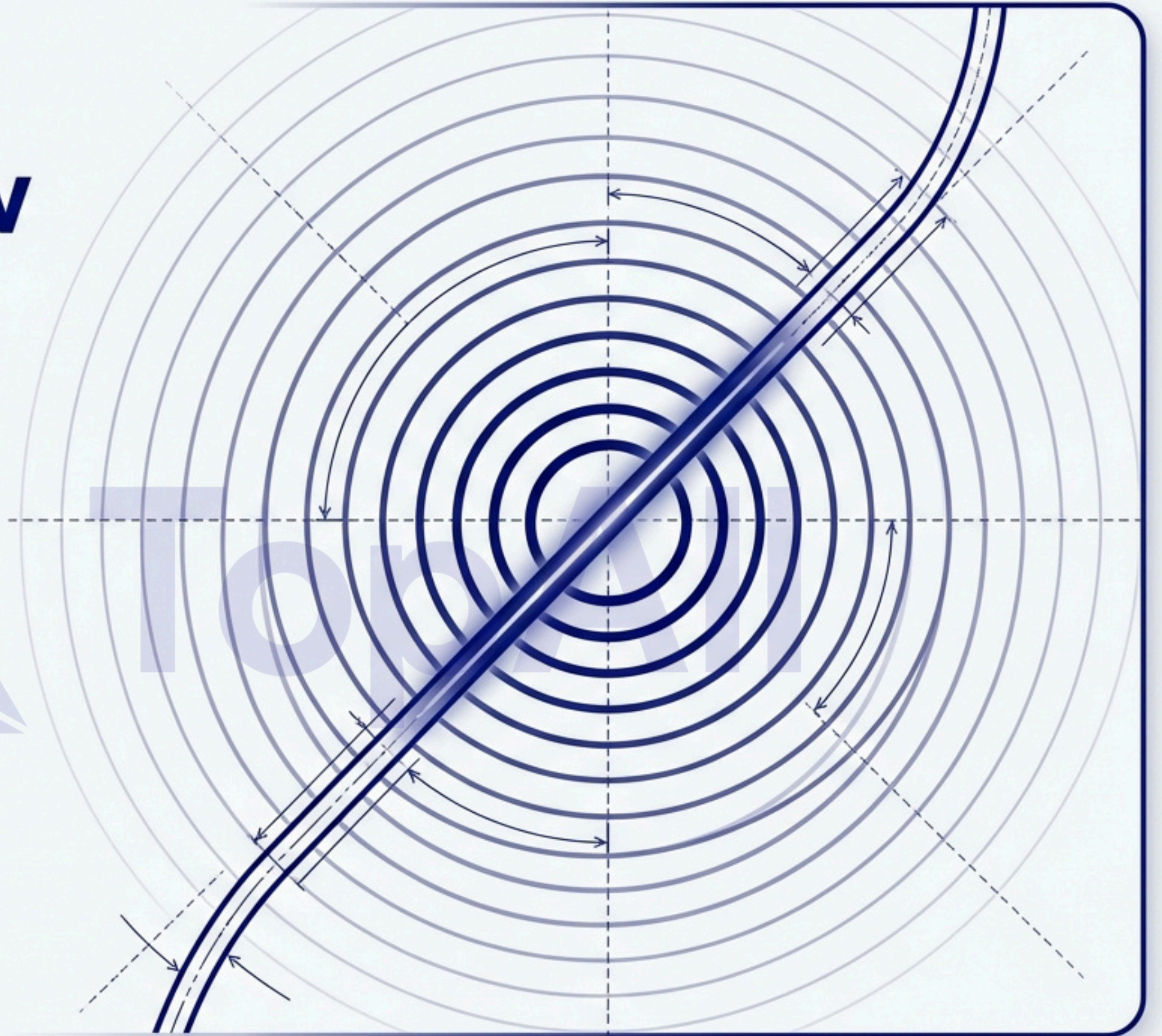
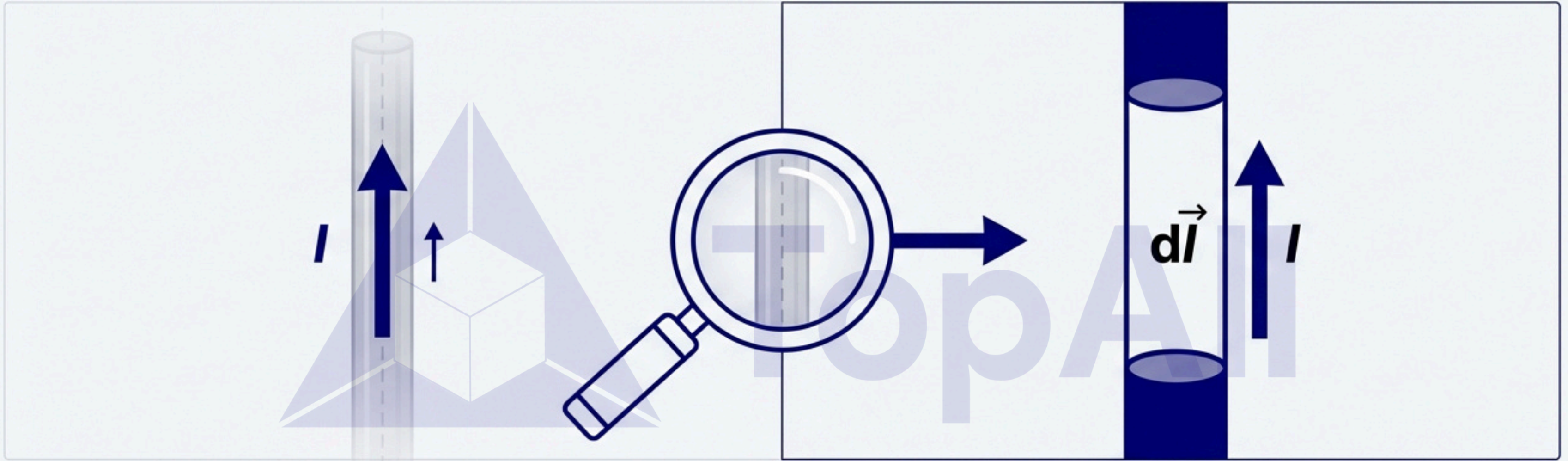


Biot-Savart Law

Calculating the magnetic field from a microscopic current element.



What Is a Current Element?



$$\text{Current Element} = I d\vec{l}$$

I (Current) = Macroscopic scalar quantity.

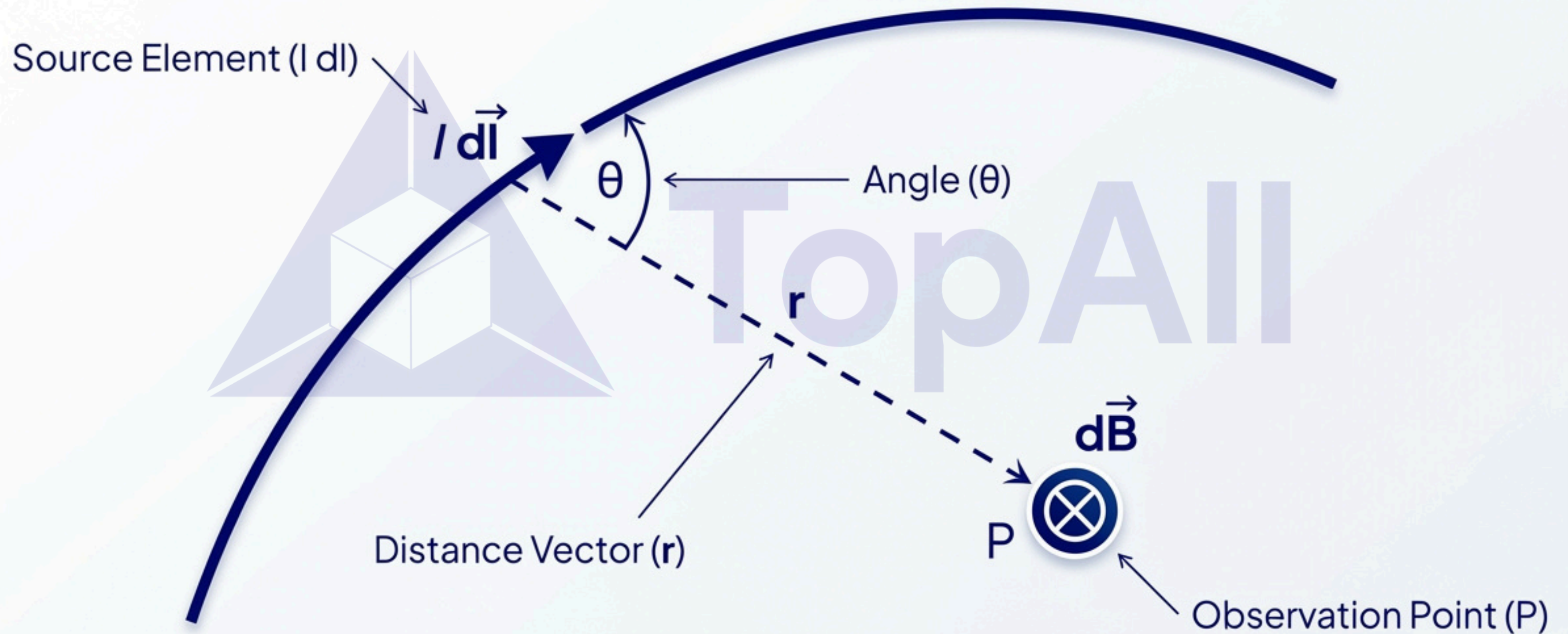
20px

$d\vec{l}$ (Length Vector) = Microscopic differential length. Direction matches the flow of current.

20px

$I d\vec{l}$ (Current Element) = The fundamental vector source of the magnetic field.

Field Contribution Geometry





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The Biot-Savart Formula

$\mu_0 / 4\pi$: Permeability constant.

$$d\vec{B} = \frac{\mu_0}{4\pi} \cdot \frac{(I d\vec{l} \times \vec{r})}{r^3}$$

$\sin\theta$: Angle dependence (Cross product $d\vec{l} \times \vec{r}$).

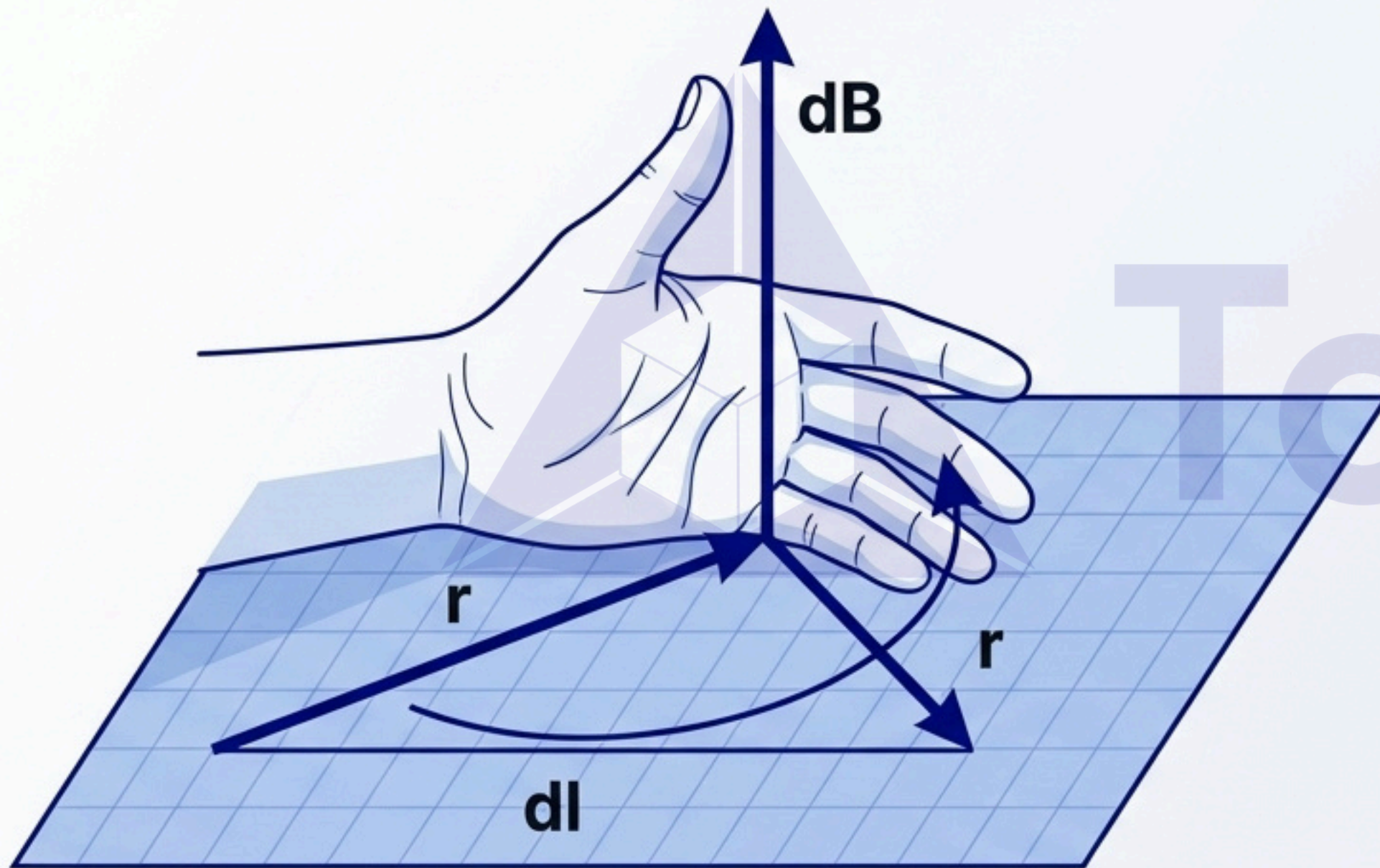
$I d\vec{l}$: Proportional to the strength of the current element.

(Magnitude: $|d\vec{B}| = \frac{\mu_0}{4\pi} \cdot \frac{I dl \sin\theta}{r^2}$)

r^2 : Follows the inverse-square law for distance.

EXAM NOTE: $\mu_0 = 4\pi \times 10^{-7} \text{ T m/A}$ (Permeability of free space)

Direction of dB (Right-Hand Rule)



Iconographic Legend



Cross Icon: Field directed INTO the plane of the page.



Dot Icon: Field directed OUT OF the plane of the page.

The direction of dB is strictly perpendicular to the plane containing both the current element dl and the position vector r .

Key Takeaways

1. **The Source:** Magnetic fields are generated by vector current elements ($I d\vec{l}$), not just scalar charges.
2. **The Inverse Square:** Like Coulomb's law, the magnetic field drops off with the square of the distance ($1/r^2$).
3. **Maximum Field ($\theta = 90^\circ$):** Field magnitude is strongest when the observation point is perfectly perpendicular to the current element ($\sin 90^\circ = 1$).
4. **CRITICAL EDGE CASE - Zero Field ($\theta = 0^\circ$):** The magnetic field at any point directly along the axis of the wire is exactly ZERO ($\sin 0^\circ = 0$).



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