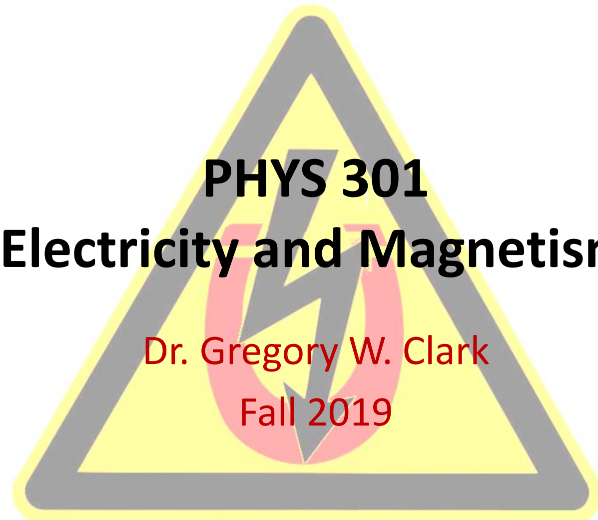


PHYS 301
Electricity and Magnetism

Dr. Gregory W. Clark

Fall 2019

Today!

- Do you know everyone here?
- What did you do this summer?
- Lab time: R 1:00 – 2:50 PM
- Syllabus/website
- Pop Quiz!!
- E&M Overview
- Vector review
- The Gradient

The Four Great Realms of Physics

smaller distances

higher speeds

Classical Physics Newton, Maxwell	Quantum Physics Schrödinger, Bohr Heisenberg, etc.
Relativistic Physics Einstein	Quantum Field Theory Dirac, Pauli, Fermi, Feynman, etc.

The Four Fundamental Forces of Nature

increasing strength

- Gravitation
- Electromagnetic
- Weak Nuclear
- Strong Nuclear

What are **Maxwell's Equations**?

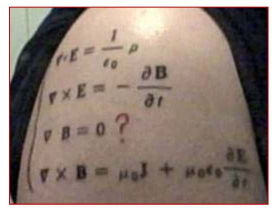
- In integral form:

$$\oint \vec{E}\cdot d\vec{a} = \frac{Q_{encl}}{\varepsilon_o} \qquad \oint \vec{B}\cdot d\vec{l} = \mu_o i_{encl} + \mu_o \varepsilon_o \frac{d\Phi_E}{dt}$$

$$\oint \vec{B}\cdot d\vec{a} = 0 \qquad \oint \vec{E}\cdot d\vec{l} = -\frac{d\Phi_B}{dt}$$

- How about the
  Lorentz Force Law?

$$\vec{F} = q\vec{E} + q\vec{v}\times\vec{B}$$



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- Now, what do they *mean?*

Vectors

- Basis (unit) vector form for writing an arbitrary vector, $\vec{A}$

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k} = A_x\hat{e}_1 + A_y\hat{e}_2 + A_z\hat{e}_3$$

Cartesian unit vectors

- So we can write fun things like

$$\vec{A}+\vec{B} = (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j} + (A_z + B_z)\hat{k}$$

$$a\vec{A} = (aA_x)\hat{i} + (aA_y)\hat{j} + (aA_z)\hat{k}$$

scalar multiplication

increase length of vector by a

Vectors: scalar (dot) product

$$\vec{A}\cdot\vec{B} = (A_xB_x) + (A_yB_y) + (A_zB_z)$$

or

$$\boxed{\vec{A}\cdot\vec{B} = \sum_{i,j=1}^{3} A_iB_j\underbrace{\hat{e}_i\cdot\hat{e}_j}_{\delta_{ij}\,=\,\text{Kronecker delta}} = \sum_{i=1}^{3} A_iB_i}$$

commutative and distributive, but not associative!

Why not?

Also $\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$

Vectors: vector (cross) product

$$\vec{A}\times\vec{B}=\hat{i}\,(A_yB_z-A_zB_y)+\hat{j}(A_zB_x-A_xB_z)+\hat{k}(A_xB_y-A_yB_x)$$

or

$$\vec{A}\times\vec{B}=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ A_x & A_y & A_z\\ B_x & B_y & B_z\end{vmatrix}$$

determinant

distributive, but not commutative

$$\vec{A}\times\vec{B}=-\vec{B}\times\vec{A}$$

nor associative

$$\vec{A}\times(\vec{B}\times\vec{C})\neq(\vec{A}\times\vec{B})\times\vec{C}$$

Also $\vec{A}\times\vec{B}=\left|\vec{A}\right|\left|\vec{B}\right|\sin\theta\,\hat{n}$

direction determined by RH Rule