EMTL

Statics

Electrostatics

$\bar{E}(r)(Q)$

Behaviour of charge at rest

Magnetostatics

$\bar{H}(r)$

Source: Static current (D.C)

Behaviour of the charge with constant velocity

Time Varying

Electromagnetics

$\bar{E} \times \bar{H} = \bar{P}(r,t) \left(\frac{di}{dt}\right)$

Source: Time varying current (A.

Accelerated charge.

Maxwell's equations:-

$\nabla \times \bar{E} = 0 \qquad D = \varepsilon E$

$\nabla \cdot \bar{D} = \rho_v \, [\neq 0]$

$\varepsilon(\nabla \cdot \bar{E}) = \rho_v \, (\neq 0)$

charge Q

$\nabla \times \Rightarrow$ curl

$\nabla \cdot \Rightarrow$ Divergence

$\Big\} \, \nabla^2 - \nabla^2$

$\nabla \times \bar{H} = J + \vec{J}_d$

$J_D = \frac{\partial D}{\partial t}$

$\varepsilon \, \nabla \cdot \bar{E} = \rho_v \, (\neq 0)$

$\mu \, \nabla \cdot \bar{H} = 0$

$\nabla \times E = \frac{-\partial B}{\partial t} \, (\neq 0)$

charge:-

Excess (or) deficiency of electrons behaves as a net charge.

Charge at rest:-

charge at rest generates static electric field.

<u>Charge with constant velocity</u> (or) uniform motion generates static Magnetic field.

<u>Accelerated charge generates electromagnetic field</u> (or) electromagnetic wave (or) Radiation.

Vector field:-

It is having magnitude and direction and for defining any vector field, its divergence and its curl has to be specified based on <u>Helmholtz principle</u>

$\bar{E}$ → $\nabla \cdot E$, $\nabla \times \bar{E}$

$\bar{H}$ → $\nabla \cdot \bar{H}$, $\nabla \times H$

Divergence :-

Divergence - it gives variation of any vector field in the direction of propagation (or) it gives net out (or) in flow of flux (or) energy

$$\nabla\cdot\bar{D} = \lim_{\Delta v \to 0} \frac{\oint \bar{D}\cdot d\bar{s}}{\Delta v}$$

$$\oint_S \bar{D}\cdot d\bar{s} = \int_V \nabla\cdot\bar{D}\, dv$$

∴ Gauss (or) Divergence theorem.

Gauss (or) Divergence theorem is used for converting closed surface integral to volume integral.

$$\nabla\cdot\bar{D} = \lim_{\Delta V \to 0} \frac{\oint \bar{D}\cdot d\bar{s}}{\Delta V} = \frac{\Delta Q}{\Delta V} = \rho_v$$

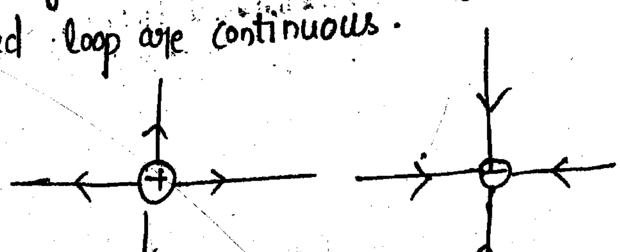
$\boxed{\nabla\cdot\bar{D} = \rho_v}$ ⇒ Gauss law in point (or) Differential form.

$\nabla\cdot\bar{D} = \rho_v$ → Isolated electric charge (or) Source existing.
out/in flow

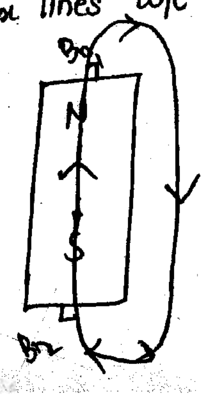
$\nabla\cdot\bar{B} = 0$ → Isolated magnetic source (or) charge (or) magnetic monopole doesnot exists.

Electric flux is always leaving from Isolated positive charge and are entering at isolated negative charge (or) electric flux lines are discontinuous.

Magnetic flux lines are leaving from North pole and are entering at South pole externally. These lines are leaving from south pole and entering at North pole internally (or) Magnetic flux lines are existing in closed loop are continuous.



Discontinuous



$\nabla \cdot \bar{D} = \rho_v$

$D_{n_1} - D_{n_2} = \rho_v$

$D_{n_1} \neq D_{n_2}$ => Normal electric flux is discontinuous

Divergence => gives about source

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

Net divergence = '0'

Inflow = outflow

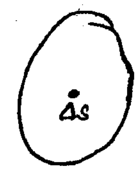
$B_{nor1} = B_{nor2}$

Magnetic flux lines are continuous

Curl:-

It gives variation of any vector field in its normal plane w.r.t direction of propagation (or) it gives rotational (or) circulating motion.

$$\nabla \times \bar{H} = \underset{\Delta s \to 0}{Lt} \frac{\oint \bar{H} \cdot d\bar{l}}{\Delta s}$$



$$\oint_l \bar{H} \cdot d\bar{l} = \int_s (\nabla \times \bar{H}) \, ds$$ => Stoke's theorem

$$\nabla \times \bar{H} = \frac{\Delta I}{\Delta s}$$

$\nabla \times \bar{H} = \bar{J}$ => Ampere's law

Rotational motion having by magnetic field determined by current.