and M to H

$$M = \chi_m H \qquad -(11)$$

Lorentz force equation, written in point form as the force per unit volume,

$$\boxed{f = \rho_v (E + v \times B)} \qquad -(12)$$

MAXWELL'S EQUATIONS IN IN INTEGRAL FORM→

Maxwell's Equation for time-varying form, Integrating,

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

over a surface and applying Stokes' theorem, we obtain Faraday's law,

$$\oint E \cdot dL = -\int_S \frac{\partial B}{\partial t} \cdot dS \qquad -(1)$$

Integrating, we find Ampere's circuital law,

$$\nabla \times H = J + \frac{\partial D}{\partial t}$$

$$\oint H \cdot dL = I + \int_S \frac{\partial D}{\partial t} \cdot dS \qquad -(2)$$

Gauss's law for electric and magnetic fields are obtained by integrating

$$\nabla \cdot D = \rho_v \quad , \quad \nabla \cdot B = 0$$

throughout a volume and using the divergence theorem;

$$\oint_S D \cdot dS = \int_{vol} \rho_v \, dv \qquad - (3)$$

$$\oint_S B \cdot dS = 0 \qquad - (4)$$

These four integral equations enable us to find the boundary conditions on B, D, H & E which solve Maxwell's equations in partial differential form.

The boundary condition is unchanged from their forms for static or steady fields, & the same methods may be used to obtain them.

Between any two real physical media (1) enable us to relate the tangential E- field components,

$$E_{t1} = E_{t2} \qquad - (5)$$

& from Eq^n (2) $\quad H_{t1} = H_{t2} \qquad - (6)$

The surface integrals produce the boundary conditions on the normal components,

$$D_{N1} - D_{N2} = \rho_S \qquad -(7)$$

&

$$B_{N1} = B_{N2} \qquad -(8)$$

By assuming a perfect conductor for which σ is infinite but J is finite. From Ohm's law, then in a perfect conductor,

$$E = 0$$

& it follows from the point form of Faraday's law that

$$H = 0$$

for time varying fields. The point form of Ampere's circuital law then shows that the finite value of J is

$$J = 0$$

& current must be carried on the conductor surface as a surface current K. Thus if region (2) is a perfect conductor, (5) to (8) become respectively.

$$E_{t1} = 0 \qquad -(9)$$

$$H_{t1} = K \qquad -(10)$$

$$D_{N1} = \rho_S \qquad -(11)$$

$$B_{N1} = 0 \qquad -(12)$$

where a_N is an outward normal at the conductor surface.

RETARTED POTENTIAL →

The time-varying potential usually called retarted potential.

The scalar electric potential V may be expressed in terms of a static charge distribution,

$$V = \int_{vol} \frac{\rho_v \, dv}{4\pi \epsilon R} \quad (\text{static}) \qquad -(1)$$

and vector magnetic potential may be found from a current distribution which is constant ~~to~~ with time,

$$A = \int_{vol} \frac{\mu J \, dv}{4\pi R} \quad (\text{dc}) \qquad -(2)$$

The differential equations satisfied by V,

$$\nabla^2 V = -\frac{\rho_v}{\epsilon} \quad (\text{static}) \qquad -(3)$$

& A

$$\nabla^2 A = -\mu J \quad (\text{dc}) \qquad -(4)$$

Eq^n (1) & (2) is integral form,

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