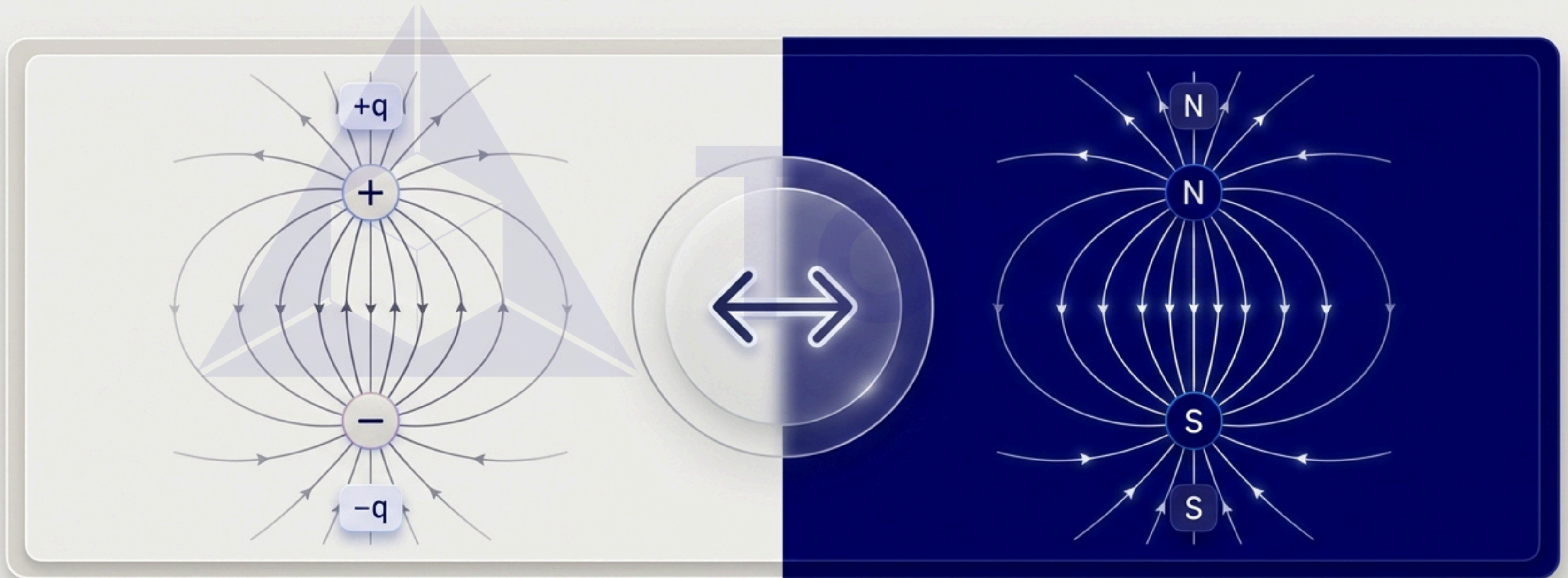


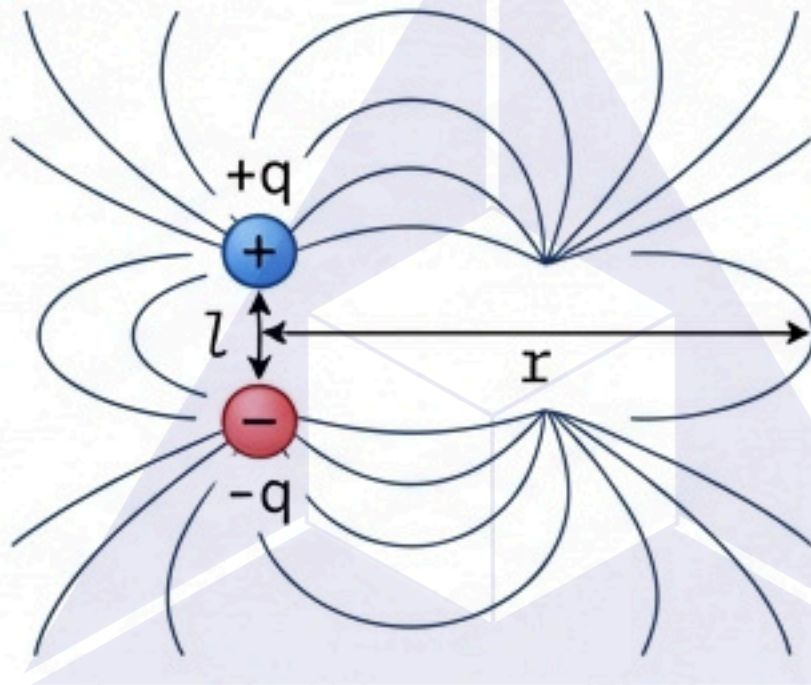
The Electrostatic Analog

The Master Key to Unlocking Magnetic Dipole Formulas



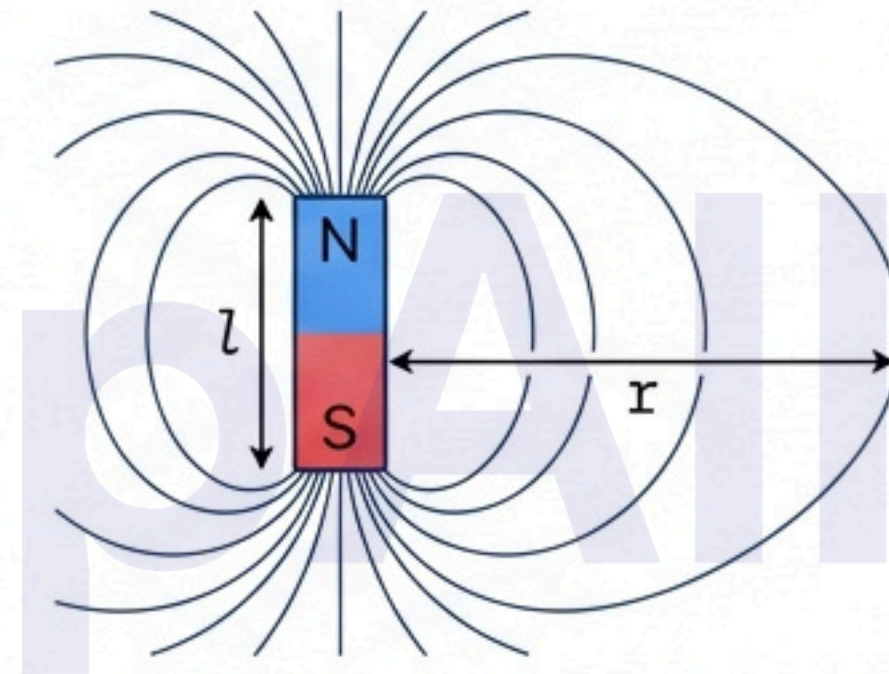
The Power of the Dipole Analogy

Electric Dipole



At distance $r \gg l$, field is governed by dipole moment $\mathbf{p}$.

Magnetic Dipole



At distance $r \gg l$, field is governed by magnetic moment $\mathbf{m}$.

Because their **far-field architectures** match perfectly, we can calculate magnetic fields by simply **translating** known electrostatic equations.

The Formula Substitution Key

The Field	$E \rightarrow B$
The Moment	$p \rightarrow m$
The Constant	$\frac{1}{4\pi\epsilon_0} \rightarrow \frac{\mu_0}{4\pi}$

Exam Smart

Apply this exact key to instantly find equatorial fields, axial fields, torque, and potential energy—without memorizing new derivations.



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Equatorial Field Comparison

Electrostatics

$$\mathbf{E} = -\frac{-\mathbf{p}}{4\pi\epsilon_0 r^3}$$

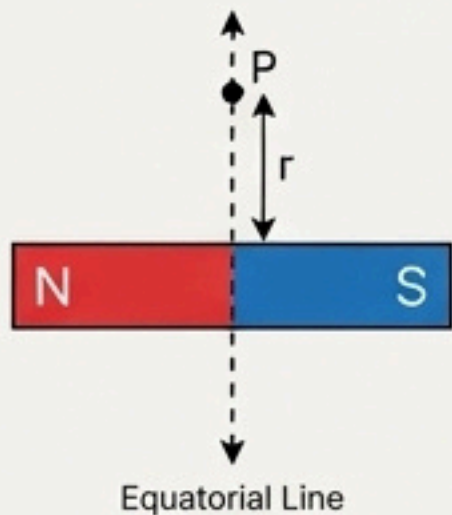
$$(\mathbf{E} \rightarrow \mathbf{B})$$

$$(\mathbf{p} \rightarrow \mathbf{m})$$

$$(1/\epsilon_0 \rightarrow \mu_0)$$

Magnetism (Eq. 5.4)

$$\mathbf{B}_E = -\frac{\mu_0 \mathbf{m}}{4\pi r^3}$$



Axial Field Comparison

Electrostatics

$$E = \frac{2p}{4\pi\epsilon_0 r^3}$$

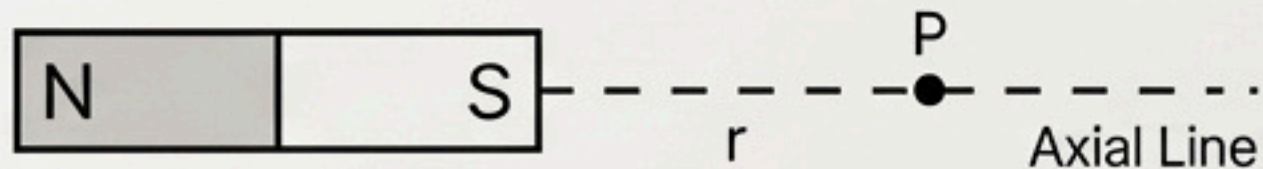
$(E \rightarrow B)$

$(p \rightarrow m)$

$(1/\epsilon_0 \rightarrow \mu_0)$

Magnetism (Eq. 5.5)

$$B_A = \frac{\mu_0 2m}{4\pi r^3}$$



Key Difference: Note the factor of **2** in the numerator. The axial field is **twice** as strong as the equatorial field at the same distance r .

The Ultimate Dipole Analogy Matrix

Property	Electrostatics	Magnetism
Constant	$1/\epsilon_0$	μ_0
Dipole Moment	$\mathbf{p}$	$\mathbf{m}$
Equatorial Field ($r \gg l$)	$\frac{-\mathbf{p}}{4\pi\epsilon_0 r^3}$	$\frac{-\mu_0 \mathbf{m}}{4\pi r^3}$
Axial Field ($r \gg l$)	$\frac{2\mathbf{p}}{4\pi\epsilon_0 r^3}$	$\frac{\mu_0 2\mathbf{m}}{4\pi r^3}$
External Field Torque	$\mathbf{p} \times \mathbf{E}$	$\mathbf{m} \times \mathbf{B}$
External Field Energy	$-\mathbf{p} \cdot \mathbf{E}$	$-\mathbf{m} \cdot \mathbf{B}$

All complex magnetic dipole behaviors can be flawlessly predicted using this single symmetry table.



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