

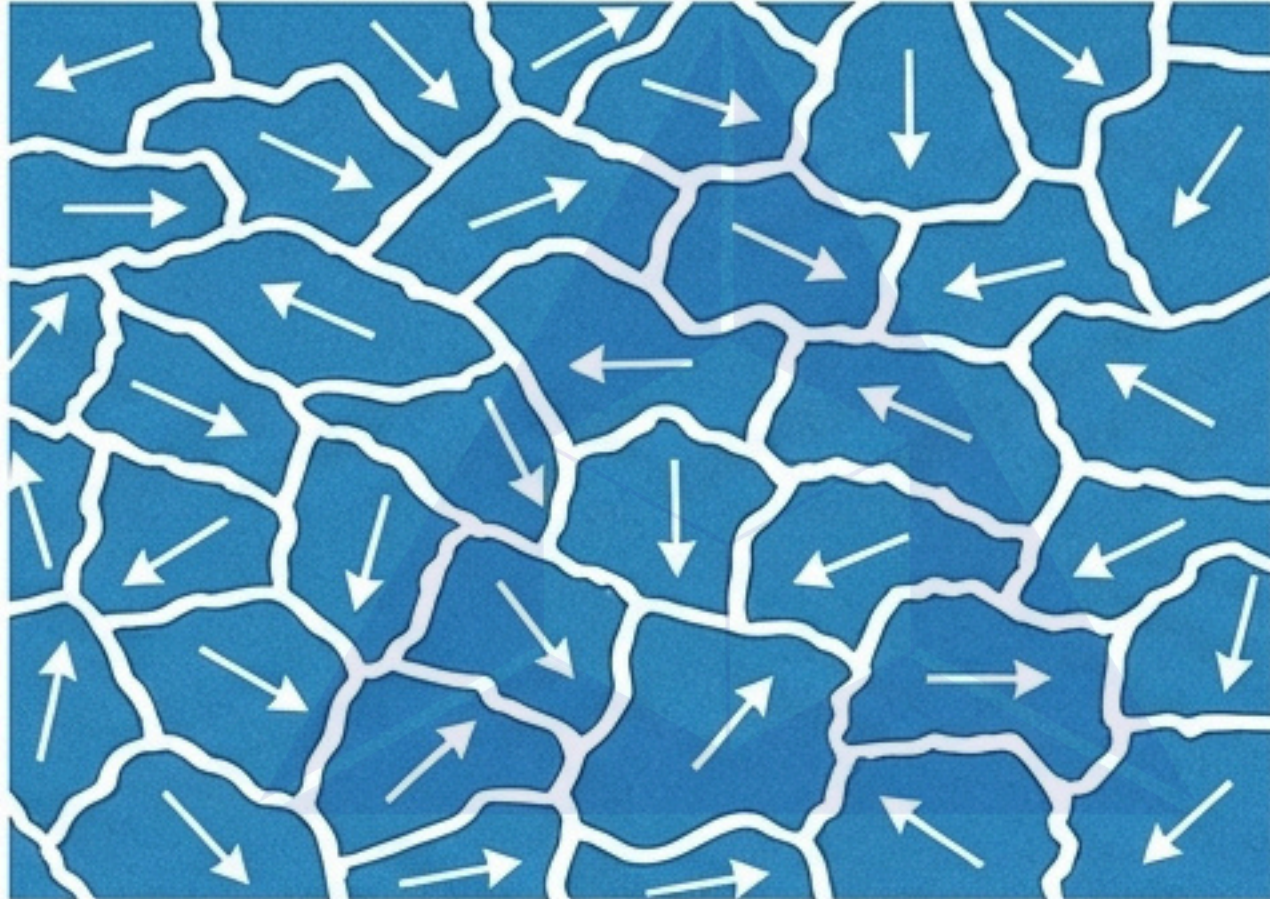
CLASS 12 PHYSICS • SECTION 5.4

Magnetisation and Magnetic Intensity

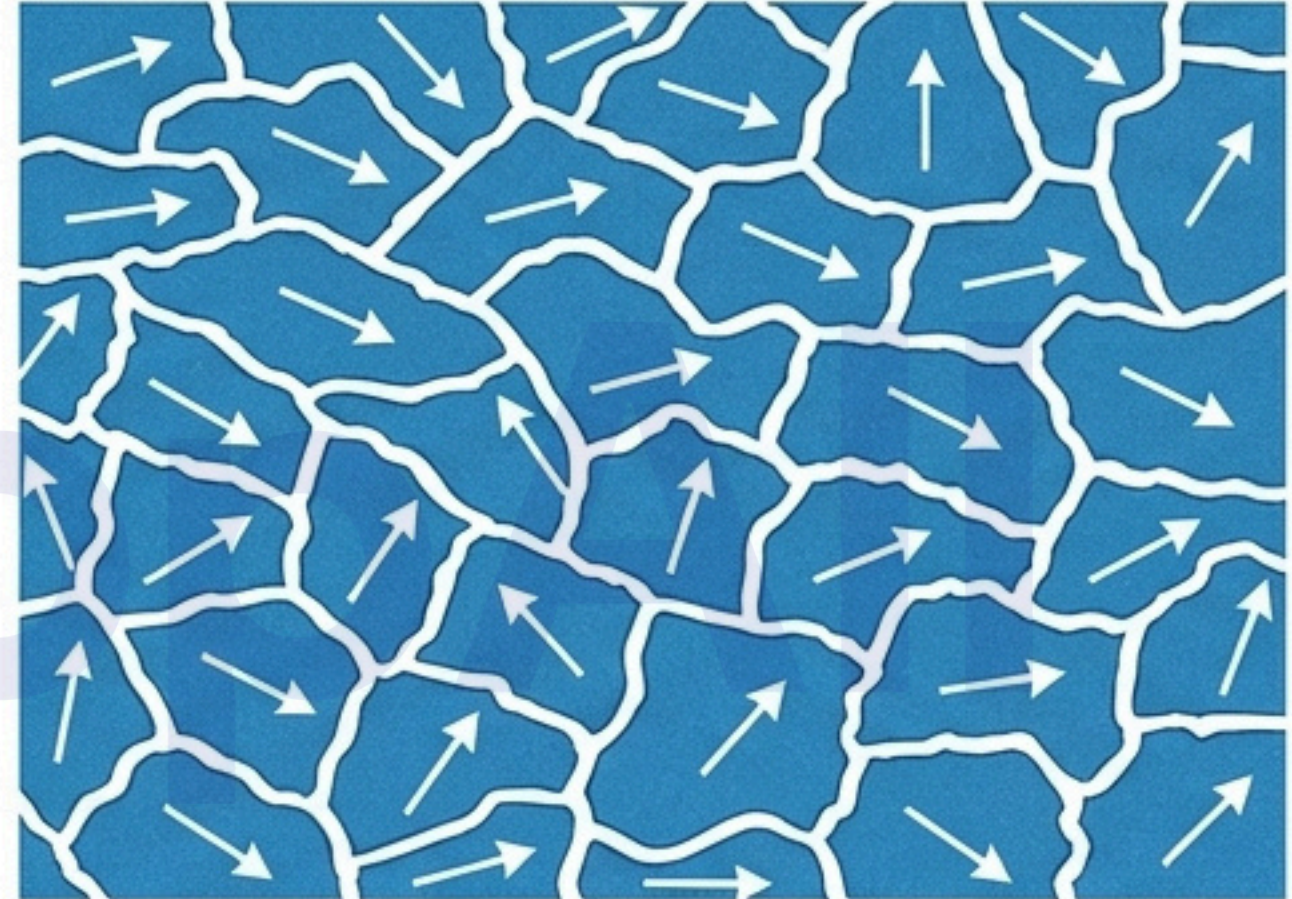
Understanding the microscopic origins of bulk magnetism and the exact mathematical relationships between B , H , M , χ , and μ .

[Swipe to begin concept mastery →]

From Atoms to Bulk Materials



Random Thermal Motion = Zero Net Moment



Aligned Moments = Net Bulk Magnetism

Every circulating electron in an atom acts as a tiny magnetic dipole. In bulk materials, these individual atomic moments can add up vectorially.

[Micro-Insight] The magnetic behavior of an everyday object is just the macroscopic sum of trillions of aligned atomic moments.

Defining Magnetisation (M)

Magnetisation (Vector)

- Represents the density of dipole moments.

Dimensions: $L^{-1} A$

Units: $A m^{-1}$

$$M = m_{\text{net}} / V$$

Net Magnetic Moment

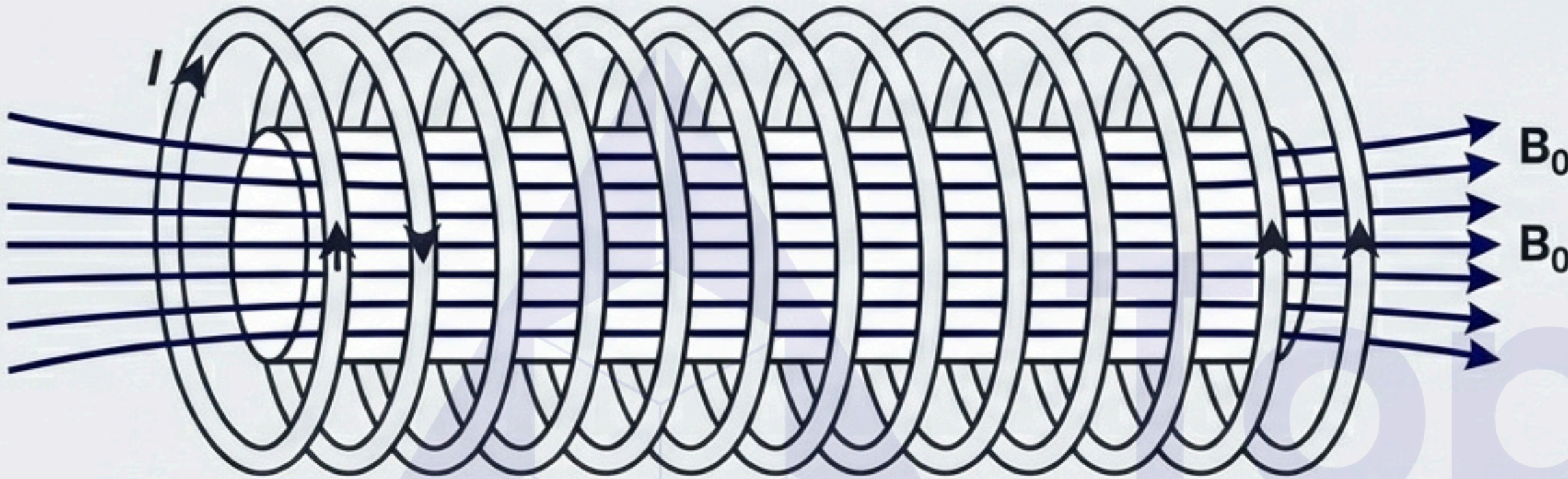
- The vectorial sum of all atomic moments in the sample.

Volume

- The total volume of the bulk material.

It answers the question: How strongly magnetized is this specific piece of material?

The Solenoid (Empty Core)



Before adding any magnetic materials, an empty current-carrying solenoid generates a baseline field. This field is created entirely by external factors (the current).

$$B_0 = \mu_0 n I$$

[n = turns per unit length]

[I = current]

[μ_0] = permeability of vacuum]



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Let's Test Them Now.**

$$E=mc^2$$



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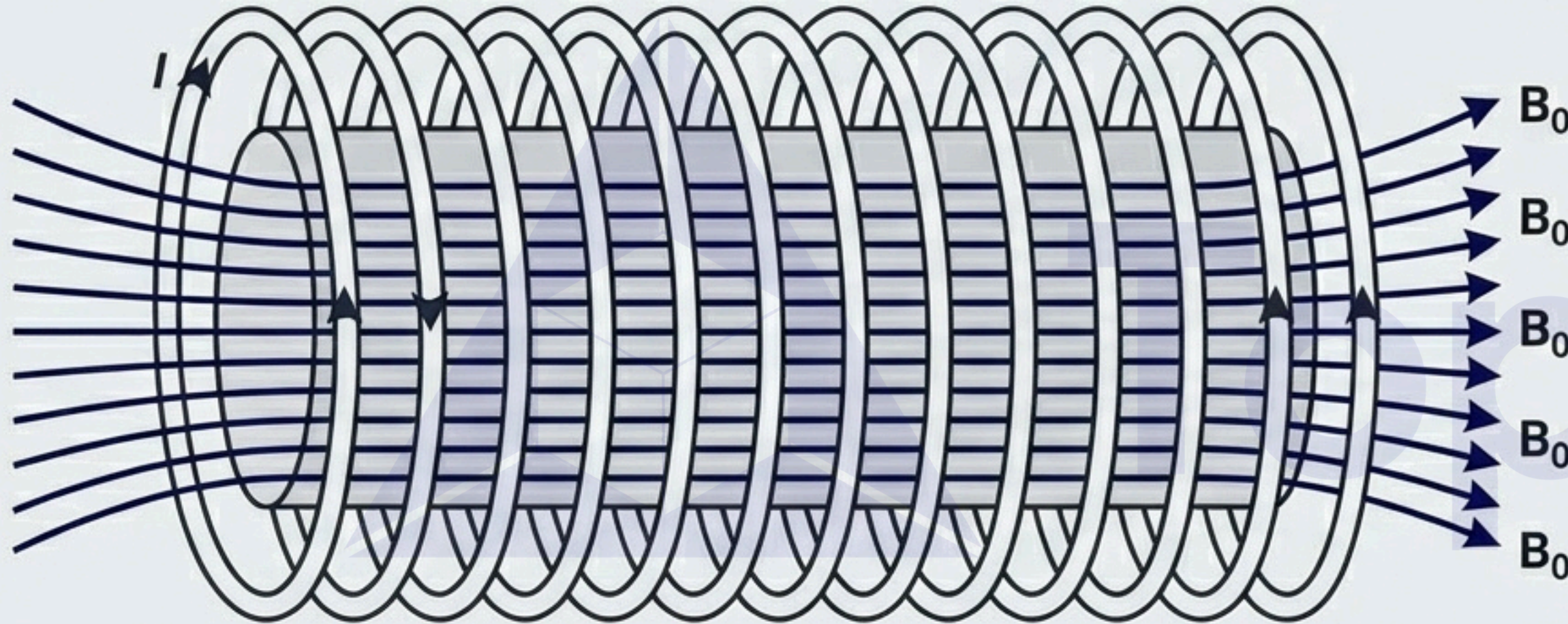
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Introducing the Magnetic Core



When a material with non-zero magnetisation is placed inside, the total magnetic field (B) increases. The material contributes its own field (B_m).

Formula Breakdown

Total Field: $B = B_0 + B_m$

Material Contribution: $B_m = \mu_0 M$

Total Field = (Field from Current) + (Field from Material's Magnetisation)

Defining Magnetic Intensity (H)

We need a variable that represents only the external driving force, entirely independent of the specific material we put inside the solenoid.

Total Field:

$$\mathbf{B} = \mu_0(\mathbf{H} + \mathbf{M})$$



Rearrange to isolate external drive:

$$\mathbf{H} = \mathbf{B}/\mu_0 - \mathbf{M}$$

Context Pill

For a standard solenoid, this drive simplifies to just $\mathbf{H} = n\mathbf{l}$.

Magnetic Intensity (H) has the same dimensions as $\mathbf{M}$ (A m^{-1}) and represents the pure external magnetic influence.

Susceptibility (χ) & Permeability (μ)

How exactly does the material's magnetisation ($\mathbf{M}$) respond to the external drive ($\mathbf{H}$)?

Susceptibility

$$\mathbf{M} = \chi \mathbf{H}$$

χ (Chi) is dimensionless.
It measures how easily the material responds.
(Paramagnetic: small +,
Diamagnetic: small -).

Relative Permeability

$$\mu_r = 1 + \chi$$

μ_r is the dimensionless
analog of the dielectric
constant.

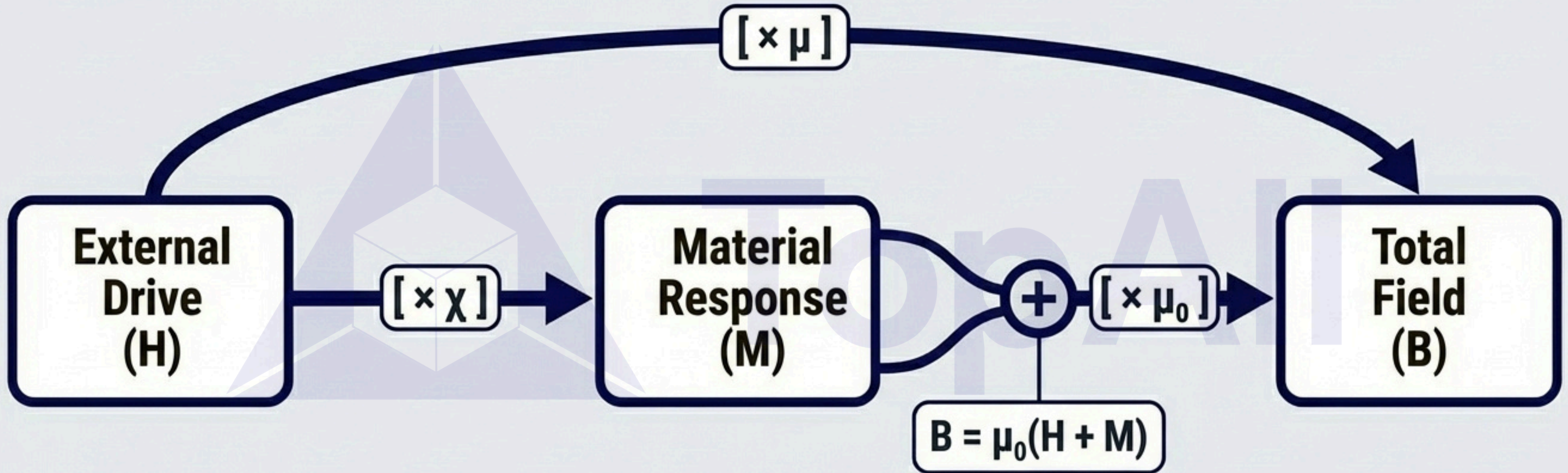
Total Permeability

$$\mu = \mu_0 \mu_r$$

Combining these
transforms the Total Field
equation to just:

$$\mathbf{B} = \mu \mathbf{H}$$

The Master Map of Magnetism



H = What you apply.

χ = How the material reacts.

M = The material's own magnetism.

B = The final total magnetic field.



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