MAGNETIC / ELECTRIC FORCES

#1 ~~COULOMB'S LAW / MAGN~~

#2 GAUSS'S LAW

#3 CAPACITANCE (DIELECTRICS)

#4 TIME DEPENDENT CIRCUITS

#5 AMPERE'S LAW / BIOT SAVART

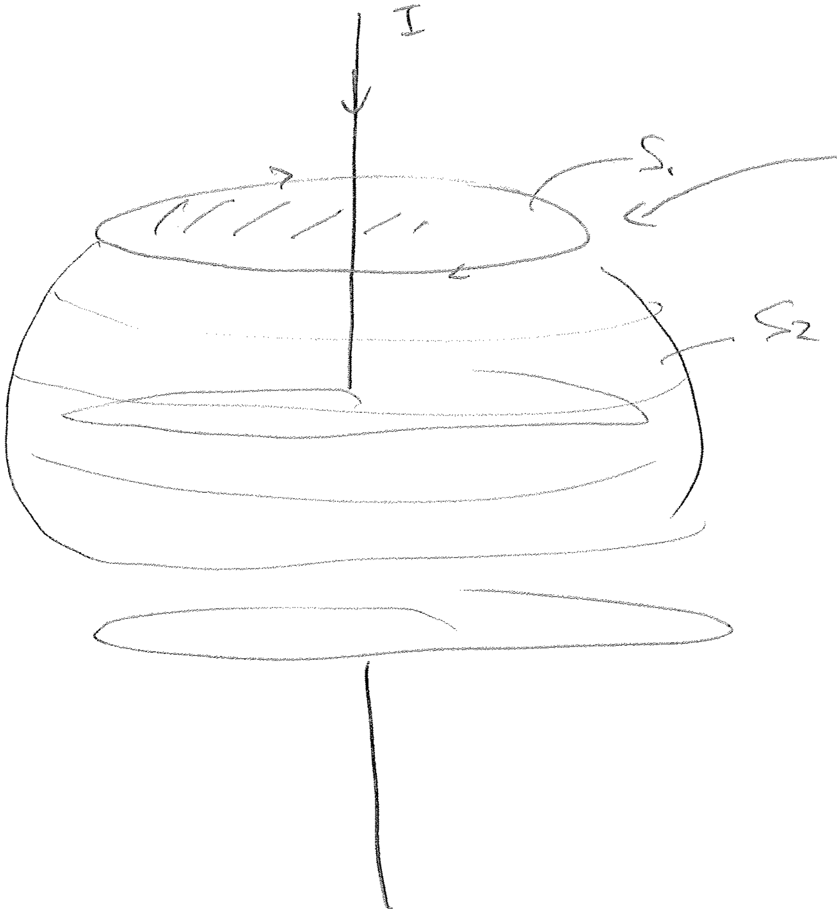
#6 EMF (MOTIONAL + OTHER)

#7 INDUCTANCE (L)

#8 AC CIRCUIT

$\left.\begin{array}{l}\text{\#7}\\ \text{\#8}\end{array}\right]$ LAST PART

12.5 PT EACH

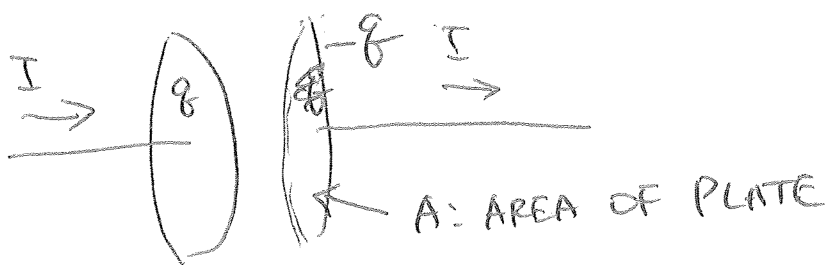


$$\oint B\cdot ds = \mu_0 I$$

S_1

$$\oint B\cdot ds = \mu_0 \cancel{I_{enc}}^{\,0}$$

$$= 0$$



$$\frac{dq}{dt} = I \qquad \frac{q}{A} = \sigma$$

$$E = \frac{\sigma}{\varepsilon_0} = \frac{q}{A\varepsilon_0} \Rightarrow q = A\varepsilon_0 E$$

$$I = \frac{dq}{dt} = \frac{d}{dt} A\varepsilon_0 E = A\varepsilon_0 \frac{dE}{dt}$$

SO REALLY AMPÈRE'S LAW

$$\oint \vec{B}\cdot d\vec{s} = \mu_0 \left(I + A \varepsilon_0 \frac{dE}{dt} \right)$$

$$= \mu_0 I + \varepsilon_0 \mu_0 \frac{d\Phi_E}{dt}$$

IN VACUUM

$$\vec{\nabla}\cdot\vec{E} = 0$$

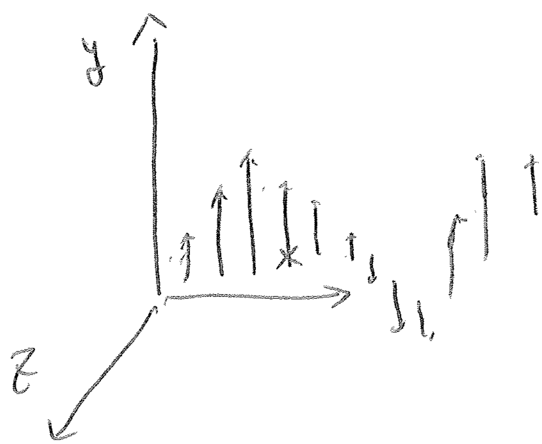
$$\vec{\nabla}\cdot\vec{B} = 0$$

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

$$\vec{\nabla}\times\vec{B} = \mu_0 \varepsilon_0 \frac{d\vec{E}}{dt}$$

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

$$\vec{E}(x,t) = E_{MAX} \sin(kx - \omega t)\,\hat{y}$$



$$\vec{\nabla} \times \vec{E} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & E_y & E_z \end{vmatrix}$$

$$= -\frac{d\vec{B}}{dt}$$

$$\vec{B} = \frac{E_{MAX}\, k}{\omega} \sin(kx - \omega t)\,\hat{z}$$

$$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B} \qquad W/m^2$$

POYNTING VECTOR

$$S_{AVERAGE} = \frac{E_{MAX} B_{MAX}}{2\mu_0} \qquad E_{MAX} = c B_{MAX}$$

$$= \frac{c B_{MAX}^2}{2\mu_0}$$

$$\vec{\nabla} \times (\vec{\nabla} \times \vec{E}) = \vec{\nabla}(\underbrace{\cancel{\vec{\nabla} \cdot \vec{E}}}_{0}) - \nabla^2 \vec{E} = \vec{\nabla} \times \left(-\frac{d\vec{B}}{dt}\right)$$

$$-\nabla^2 E = -\frac{d}{dt}(\vec{\nabla} \times \vec{B})$$

$$\vec{\nabla} \times \vec{B} = \mu_0 \varepsilon_0 \frac{d\vec{E}}{dt}$$

$$-\nabla^2 E = -\frac{d}{dt}\left(\mu_0 \varepsilon_0 \frac{dE}{dt}\right)$$

$$\nabla^2 E = \mu_0 \varepsilon_0 \frac{d^2}{dt^2} \vec{E}$$

IN 1D

$$\vec{E}(x,t) = E_{MAX} \sin(kx - \omega t)$$

$$\frac{d^2 \vec{E}}{dx^2} = \mu_0 \varepsilon_0 \frac{d^2 \vec{E}}{dt^2}$$

$$\Downarrow$$

$$k^2 = \mu_0 \varepsilon_0 \omega^2 \qquad \frac{\omega^2}{k^2} = \frac{1}{\mu_0 \varepsilon_0}$$

$$\mu_0 = 4\pi \times 10^{-7} \ T \cdot m/A$$

$$\varepsilon_0 = 8.85 \times 10^{-12} \ C^2/N \cdot m^2$$

$$\mu_0 \varepsilon_0 = 1.11 \times 10^{-17} \ \frac{s^2}{m^2} \qquad c \,\hat{=}\, 3 \times 10^8 \ m/s$$

$$\frac{1}{\mu_0 \varepsilon_0} = 9.01 \times 10^{16} \ m^2/s^2 = c^2$$

$$\boxed{\frac{w}{k} = c}$$

$$\sin(kx - wt)$$

$$\lambda = \frac{2\pi}{k}$$

$$w = \frac{f}{2\pi}$$

$$\frac{w}{k} = c = \lambda f$$

$$U_{MAX} = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2\mu_0} B^2$$

$$E_{MAX} = C B_{MAX}$$

$$= \frac{1}{2}\varepsilon_0 C^2 B_{MAX}^2 + \frac{1}{2\mu_0} B_{MAX}^2$$

$$= \frac{B_{MAX}^2}{\mu_0}$$

$$U_{AVERAGE} = \frac{B_{MAX}^2}{2\mu_0} \qquad S_{AVERAGE} = \frac{C\, B_{MAX}^2}{2\mu_0}$$

$$S_{AVERAGE\ BY\ SUN} = 1000\,W/m^2$$