E8-202 CEM Class 1.

Slide 4

E	Electric Field	(V/m)
H.	Magnetic Field	(A/m)
D	Electric Flux density	(coulombs/m^2)
B	Magnetic Flux density	(W/m^2)
J	Electric current density	(A/m^2)

$$V \longleftrightarrow E$$

$$I \longleftrightarrow H$$

$$\nabla \times \vec{V} \longrightarrow \begin{bmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ V_x & V_y & V_z \end{bmatrix}$$ curl.

$$\nabla \cdot V \longrightarrow \begin{bmatrix} \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \end{bmatrix} \begin{bmatrix} V_x \\ V_y \\ V_z \end{bmatrix}$$ div.

$$\nabla s \longrightarrow \hat{x}\frac{\partial s}{\partial x} + \hat{y}\frac{\partial s}{\partial y} + \hat{z}\frac{\partial s}{\partial z}$$ grad.

Slide 5

$$\nabla \times E = -j\omega B$$

$$\nabla \times H = j\omega D + J$$

$$\nabla \cdot D = \rho$$

F, D.

$$\nabla \cdot B = 0.$$

$$\iint_{ds} (\nabla \times E) \cdot ds = -\iint_{S} \frac{\partial B}{\partial t} ds$$

$$\Rightarrow \oint_{dl} E \cdot dl = \iint_{S} -\frac{\partial B}{\partial t} ds$$

$$\oint_{dl} H \cdot dl = \iint_{S} \frac{\partial D}{\partial t} \cdot ds + \iint_{S} J$$

$$\oiint_{S} D \cdot ds = \iiint_{V} \rho \, dv$$

$$\oiint_{S} B \cdot ds = 0$$

Slide 6 :-

$D = \epsilon E$ $\quad \epsilon \rightarrow$ permittivity (F/m)

$C = \frac{A\epsilon}{d}$ $\quad \epsilon = \frac{Cd}{A}$

$\epsilon = \frac{D}{E}$

$\frac{\text{coulomb}/m^2}{V/m}$

= Farads/m

$B = \mu H$

$\downarrow$

H/m

$C = \frac{1}{\sqrt{\mu \epsilon}}$

$J_c = \sigma E$

$\downarrow$

S/m.

$\eta = \sqrt{\frac{\mu}{\epsilon}}$

intrinsic impedance.

(Displacement current, conduction current, ~~incident~~ imposed current)

Homogenous $\longrightarrow$

NonLinear $\longrightarrow$ plasma.

AniIsotropic $\longrightarrow$ sapphire

Slide 8:-

$$\nabla \times H = j\omega D + J_c + J_i$$

$$= j\omega \epsilon_0 \epsilon_r E + \sigma E + J_i$$

$$= j\omega \epsilon_0 \epsilon_c E + J_i$$

$$\epsilon_0 \epsilon_c = \left(\epsilon_0 \epsilon_r + \frac{\sigma}{j\omega} \right)$$

$$\left[\epsilon_c = \epsilon_r - j \frac{\sigma}{\epsilon_0 \omega} \right]$$

$$\epsilon_c = \epsilon_r - j\, \epsilon_{imag}.$$

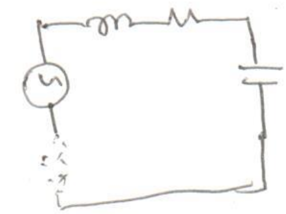
$$\tan \delta = \frac{\epsilon_{imag}}{\epsilon_{real}}.$$

Slide 9:-

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

$$\Sigma v = \oint E \cdot dl = -\frac{\partial}{\partial t}\iint B \cdot ds$$

$$-v_s + v_R + v_L + v_C = -\frac{\partial \Psi_m}{\partial t} = L_s \frac{di}{dt} = -v_{sL}$$

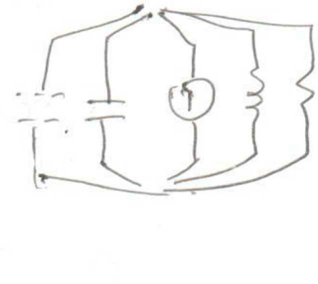


$$\nabla \cdot J = -\frac{\partial \rho}{\partial t}$$

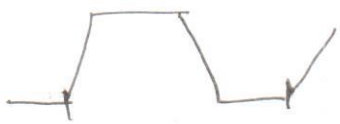
$$\oiint J \cdot ds = -\iiint \frac{\partial}{\partial t} \rho \cdot dv$$

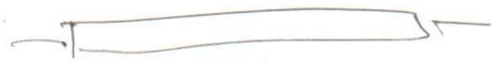
$$\Sigma i = -\frac{\partial Q}{\partial t} = -\frac{\partial}{\partial t} C v = -C \frac{\partial v}{\partial t}$$

$$-i_s + i_R + i_L + i_C = -C_s \frac{\partial v}{\partial t}$$



Fullwave :-





$$P = \frac{1}{f}$$

$$t_d = \frac{l}{c}$$

$$t_r = \frac{P}{10} = \frac{1}{10f}$$

$$t_d \gg t_r$$

$$\frac{l}{c} \gg \frac{1}{10f}$$

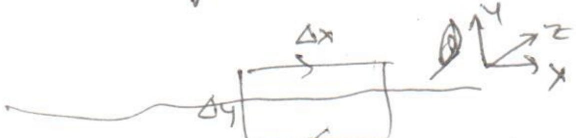
$$l \gg \frac{\lambda}{10}$$

Slide 10 :-

$$n \times (H_2 - H_1) = J_s$$

$$n \cdot (D_2 - D_1) = \rho_{es}$$

$$\oint H \cdot dl = \frac{d}{dt}\iint B \cdot ds + \iint_s J \cdot ds$$



$$(H_1 - H_2) \cdot \hat{a}_x \, \Delta x = J \cdot \hat{a}_z \, \Delta x \, \Delta y$$

$$J \Delta y \cdot \hat{a}_z \, \Delta x$$