Spherical

$\hat{r} = \sin\theta \cdot \cos\phi \cdot x + \sin\theta \cdot \sin\phi \cdot y + \cos\theta \cdot z$

$\hat{\theta} = \sin\theta \cdot \cos\phi \cdot x + \cos\theta \cdot \sin\phi \cdot y - \sin\theta \cdot z$

$\phi = -\sin\theta \cdot x + \cos\phi \cdot y$

$$\bar{\nabla} \times A = \begin{vmatrix} a_r & r\hat{a}_\theta & r\sin\theta \cdot \hat{a}_\phi \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \phi} \\ A_r & A_\theta & A_\phi \end{vmatrix}$$

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

$$\nabla J_v = -\frac{d}{dt} \cdot q_v$$

$$\bar{\nabla} \cdot \bar{A} = -\mu_0 \cdot \varepsilon_0 \cdot \frac{dV}{dt}$$ ↗ Lorentz

$\bar{\nabla} \times \bar{E} = 0$ and $\bar{\nabla} \times \bar{H} = \bar{J}$

$\bar{\nabla} \cdot \bar{D} = \rho$ $\quad \bar{\nabla} \cdot \bar{B} = 0$

$$H\mu = \bar{\nabla} \times \bar{A} = B$$

$$E = -\nabla V - jwA$$

$$\nabla A = -\mu_0 \cdot \varepsilon_0 \cdot \frac{d\phi}{dt}$$

$\nabla E = \frac{q}{\varepsilon_0}$ Gauss Law

$\nabla B = 0$

$\nabla \times E = -\frac{dB}{dt}$ Faraday's Law

$\nabla \times H = J + \frac{dD}{dt}$

J_{disp}

$$J = \sigma \cdot E$$

Helmholtz eqn $= \nabla^2 E + w^2 \cdot \mu_0 \cdot \varepsilon_0 \cdot E = 0$

$\nabla \times \nabla \times E = \nabla(\nabla E) - \nabla^2 E$ ⇒ wave equation

Vector differential eqn

$r = \sqrt{x^2 + y^2}$

$\theta = \arctan(y/x)$

cylindrical

$$\nabla \cdot A = \frac{1}{r} \cdot \frac{d}{dr} \cdot (r \cdot A_r) + \frac{1}{r} \cdot \frac{dA_\phi}{d\phi} + \frac{dA_z}{dz}$$

$x = r \cdot \cos\theta$

$y = r \cdot \sin\theta$

$z = z$

Plane waves

$$\lambda = \frac{2\pi}{k} = \frac{\frac{c}{f}}{\sqrt{\mu_r \cdot \varepsilon_r}} \qquad v = c = \frac{1}{\sqrt{\mu_0 \cdot \varepsilon_0}}$$

$$= \sqrt{\frac{\mu}{\varepsilon}} = \eta \text{ (eta)} = \frac{E_x}{H_y} = \frac{V}{A} = \Omega$$

$E \perp H$

such that

$\boxed{\bar{H} = \frac{1}{\eta} \hat{a}_z \times \bar{E}}$

or $\hat{a}_z \times \bar{E} = \eta \bar{H}$)

$\boxed{\bar{H} \times \hat{n} = \frac{\bar{E}}{\eta}}$

or

$\boxed{\hat{n} \times \bar{E} = \eta \bar{H}}$

$A_0 \cdot \cos(wt - k \cdot a_r$

$e^{-jk\bar{a}_r}$

$$a_n = \frac{\vec{k}}{|k|} \qquad k = w\sqrt{\mu . \varepsilon} \qquad \frac{w}{|k|} = v$$

$$\nabla^2 E(r,t) - \mu_0 \cdot \varepsilon_0 \cdot \frac{d^2}{dt^2} E(r,t) = \mu_0 \cdot \frac{dJ_v(r,t)}{dt} + \frac{1}{\varepsilon_0} \nabla \rho_v (r,t)$$

$$B = \frac{\mu_0 \cdot I_0}{2\pi x} \qquad V_{in} = \int \vec{J} \times \vec{B} \cdot dl \qquad \int B ds = \phi$$