$$\nabla \times E = -\mu \frac{\partial \vec{H}}{\partial t} = \underline{\underline{-i\omega\mu \vec{H}}}$$

$$\nabla \times H = \epsilon \frac{\partial \vec{E}}{\partial t} \qquad E \sim e^{i\omega t}$$

$$\frac{\partial}{\partial z} \sim -\gamma \qquad e^{-\gamma z}$$

$$i\omega\epsilon E_x = \gamma H_y + \frac{\partial}{\partial y} H_z$$

$$= \frac{\gamma}{i\omega\mu}\left(E_x + \frac{\partial}{\partial x} E_z\right) + \frac{\partial}{\partial y} H_z .$$

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\gamma^2\right)E_\alpha = \underline{\underline{-\omega^2\mu\epsilon}}\, E_\alpha .$$

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+k^2\right)H_z(x,y)=0$$

$$H_z(x,y)=X(x)\,Y(y)$$

$$Y\frac{\partial^2 X}{\partial x^2}+X\frac{\partial^2 Y}{\partial y^2}+k^2XY=0$$

$$\frac{1}{X}\frac{\partial^2 X}{\partial x^2}+\frac{1}{Y}\frac{\partial^2 Y}{\partial y^2}+k^2=0$$

$$\frac{1}{X}\frac{\partial^2 X}{\partial x^2}+k^2=-\frac{1}{Y}\frac{\partial^2 Y}{\partial y^2}=k_y^2$$

$$k_x^2=k^2-k_y^2$$

$$X = C_1 \cos(k_x x) + C_2 \sin(k_x x)$$

$$Y = C_3 \cos(k_y y) + C_4 \sin(k_y y)$$

$$k^2 = k_x^2 + k_y^2 .$$

$$\begin{aligned} H_z = XY = {} & C_3 C_1 \cos k_x x \cdot \cos k_y y \\ & + C_1 C_4 \cos k_x x \; \sin k_y y \\ & + C_2 C_3 \sin k_x x \; \cos k_y y \\ & + C_2 C_4 \sin k_x x \; \sin k_y y . \end{aligned}$$

$$e^{-\gamma z}$$

$$\gamma = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - \omega^2\mu\epsilon}$$

$$\omega_c = \frac{1}{\mu\epsilon}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}\,.$$

$$\nabla^2 E_\alpha = -\omega^2 \mu \epsilon E_\alpha$$

$$E_\alpha = X_\alpha(x) Y_\alpha(y) Z_\alpha(z)$$

$$YZ \frac{\partial^2}{\partial x^2} X_\alpha(x) + XZ \frac{\partial^2}{\partial y^2} Y_\alpha(y) + XY \frac{\partial^2}{\partial z^2} Z_\alpha(y)$$

$$= -\omega^2 \mu \epsilon . XYZ$$

$$\frac{1}{X} \frac{\partial^2}{\partial x^2} X + \frac{1}{Y} \frac{\partial^2 Y}{\partial y^2} + \frac{1}{Z} \frac{\partial^2 Z}{\partial z^2} = -\omega^2 \mu \epsilon$$

$$\frac{\partial^2 X}{\partial x^2} = -k_x^2 X \; ; \quad \frac{\partial^2 Y}{\partial y^2} = -k_y^2 Y$$

$$\frac{\partial^2 Z}{\partial z^2} = -k_z^2 Z \quad : \quad k_x^2 + k_y^2 + k_z^2 = \omega^2 \mu \epsilon$$

$$E_x^0 k_x + E_y^0 k_y + E_z^0 k_z = 0$$

$$\vec{E} \perp \vec{k}$$

$$\nabla^2 E = -\omega^2 \mu \epsilon$$

$$k_x^2 + k_y^2 + k_z^2 = \omega^2 \mu \epsilon$$

$$\frac{\ell^2 \pi^2}{a^2} + \frac{m^2 \pi^2}{b^2} + \frac{n^2 \pi^2}{d^2} = \frac{\omega^2}{c^2}$$

$(TE)_{101}$

$\ell = 1$
$m = 0$
$n = 1$