Physics 142 - November 8, 2005

Maxwell's equations

EXAM 2 - NexT Tuesday B+C 109

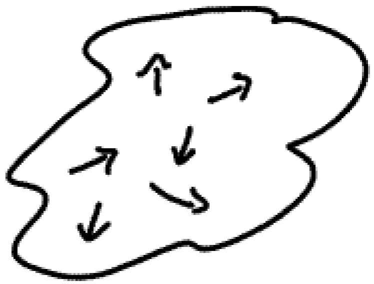
(Nov. 15)

0800

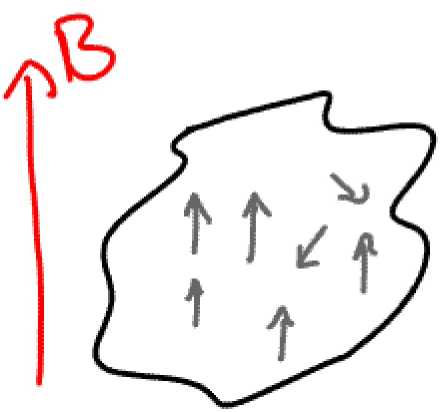
Review Session → Thursday's class

magnetic fields in matter

Paramagnetism

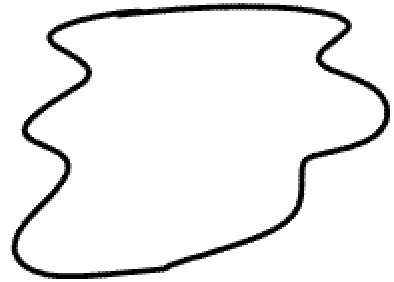


Have magnetic moments in RANDOM orientations

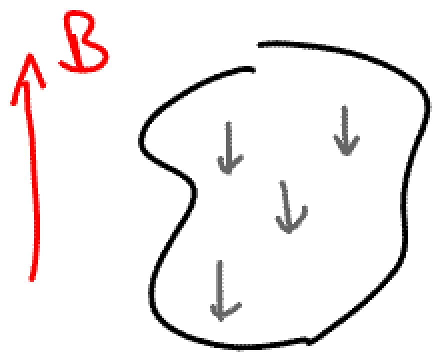


Partial Alignment enhances field

Diamagnetism



No Dipoles



Weakens B

Fe

Ferromagnetism

Domains mostly align w/ field

Field saturates at 2 Tesla

$B = \mu_0(1+\chi_M)\, B_{free}$

external Field

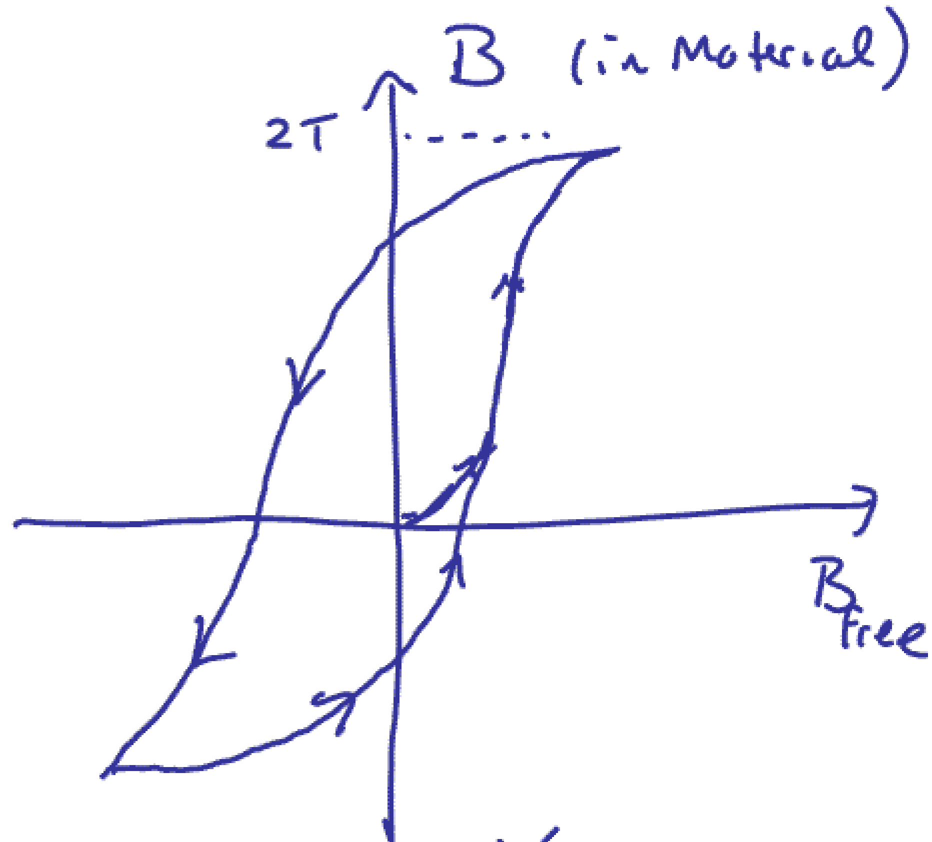
magnetic Susceptability

magnetic permeability

μ

$B = K_M\, B_{free}$

const. of relative permeability



Hysteresis Loop

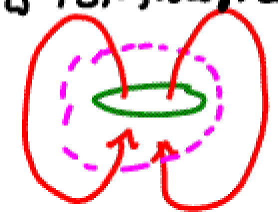
$$\oint_S \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

Gauss' Law

$$\oint_S \vec{B}\cdot d\vec{A} = 0$$

No Magnetic Monopoles

Gauss' law for Magnetism



$$\oint_C \vec{B}\cdot d\vec{l} = \mu_0 I_{encl}$$

Ampere's law

$$\oint_C \vec{E}\cdot d\vec{l} = -\frac{d\Phi_M}{dt} = -\frac{d}{dt}\int_S \vec{B}\cdot d\vec{A}$$

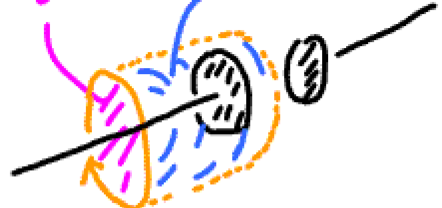
Faraday's law

1st integral

second integral

S1

S2



Amperian loop

current thru S1 = I

" " S2 = 0 ?

contr. S2

$$\mu_0\epsilon_0 \frac{d}{dt}\int_S \vec{E}\cdot d\vec{A}$$

$$\int_C \vec{B}\cdot d\vec{l} = \mu_0 I + \mu_0\epsilon_0 \frac{d\Phi_E}{dt} = \mu I + \mu_0\epsilon_0 \frac{d}{dt}\int_S \vec{E}\cdot d\vec{A}$$

Integral form of Maxwell's eqns.

$$\oint_S \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

$$\oint_S \vec{B}\cdot d\vec{A} = 0$$

$$\oint_C \vec{B}\cdot d\vec{l} = \mu_0 I_{encl} + \mu_0\epsilon_0 \frac{d}{dt}\int \vec{E}\cdot d\vec{A}$$

$$\oint_C \vec{E}\cdot d\vec{l} = -\frac{d\Phi_M}{dt} = -\frac{d}{dt}\int_S \vec{B}\cdot d\vec{A}$$

Gauss' law

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

Gauss' Theorem
Green's Theorem
divergence Theorem

$$\int_{vol} (\vec{\nabla}\cdot\vec{V})\, dV = \int_{surf} \vec{V}\cdot d\vec{A}$$

del vector operator $\vec{\nabla} \equiv \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{z}$

$$\underline{\underline{\vec{\nabla}\cdot\vec{V}}} = \frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}$$

$\hat{i}\cdot\hat{i} = 1$

$\hat{i}\cdot\hat{j} = 0$

Scalar $\to$ divergence

$$\left(\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right)\cdot\left(V_x\hat{i} + V_y\hat{j} + V_z\hat{k}\right)$$

$$\int_S \vec{E}\cdot d\vec{A} = \int_{vol}(\vec{\nabla}\cdot\vec{E})\,dv = \frac{q}{\epsilon_0} = \frac{1}{\epsilon_0}\int_{vol}\rho\,dv$$

$$\boxed{\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0}}$$

Gauss' Law in differential form

$$\oint_S \vec{B}\cdot d\vec{A} = \int_{vol}(\vec{\nabla}\cdot\vec{B})\,dv = 0 \qquad \boxed{\vec{\nabla}\cdot\vec{B} = 0}$$

$$\oint_C \vec{E}\cdot d\vec{l} = -\frac{d}{dt}\int_S \vec{B}\cdot d\vec{A}$$

Stoke's Theorem

$$\oint_{\text{surf}} (\vec{\nabla}\times\vec{V})\cdot d\vec{A} = \oint_{\text{line}} \vec{V}\cdot d\vec{l}$$

Curl of vector field $\vec{V}$

amount of twist

$$\vec{\nabla}\times\vec{V} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ V_x & V_y & V_z \end{vmatrix} = \hat{i}\left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z}\right) - \hat{j}\left(\frac{\partial V_z}{\partial x} - \frac{\partial V_x}{\partial z}\right) + \hat{k}\left(\qquad\right)$$

$$\oint_C E \cdot dl = \oint_S (\vec{\nabla} \times \vec{E}) \cdot \vec{dA} = -\frac{d}{dt} \int \vec{B} \cdot \vec{dA}$$

$$\boxed{\vec{\nabla} \times \vec{E} = -\frac{d\vec{B}}{dt}}$$

Faraday's law in differential form