Electromagnetic Theory

- Dot product (scalar), $\vec{A}\cdot\vec{B} = |A|\,|B|\cos\theta_{AB}$
- Vector product $\vec{A}\times\vec{B} = |A||B|\sin\theta_{AB}\cdot\vec{n}$
- Scalar triple product

$$\vec{A}\cdot(\vec{B}\times\vec{C}) = \vec{B}\cdot(\vec{C}\times\vec{A}) = \vec{C}(\vec{A}\times\vec{B})$$

- Vector triple product

$$\vec{A}\times(\vec{B}\times\vec{C}) = \vec{B}(\vec{A}\cdot\vec{C}) - \vec{C}(\vec{A}\cdot\vec{B})$$

- Value of gradient:

(a) In Cartesian coordinates

$$\nabla V = \frac{\partial V}{\partial x}\hat{a}_x + \frac{\partial V}{\partial y}\hat{a}_y + \frac{\partial V}{\partial z}\hat{a}_z$$

(b) In cylindrical coordinate

$$\nabla V = \frac{\partial V}{\partial \rho}\hat{a}_\rho + \frac{1}{\rho}\frac{\partial V}{\partial \phi}\hat{a}_\phi + \frac{\partial V}{\partial z}\hat{a}_z$$

(c) In spherical polar coordinates

$$\nabla V = \frac{\partial V}{\partial r}\hat{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\hat{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\hat{a}_\phi$$

- Values of Divergence

(a) In Cartesian coordinates

$$\nabla\cdot\vec{A} = \frac{\partial A_x}{\partial x} + \frac{\partial A_y}{\partial y} + \frac{\partial A_z}{\partial z}$$

(b) In Cylindrical coordinate

$$\nabla\cdot\vec{A} = \frac{1}{\rho}\frac{\partial(\rho A_\rho)}{\partial \rho} + \frac{1}{\rho}\frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

(c) In Spherical polar coordinate

$$\nabla\cdot\vec{A} = \frac{1}{r^2}\frac{\partial(r^2 A_r)}{\partial r} + \frac{1}{r\sin\theta}\frac{\partial(\sin\theta A_\theta)}{\partial \theta} + \frac{1}{r\sin\theta}$$

- Divergence theorem $\int_V \nabla\cdot\vec{A}\,dv = \oint_S \vec{A}\cdot d\vec{s}$
- Stoke's theorem $\oint_L \vec{A}\cdot d\vec{l} = \int_S \nabla\times\vec{A}\cdot d\vec{s}$

- Gauss's Law- $\overline{D} = \varepsilon\overline{E} = \frac{Q}{4\pi r^2}\hat{a}_r$
- Flux density $\overline{D} = \varepsilon\overline{E}$
- Electric flux as $\psi = \int_S \overline{D}.d\overline{s}$
- Poisson's equation $\nabla^2 V = -\frac{\rho_v}{\varepsilon}$
- Laplace's equation $\boxed{\nabla^2 V = 0}$
- Magnetic Force $F = \int (I \times B)\, d\ell = BIL$
- Biot-Savartlaw $d\overline{H} = \frac{Id\overline{l} \times \hat{a}_R}{4\pi R^2} = \frac{Id\overline{l} \times \overline{R}}{4\pi R^3}$
- Ampere's Circuital Law

  $\oint \overline{H}.d\overline{l} = I_{enc}$ OR $\nabla \times \overline{H} = \overline{J}$
- Boundary Conditions (FOR ELECTRIC FIELD):
  Tangential component

  $E_{1t} = E_{2t}$ or $\frac{D_{1t}}{\varepsilon_1} = \frac{D_{2t}}{\varepsilon_2}$

  Normal component

  $D_{1n} - D_{2n} = \rho_s$

  $\varepsilon_1 E_{1n} - \varepsilon_2 E_{2n} = \rho_s$
- Boundary Conditions(FOR magnetic fiels):
  For normal component
  For tangential component

  $B_{1n} = B_{2n}$ $H_{1t} - H_{2t} = J_{Sn}$
- Energy stored in Magnetic Field

  $W = \int_0^I Li\,di = \frac{1}{2}LI^2$ Joule
- Poynting Vector $\boxed{\overline{P} = \overline{E} \times \overline{H}}$
- Value of attenuation, phase constant for per fect dielectric are $\alpha = \frac{\sigma}{2}\sqrt{\frac{\mu}{\varepsilon}}$, $\beta = \omega\sqrt{\mu\varepsilon}$.
- Skin Depth $\partial = \frac{1}{\alpha} = \sqrt{\frac{2}{\omega\mu\sigma}}$
- Reflection coefficient $\tau = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$ and

  tranmission coefficient $T = \frac{2\eta_2}{\eta_1 + \eta_2} = 1 + \tau$
- Standing wave ratio $S = \frac{|E|_{max}}{|E|_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$
- Brewster angle $\tan\theta_B = \sqrt{\frac{\epsilon_2}{\epsilon_1}}$

- Reflection coefficient at the load end of the line $\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$
- Impedance at any Point on the Line

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan \beta \ell}{Z_0 + jZ_L \tan \beta \ell} \right]$$

- Return loss (RL) = $-20 \log |\Gamma_L|$ dB
- Approximate beam width of horn antenna

$$\theta_E = \frac{56 \lambda^\circ}{h} \quad \text{and} \quad \theta_H = \frac{67 \lambda^\circ}{w}$$

- Directivity of horn $D = \frac{7.5 A}{\lambda^2}$
- Maximum Radar Range (R_{max})

$$R_{max} = \left[\frac{P_t . G \sigma A_e}{(4\pi)^2 . S_{min}} \right]^{\frac{1}{4}}$$

- Maximum unambiguous range

$$R_{unamb} = \frac{c(T_{ON} + T_{FF})}{2} = \frac{c}{2\,prf}$$