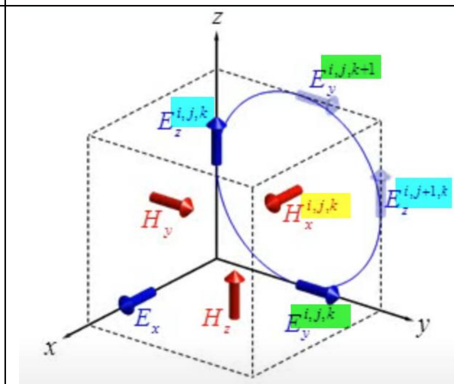
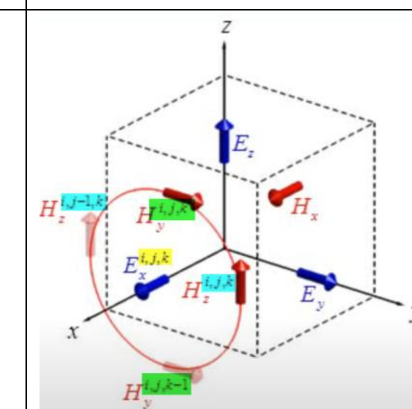
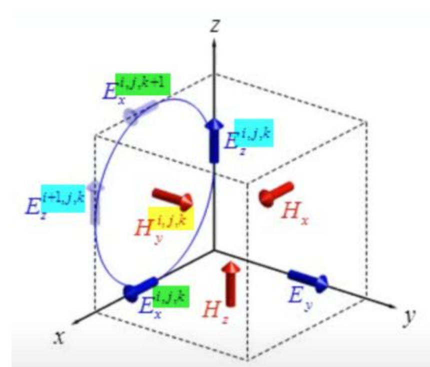
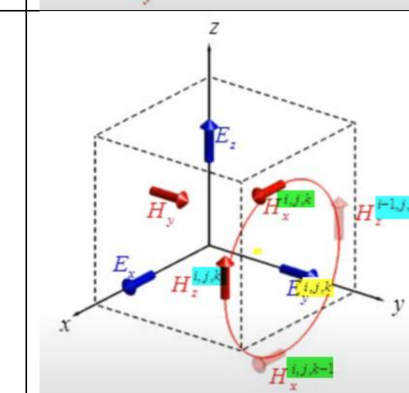
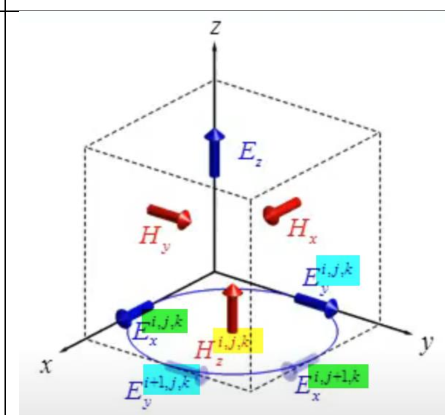
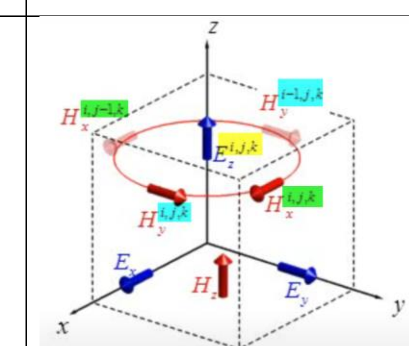
Normalize Maxwell's Equations	$[a]$ – $Tensor$ $\vec{v} - vector$		
$\nabla \times \vec{E} = -[\mu]\frac{\partial \vec{H}}{\partial t}$	$\nabla \times \vec{H} = [\epsilon]\frac{\partial \vec{E}}{\partial t}$	$\nabla \times \vec{E} = -[\mu]\frac{\partial \vec{H}}{\partial t}$	$\nabla \times \vec{H} = [\epsilon]\frac{\partial \vec{E}}{\partial t}$
let: $\vec{\tilde{H}} = \sqrt{\frac{\mu_0}{\epsilon_0}}\vec{H}$	or: $\vec{H} = \sqrt{\frac{\epsilon_0}{\mu_0}}\vec{\tilde{H}}$	let: $\vec{\tilde{E}} = \sqrt{\frac{\epsilon_0}{\mu_0}}\vec{E}$	or: $\vec{E} = \sqrt{\frac{\mu_0}{\epsilon_0}}\vec{\tilde{E}}$
Substitute: $\nabla \times \vec{E} = -[\mu]\frac{\partial\left(\sqrt{\frac{\epsilon_0}{\mu_0}}\vec{\tilde{H}}\right)}{\partial t}$	And: $\nabla \times \left(\vec{\tilde{H}}\sqrt{\frac{\epsilon_0}{\mu_0}}\right) = [\epsilon]\frac{\partial \vec{E}}{\partial t}$	Substitute: $\nabla \times \sqrt{\frac{\mu_0}{\epsilon_0}}\vec{\tilde{E}} = -[\mu]\frac{\partial(\vec{H})}{\partial t}$	And: $\nabla \times \vec{H} = [\epsilon]\frac{\partial\left(\sqrt{\frac{\mu_0}{\epsilon_0}}\vec{\tilde{E}}\right)}{\partial t}$
$\nabla \times \vec{E} = -[\mu_r\mu_0]\sqrt{\frac{\epsilon_0}{\mu_0}}\frac{\partial(\vec{\tilde{H}})}{\partial t}$	$\nabla \times \vec{\tilde{H}} = -\sqrt{\frac{\mu_0}{\epsilon_0}}[\epsilon_r\epsilon_0]\frac{\partial \vec{E}}{\partial t}$	$\nabla \times \vec{\tilde{E}} = -[\mu_r\mu_0]\sqrt{\frac{\epsilon_0}{\mu_0}}\frac{\partial(\vec{H})}{\partial t}$	$\nabla \times \vec{H} = \sqrt{\frac{\mu_0}{\epsilon_0}}[\epsilon_r\epsilon_0]\frac{\partial \vec{\tilde{E}}}{\partial t}$
$\nabla \times \vec{E} = -[\mu_r]\sqrt{\mu_0\epsilon_0}\frac{\partial(\vec{\tilde{H}})}{\partial t}$	$\nabla \times \vec{\tilde{H}} = \sqrt{\mu_0\epsilon_0}[\epsilon_r]\frac{\partial \vec{E}}{\partial t}$	$\nabla \times \vec{\tilde{E}} = -[\mu_r]\sqrt{\mu_0\epsilon_0}\frac{\partial(\vec{H})}{\partial t}$	$\nabla \times \vec{H} = \sqrt{\mu_0\epsilon_0}[\epsilon_r]\frac{\partial \vec{\tilde{E}}}{\partial t}$
recall: $c_0 = \frac{1}{\sqrt{\mu_0\epsilon_0}}$		recall: $c_0 = \frac{1}{\sqrt{\mu_0\epsilon_0}}$	Also let: $\vec{\tilde{E}} = \frac{\vec{\tilde{D}}}{\epsilon_r}$
$\nabla \times \vec{E} = -\frac{[\mu_r]}{c_0}\frac{\partial(\vec{\tilde{H}})}{\partial t}$	$\nabla \times \vec{\tilde{H}} = \frac{[\epsilon_r]}{c_0}\frac{\partial \vec{E}}{\partial t}$	$\nabla \times \vec{\tilde{E}} = -\frac{[\mu_r]}{c_0}\frac{\partial(\vec{H})}{\partial t}$	$\nabla \times \vec{H} = \frac{[\epsilon_r]}{c_0}\frac{\partial \vec{\tilde{E}}}{\partial t} = \frac{1}{c_0}\frac{\partial \vec{\tilde{D}}}{\partial t}$

Expansion of spatial component (Analytic)		**Expansion of temporal component (Analytic)**	
$\nabla \times \vec{\tilde{E}} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & E_y & E_z \end{vmatrix}$	$\hat{x}\left[\frac{\partial \tilde{E}_z}{\partial y} - \frac{\partial \tilde{E}_y}{\partial z}\right] - \hat{y}\left[\frac{\partial \tilde{E}_z}{\partial x} - \frac{\partial \tilde{E}_x}{\partial z}\right] + \hat{z}\left[\frac{\partial \tilde{E}_y}{\partial x} - \frac{\partial \tilde{E}_x}{\partial y}\right]$ or $\begin{bmatrix} \frac{\partial \tilde{E}_z}{\partial y} - \frac{\partial \tilde{E}_y}{\partial z} \\ \frac{\partial \tilde{E}_z}{\partial x} - \frac{\partial \tilde{E}_x}{\partial z} \\ \frac{\partial \tilde{E}_y}{\partial x} - \frac{\partial \tilde{E}_x}{\partial y} \end{bmatrix}$	$-\frac{[\mu_r]}{c_0}\frac{\partial(\vec{\tilde{H}})}{\partial t} = -\frac{\begin{bmatrix} \mu_{xx} & \mu_{xy} & \mu_{xz} \\ \mu_{yx} & \mu_{yy} & \mu_{yz} \\ \mu_{zx} & \mu_{zy} & \mu_{zz} \end{bmatrix}\begin{bmatrix} \frac{\partial H_x}{\partial t} \\ \frac{\partial H_y}{\partial t} \\ \frac{\partial H_z}{\partial t} \end{bmatrix}}{c_0} = -\frac{1}{c_0}\begin{bmatrix} \mu_{xx}\frac{\partial H_x}{\partial t} + \mu_{xy}\frac{\partial H_y}{\partial t} + \mu_{xz}\frac{\partial H_z}{\partial t} \\ \mu_{yx}\frac{\partial H_x}{\partial t} + \mu_{yy}\frac{\partial H_y}{\partial t} + \mu_{yz}\frac{\partial H_z}{\partial t} \\ \mu_{zx}\frac{\partial H_x}{\partial t} + \mu_{zy}\frac{\partial H_y}{\partial t} + \mu_{zz}\frac{\partial H_z}{\partial t} \end{bmatrix}$	
$\nabla \times \vec{H} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ H_x & H_y & H_z \end{vmatrix}$	$\hat{x}\left[\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right] - \hat{y}\left[\frac{\partial H_z}{\partial x} - \frac{\partial H_x}{\partial z}\right] + \hat{z}\left[\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y}\right]$ or $\begin{bmatrix} \frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z} \\ \frac{\partial H_z}{\partial x} - \frac{\partial H_x}{\partial z} \\ \frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} \end{bmatrix}$	$\frac{[\epsilon_r]}{c_0}\frac{\partial \vec{\tilde{E}}}{\partial t} = \frac{\begin{bmatrix} \epsilon_{xx} & \epsilon_{xy} & \epsilon_{xz} \\ \epsilon_{yx} & \epsilon_{yy} & \epsilon_{yz} \\ \epsilon_{zx} & \epsilon_{zy} & \epsilon_{zz} \end{bmatrix}\begin{bmatrix} \frac{\partial \tilde{E}_x}{\partial t} \\ \frac{\partial \tilde{E}_y}{\partial t} \\ \frac{\partial \tilde{E}_z}{\partial t} \end{bmatrix}}{c_0} = \frac{1}{c_0}\begin{bmatrix} \epsilon_{xx}\frac{\partial \tilde{E}_x}{\partial t} + \epsilon_{xy}\frac{\partial \tilde{E}_y}{\partial t} + \epsilon_{xz}\frac{\partial \tilde{E}_z}{\partial t} \\ \epsilon_{yx}\frac{\partial \tilde{E}_x}{\partial t} + \epsilon_{yy}\frac{\partial \tilde{E}_y}{\partial t} + \epsilon_{yz}\frac{\partial \tilde{E}_z}{\partial t} \\ \epsilon_{zx}\frac{\partial \tilde{E}_x}{\partial t} + \epsilon_{zy}\frac{\partial \tilde{E}_y}{\partial t} + \epsilon_{zz}\frac{\partial \tilde{E}_z}{\partial t} \end{bmatrix}$	

Combine Like terms

				Spatial	*Temporal*	
1)	$\frac{\partial \tilde{E}_z}{\partial y} - \frac{\partial \tilde{E}_y}{\partial z} =$	$\frac{\mu_{xx}}{c_0}\frac{\partial H_x}{\partial t} + \frac{\mu_{xy}}{c_0}\frac{\partial H_y}{\partial t} + \frac{\mu_{xz}}{c_0}\frac{\partial H_z}{\partial t}$		$\frac{\partial \tilde{E}_z}{\partial y} - \frac{\partial \tilde{E}_y}{\partial z} =$	$\frac{\mu_{xx}}{c_0}\frac{\partial H_x}{\partial t}$	Temporal Derivative: https://youtu.be/TbzFef5gUms?si=RskghzimP8cbLjer&t=2488 Spatial Derivative: https://youtu.be/sxv_L4rscL0?si=CZmMD1BDGB6J-39e&t=1150
2)	$\frac{\partial \tilde{E}_x}{\partial z} - \frac{\partial \tilde{E}_z}{\partial x} =$	$\frac{\mu_{yx}}{c_0}\frac{\partial H_x}{\partial t} + \frac{\mu_{yy}}{c_0}\frac{\partial H_y}{\partial t} + \frac{\mu_{yz}}{c_0}\frac{\partial H_z}{\partial t}$		$\frac{\partial \tilde{E}_x}{\partial z} - \frac{\partial \tilde{E}_z}{\partial x} =$	$\frac{\mu_{yy}}{c_0}\frac{\partial H_y}{\partial t}$	
3)	$\frac{\partial \tilde{E}_y}{\partial x} - \frac{\partial \tilde{E}_x}{\partial y} =$	$\frac{\mu_{zx}}{c_0}\frac{\partial H_x}{\partial t} + \frac{\mu_{zy}}{c_0}\frac{\partial H_y}{\partial t} + \frac{\mu_{zz}}{c_0}\frac{\partial H_z}{\partial t}$	Assume Diagonal ϵ & μ Tensor →	$\frac{\partial \tilde{E}_y}{\partial x} - \frac{\partial \tilde{E}_x}{\partial y} =$	$\frac{\mu_{zz}}{c_0}\frac{\partial H_z}{\partial t}$	
4)	$\frac{\partial \tilde{H}_z}{\partial y} - \frac{\partial \tilde{H}_y}{\partial z} =$	$\frac{\epsilon_{xx}}{c_0}\frac{\partial \tilde{E}_x}{\partial t} + \frac{\epsilon_{xy}}{c_0}\frac{\partial \tilde{E}_y}{\partial t} + \frac{\epsilon_{xz}}{c_0}\frac{\partial \tilde{E}_z}{\partial t}$		$\frac{\partial \tilde{H}_z}{\partial y} - \frac{\partial \tilde{H}_y}{\partial z} =$	$\frac{\epsilon_{xx}}{c_0}\frac{\partial \tilde{E}_x}{\partial t}$	
5)	$\frac{\partial \tilde{H}_x}{\partial z} - \frac{\partial \tilde{H}_z}{\partial x} =$	$\frac{\epsilon_{yx}}{c_0}\frac{\partial \tilde{E}_x}{\partial t} + \frac{\epsilon_{yy}}{c_0}\frac{\partial \tilde{E}_y}{\partial t} + \frac{\epsilon_{yz}}{c_0}\frac{\partial \tilde{E}_z}{\partial t}$		$\frac{\partial \tilde{H}_x}{\partial z} - \frac{\partial \tilde{H}_z}{\partial x} =$	$\frac{\epsilon_{yy}}{c_0}\frac{\partial \tilde{E}_y}{\partial t}$	
6)	$\frac{\partial \tilde{H}_y}{\partial x} - \frac{\partial \tilde{H}_x}{\partial y} =$	$\frac{\epsilon_{zx}}{c_0}\frac{\partial \tilde{E}_x}{\partial t} + \frac{\epsilon_{zy}}{c_0}\frac{\partial \tilde{E}_y}{\partial t} + \frac{\epsilon_{zz}}{c_0}\frac{\partial \tilde{E}_z}{\partial t}$		$\frac{\partial \tilde{H}_y}{\partial x} - \frac{\partial \tilde{H}_x}{\partial y} =$	$\frac{\epsilon_{zz}}{c_0}\frac{\partial \tilde{E}_z}{\partial t}$	

Expansion of Temporal component (numeric)			
$\frac{\partial \tilde{E}_z(t)}{\partial y} - \frac{\partial \tilde{E}_y(t)}{\partial z} = \overbrace{\frac{\mu_{xx}}{c_0}\frac{\partial H_x(t)}{\partial t}}^{Temporal}$	$\frac{\partial \tilde{E}_z(t)}{\partial y} - \frac{\partial \tilde{E}_y(t)}{\partial z} = \frac{\mu_{xx}}{c_0}\frac{\overbrace{H_x(t+\Delta t/2)}^{Future\ value} - H_x(t-\Delta t/2)}{\Delta t}$	Solve for the future value of the field →	$H_x(t+\Delta t/2) = \frac{c_0\Delta t}{\mu_{xx}}\left[\frac{\partial \tilde{E}_z(t)}{\partial y} - \frac{\partial \tilde{E}_y(t)}{\partial z}\right] + H_x(t-\Delta t/2)$
$\frac{\partial \tilde{E}_x(t)}{\partial z} - \frac{\partial \tilde{E}_z(t)}{\partial x} = \frac{\mu_{yy}}{c_0}\frac{\partial H_y(t)}{\partial t}$	$\frac{\partial \tilde{E}_x(t)}{\partial z} - \frac{\partial \tilde{E}_z(t)}{\partial x} = \frac{\mu_{yy}}{c_0}\frac{H_y(t+\Delta t/2) - H_y(t-\Delta t/2)}{\Delta t}$		$H_y(t+\Delta t/2) = \frac{c_0\Delta t}{\mu_{yy}}\left[\frac{\partial \tilde{E}_x(t)}{\partial z} - \frac{\partial \tilde{E}_z(t)}{\partial x}\right] + H_y(t-\Delta t/2)$
$\frac{\partial \tilde{E}_y(t)}{\partial x} - \frac{\partial \tilde{E}_x(t)}{\partial y} = \frac{\mu_{zz}}{c_0}\frac{\partial H_z(t)}{\partial t}$	$\frac{\partial \tilde{E}_y(t)}{\partial x} - \frac{\partial \tilde{E}_x(t)}{\partial y} = \frac{\mu_{zz}}{c_0}\frac{H_z(t+\Delta t/2) - H_z(t-\Delta t/2)}{\Delta t}$		$H_z(t+\Delta t/2) = \frac{c_0\Delta t}{\mu_{zz}}\left[\frac{\partial \tilde{E}_y(t)}{\partial x} - \frac{\partial \tilde{E}_x(t)}{\partial y}\right] + H_z(t-\Delta t/2)$
$\frac{\partial H_z(t+\Delta t/2)}{\partial y} - \frac{\partial H_y(t+\Delta t/2)}{\partial z} = \frac{\epsilon_{xx}}{c_0}\frac{\partial \tilde{E}_x(t+\Delta t/2)}{\partial t}$	$\frac{\partial H_z(t+\Delta t/2)}{\partial y} - \frac{\partial H_y(t+\Delta t/2)}{\partial z} = \frac{\epsilon_{xx}}{c_0}\frac{\tilde{E}_x(t+\Delta t) - \tilde{E}_x(t)}{\Delta t}$		$\tilde{E}_x(t+\Delta t) = \frac{c_0\Delta t}{\epsilon_{xx}}\left[\frac{\partial H_z(t+\Delta t/2)}{\partial y} - \frac{\partial H_y(t+\Delta t/2)}{\partial z}\right] + \tilde{E}_x(t)$
$\frac{\partial H_x(t+\Delta t/2)}{\partial z} - \frac{\partial H_z(t+\Delta t/2)}{\partial x} = \frac{\epsilon_{yy}}{c_0}\frac{\partial \tilde{E}_y(t+\Delta t/2)}{\partial t}$	$\frac{\partial H_x(t+\Delta t/2)}{\partial z} - \frac{\partial H_z(t+\Delta t/2)}{\partial x} = \frac{\epsilon_{yy}}{c_0}\frac{\tilde{E}_y(t+\Delta t) - \tilde{E}_y(t)}{\Delta t}$		$\tilde{E}_y(t+\Delta t) = \frac{c_0\Delta t}{\epsilon_{yy}}\left[\frac{\partial H_x(t+\Delta t/2)}{\partial z} - \frac{\partial H_z(t+\Delta t/2)}{\partial x}\right] + \tilde{E}_y(t)$
$\frac{\partial H_y(t+\Delta t/2)}{\partial x} - \frac{\partial H_x(t+\Delta t/2)}{\partial y} = \frac{\epsilon_{zz}}{c_0}\frac{\partial \tilde{E}_z(t+\Delta t/2)}{\partial t}$	$\frac{\partial H_y(t+\Delta t/2)}{\partial x} - \frac{\partial H_x(t+\Delta t/2)}{\partial y} = \frac{\epsilon_{zz}}{c_0}\frac{\tilde{E}_z(t+\Delta t) - \tilde{E}_z(t)}{\Delta t}$		$\tilde{E}_z(t+\Delta t) = \frac{c_0\Delta t}{\epsilon_{zz}}\left[\frac{\partial H_y(t+\Delta t/2)}{\partial x} - \frac{\partial H_x(t+\Delta t/2)}{\partial y}\right] + \tilde{E}_z(t)$

Expansion of Spatial component (numeric)					
Analytical	Numerical	Yee Grid Cell	Analytical	Numerical	Yee Grid
$\overbrace{\frac{\partial \tilde{E}_z(t)}{\partial y} - \frac{\partial \tilde{E}_y(t)}{\partial z}}^{Spatial} = \mu_{xx}\frac{\partial H_x^{i,j,k}(t)}{\partial t}$	$\frac{\tilde{E}_z^{i,j+1,k}(t) - \tilde{E}_z^{i,j,k}(t)}{\Delta y} - \frac{\tilde{E}_y^{i,j,k+1}(t) - \tilde{E}_y^{i,j,k}(t)}{\Delta z}$		$\frac{\partial H_z\left(t+\frac{\Delta t}{2}\right)}{\partial y} - \frac{\partial H_y\left(t+\frac{\Delta t}{2}\right)}{\partial z} = \epsilon_{xx}\frac{\partial \tilde{E}_x^{i,j,k}\left(t+\frac{\Delta t}{2}\right)}{\partial t}$	$\frac{H_z^{i,j,k}\left(t+\frac{\Delta t}{2}\right) - H_z^{i,j-1,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta y} - \frac{H_y^{i,j,k}\left(t+\frac{\Delta t}{2}\right) - H_y^{i,j,k-1}\left(t+\frac{\Delta t}{2}\right)}{\Delta z}$	
$\frac{\partial \tilde{E}_x(t)}{\partial z} - \frac{\partial \tilde{E}_z(t)}{\partial x} = \mu_{yy}\frac{\partial H_y^{i,j,k}(t)}{\partial t}$	$\frac{\tilde{E}_x^{i,j,k+1}(t) - \tilde{E}_x^{i,j,k}(t)}{\Delta z} - \frac{\tilde{E}_z^{i+1,j,k}(t) - \tilde{E}_z^{i,j,k}(t)}{\Delta x}$		$\frac{\partial H_x\left(t+\frac{\Delta t}{2}\right)}{\partial z} - \frac{\partial H_z\left(t+\frac{\Delta t}{2}\right)}{\partial x} = \epsilon_{yy}\frac{\partial \tilde{E}_y^{i,j,k}\left(t+\frac{\Delta t}{2}\right)}{\partial t}$	$\frac{H_x^{i,j,k}\left(t+\frac{\Delta t}{2}\right) - H_x^{i,j,k-1}\left(t+\frac{\Delta t}{2}\right)}{\Delta z} - \frac{H_z^{i,j,k}\left(t+\frac{\Delta t}{2}\right) - H_z^{i-1,j,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta x}$	
$\frac{\partial \tilde{E}_y(t)}{\partial x} - \frac{\partial \tilde{E}_x(t)}{\partial y} = \mu_{zz}\frac{\partial H_z^{i,j,k}(t)}{\partial t}$	$\frac{\tilde{E}_y^{i+1,j,k}(t) - \tilde{E}_y^{i,j,k}(t)}{\Delta x} - \frac{\tilde{E}_x^{i,j+1,k}(t) - \tilde{E}_x^{i,j,k}(t)}{\Delta y}$		$\frac{\partial H_y\left(t+\frac{\Delta t}{2}\right)}{\partial x} - \frac{\partial H_x\left(t+\frac{\Delta t}{2}\right)}{\partial y} = \epsilon_{zz}\frac{\partial \tilde{E}_z^{i,j,k}\left(t+\frac{\Delta t}{2}\right)}{\partial t}$	$\frac{H_y^{i,j,k}\left(t+\frac{\Delta t}{2}\right) - H_y^{i-1,j,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta x} - \frac{H_x^{i,j,k}\left(t+\frac{\Delta t}{2}\right) - H_x^{i,j-1,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta y}$	

2D Comparison: https://youtu.be/f0orcF2ubIs?si=-7h2Lm5PVs6STM72&t=555

Create Short-Hand Variable for Curl terms		
Analytical	Numerical	
$C_x^{\tilde{E}}(t)=\frac{\partial \tilde{E}_z(t)}{\partial y}-\frac{\partial \tilde{E}_y(t)}{\partial z}$	$C_x^{\tilde{E}}(t)=\frac{\tilde{E}_z^{i,j+1,k}(t)-\tilde{E}_z^{i,j,k}(t)}{\Delta y}-\frac{\tilde{E}_y^{i,j,k+1}(t)-\tilde{E}_y^{i,j,k}(t)}{\Delta z}$	
$C_y^{\tilde{E}}(t)=\frac{\partial \tilde{E}_x(t)}{\partial z}-\frac{\partial \tilde{E}_z(t)}{\partial x}$	$C_y^{\tilde{E}}(t)=\frac{\tilde{E}_x^{i,j,k+1}(t)-\tilde{E}_x^{i,j,k}(t)}{\Delta z}-\frac{\tilde{E}_z^{i+1,j,k}(t)-\tilde{E}_z^{i,j,k}(t)}{\Delta x}$	
$C_z^{\tilde{E}}(t)=\frac{\partial \tilde{E}_y(t)}{\partial x}-\frac{\partial \tilde{E}_x(t)}{\partial y}$	$C_z^{\tilde{E}}(t)=\frac{\tilde{E}_y^{i+1,j,k}(t)-\tilde{E}_y^{i,j,k}(t)}{\Delta x}-\frac{\tilde{E}_x^{i,j+1,k}(t)-\tilde{E}_x^{i,j,k}(t)}{\Delta y}$	
$C_x^{H}(t+\Delta t/2)=\frac{\partial H_z(t+\Delta t/2)}{\partial y}-\frac{\partial H_y(t+\Delta t/2)}{\partial z}$	$C_x^{H}(t+\Delta t/2)=\frac{H_z^{i,j,k}(t+\Delta t/2)-H_z^{i,j-1,k}(t+\Delta t/2)}{\Delta y}-\frac{H_y^{i,j,k}(t+\Delta t/2)-H_y^{i,j,k-1}(t+\Delta t/2)}{\Delta z}$	
$C_y^{H}(t+\Delta t/2)=\frac{\partial H_x(t+\Delta t/2)}{\partial z}-\frac{\partial H_z(t+\Delta t/2)}{\partial x}$	$C_y^{H}(t+\Delta t/2)=\frac{H_x^{i,j,k}(t+\Delta t/2)-H_x^{i,j,k-1}(t+\Delta t/2)}{\Delta z}-\frac{H_z^{i,j,k}(t+\Delta t/2)-H_z^{i-1,j,k}(t+\Delta t/2)}{\Delta x}$	
$C_z^{H}(t+\Delta t/2)=\frac{\partial H_y(t+\Delta t/2)}{\partial x}-\frac{\partial H_x(t+\Delta t/2)}{\partial y}$	$C_z^{H}(t+\Delta t/2)=\frac{H_y^{i,j,k}(t+\Delta t/2)-H_y^{i-1,j,k}(t+\Delta t/2)}{\Delta x}-\frac{H_x^{i,j,k}(t+\Delta t/2)-H_x^{i,j-1,k}(t+\Delta t/2)}{\Delta y}$	
$\tilde{D}_x^{i,j,k}(t)=\epsilon_{xx}^{i,j,k}\tilde{E}_x^{i,j,k}(t+\Delta t)$	$\tilde{D}$ is going to make our code more modular	
$\tilde{D}_y^{i,j,k}(t)=\epsilon_{yy}^{i,j,k}\tilde{E}_y^{i,j,k}(t+\Delta t)$		
$\tilde{D}_z^{i,j,k}(t)=\epsilon_{zz}^{i,j,k}\tilde{E}_z^{i,j,k}(t+\Delta t)$		

Rewrite Maxwell's Equations with Short-Hand Curl Terms		
Analytical	Numerical	Solve for future value: **FDTD UPDATE EQUATIONS**
$C_x^{\tilde{E}}(t)=-\frac{\mu_{xx}}{c_0}\frac{\partial H_x(t)}{\partial t}$	$C_x^{\tilde{E}}(t)=-\frac{\mu_{xx}}{c_0}\frac{\overbrace{H_x(t+\Delta t/2)}^{Future\ value}-H_x(t-\Delta t/2)}{\Delta t}$	$H_x(t+\Delta t/2)=\frac{c_0\Delta t}{\mu_{xx}}C_x^{\tilde{E}}(t)+H_x(t-\Delta t/2)$
$C_y^{\tilde{E}}(t)=-\frac{\mu_{xx}}{c_0}\frac{\partial H_y(t)}{\partial t}$	$C_y^{\tilde{E}}(t)=-\frac{\mu_{yy}}{c_0}\frac{H_y(t+\Delta t/2)-H_y(t-\Delta t/2)}{\Delta t}$	$H_y(t+\Delta t/2)=\frac{c_0\Delta t}{\mu_{yy}}C_y^{\tilde{E}}(t)+H_y(t-\Delta t/2)$
$C_z^{\tilde{E}}(t)=-\frac{\mu_{xx}}{c_0}\frac{\partial H_z(t)}{\partial t}$	$C_z^{\tilde{E}}(t)=-\frac{\mu_{zz}}{c_0}\frac{H_z(t+\Delta t/2)-H_z(t-\Delta t/2)}{\Delta t}$	$H_z(t+\Delta t/2)=\frac{c_0\Delta t}{\mu_{zz}}C_z^{\tilde{E}}(t)+H_z(t-\Delta t/2)$
$C_x^{H}(t+\Delta t/2)=\frac{\epsilon_{xx}}{c_0}\frac{\partial \tilde{E}_x(t+\Delta/2)}{\partial t}=\frac{1}{c_0}\frac{\partial \tilde{D}_x(t+\Delta/2)}{\partial t}$	$C_x^{H}(t+\Delta t/2)=\frac{1}{c_0}\frac{\tilde{D}_x(t+\Delta t)-\tilde{D}_x(t)}{\Delta t}$	$\tilde{D}_x(t+\Delta t)=\frac{c_0\Delta t}{1}C_x^{H}(t+\Delta t/2)+\tilde{D}_x(t)$
$C_y^{H}(t+\Delta t/2)=\frac{\epsilon_{yy}}{c_0}\frac{\partial \tilde{E}_y(t+\Delta/2)}{\partial t}=\frac{1}{c_0}\frac{\partial \tilde{D}_y(t+\Delta/2)}{\partial t}$	$C_y^{H}(t+\Delta t/2)=\frac{1}{c_0}\frac{\tilde{D}_y(t+\Delta t)-\tilde{D}_y(t)}{\Delta t}$	$\tilde{D}_y(t+\Delta t)=\frac{c_0\Delta t}{1}C_y^{H}(t+\Delta t/2)+\tilde{D}_y(t)$
$C_z^{H}(t+\Delta t/2)=\frac{\epsilon_{zz}}{c_0}\frac{\partial \tilde{E}_z(t+\Delta/2)}{\partial t}=\frac{1}{c_0}\frac{\partial \tilde{D}_z(t+\Delta/2)}{\partial t}$	$C_z^{H}(t+\Delta t/2)=\frac{1}{c_0}\frac{\tilde{D}_z(t+\Delta t)-\tilde{D}_z(t)}{\Delta t}$	$\tilde{D}_z(t+\Delta t)=\frac{c_0\Delta t}{1}C_z^{H}(t+\Delta t/2)+\tilde{D}_z(t)$
$\tilde{D}_x^{i,j,k}(t)=\epsilon_{xx}^{i,j,k}\tilde{E}_x^{i,j,k}(t+\Delta t)$	$\tilde{D}_x^{i,j,k}(t+\Delta t)=\epsilon_{xx}^{i,j,k}\tilde{E}_x^{i,j,k}(t+\Delta t)$	$\tilde{E}_x^{i,j,k}(t+\Delta t)=\frac{1}{\epsilon_{xx}^{i,j,k}}\tilde{D}_x^{i,j,k}(t+\Delta t)$
$\tilde{D}_y^{i,j,k}(t)=\epsilon_{yy}^{i,j,k}\tilde{E}_y^{i,j,k}(t+\Delta t)$	$\tilde{D}_y^{i,j,k}(t+\Delta t)=\epsilon_{yy}^{i,j,k}\tilde{E}_y^{i,j,k}(t+\Delta t)$	$\tilde{E}_y^{i,j,k}(t+\Delta t)=\frac{1}{\epsilon_{yy}^{i,j,k}}\tilde{D}_y^{i,j,k}(t+\Delta t)$
$\tilde{D}_z^{i,j,k}(t)=\epsilon_{zz}^{i,j,k}\tilde{E}_z^{i,j,k}(t+\Delta t)$	$\tilde{D}_z^{i,j,k}(t+\Delta t)=\epsilon_{zz}^{i,j,k}\tilde{E}_z^{i,j,k}(t+\Delta t)$	$\tilde{E}_z^{i,j,k}(t+\Delta t)=\frac{1}{\epsilon_{zz}^{i,j,k}}\tilde{D}_z^{i,j,k}(t+\Delta t)$

Update Equations: https://youtu.be/f0orcF2ubIs?si=eFNDKVIReuYxd584&t=1326

Variable List	Matlab variable	Dimension	Matlab Initialization
	t		
	T	1×1	
	Nx	1×1	
	Ny	1×1	
	Nz	1×1	
$C_x^{\tilde{E}}$	CEx	Nx × Ny × Nz	
$C_y^{\tilde{E}}$	CEy	Nx × Ny × Nz	
$C_z^{\tilde{E}}$	CEz	Nx × Ny × Nz	
C_x^H	CHx	Nx × Ny × Nz	
C_y^H	CHy	Nx × Ny × Nz	
C_z^H	CHz	Nx × Ny × Nz	
H_x	Hx	Nx × Ny × Nz	
H_y	Hy	Nx × Ny × Nz	
H_z	Hz	Nx × Ny × Nz	
$\tilde{D}_x$	Dx	Nx × Ny × Nz	
$\epsilon_{xx}^{i,j,k}$	exx	Nx × Ny × Nz	
$\epsilon_{yy}^{i,j,k}$	eyy	Nx × Ny × Nz	
$\epsilon_{zz}^{i,j,k}$	ezz	Nx × Ny × Nz	
$\mu_{xx}^{i,j,k}$	uxx	Nx × Ny × Nz	
$\mu_{yy}^{i,j,k}$	uyy	Nx × Ny × Nz	
$\mu_{zz}^{i,j,k}$	uzz	Nx × Ny × Nz	
c_0	c0	1×1	
ϵ_0	e0	1×1	
μ_0	u0	1×1	
Δt	dt	1×1	
Δx	dx	1×1	
Δy	dy	1×1	
Δz	dz	1×1	

Solve for future value: **FDTD UPDATE EQUATIONS (...same ones highlighted above.)**	
Written	Matlab Code: Update Equations
$C_x^{\tilde{E}}(t) = \frac{\tilde{E}_z^{i,j+1,k}(t) - \tilde{E}_z^{i,j,k}(t)}{\Delta y} - \frac{\tilde{E}_y^{i,j,k+1}(t) - \tilde{E}_y^{i,j,k}(t)}{\Delta z}$	
$C_y^{\tilde{E}}(t) = \frac{\tilde{E}_x^{i,j,k+1}(t) - \tilde{E}_x^{i,j,k}(t)}{\Delta z} - \frac{\tilde{E}_z^{i+1,j,k}(t) - \tilde{E}_z^{i,j,k}(t)}{\Delta x}$	
$C_z^{\tilde{E}}(t) = \frac{\tilde{E}_y^{i+1,j,k}(t) - \tilde{E}_y^{i,j,k}(t)}{\Delta x} - \frac{\tilde{E}_x^{i,j+1,k}(t) - \tilde{E}_x^{i,j,k}(t)}{\Delta y}$	
$C_x^{H}(t + \Delta t/2) = \frac{H_z^{i,j,k}(t + \Delta t/2) - H_z^{i,j-1,k}(t + \Delta t/2)}{\Delta y} - \frac{H_y^{i,j,k}(t + \Delta t/2) - H_y^{i,j,k-1}(t + \Delta t/2)}{\Delta z}$	
$C_y^{H}(t + \Delta t/2) = \frac{H_x^{i,j,k}(t + \Delta t/2) - H_x^{i,j,k-1}(t + \Delta t/2)}{\Delta z} - \frac{H_z^{i,j,k}(t + \Delta t/2) - H_z^{i-1,j,k}(t + \Delta t/2)}{\Delta x}$	
$C_z^{H}(t + \Delta t/2) = \frac{H_y^{i,j,k}(t + \Delta t/2) - H_y^{i-1,j,k}(t + \Delta t/2)}{\Delta x} - \frac{H_x^{i,j,k}(t + \Delta t/2) - H_x^{i,j-1,k}(t + \Delta t/2)}{\Delta y}$	
$H_x(t + \Delta t/2) = \frac{c_0 \Delta t}{\mu_{xx}} C_x^{\tilde{E}}(t) + H_x(t - \Delta t/2)$	
$H_y(t + \Delta t/2) = \frac{c_0 \Delta t}{\mu_{yy}} C_y^{\tilde{E}}(t) + H_y(t - \Delta t/2)$	
$H_z(t + \Delta t/2) = \frac{c_0 \Delta t}{\mu_{zz}} C_z^{\tilde{E}}(t) + H_z(t - \Delta t/2)$	
$\tilde{D}_x(t + \Delta t) = \frac{c_0 \Delta t}{1} C_x^{H}(t + \Delta t/2) + \tilde{D}_x(t)$	
$\tilde{D}_y(t + \Delta t) = \frac{c_0 \Delta t}{1} C_y^{H}(t + \Delta t/2) + \tilde{D}_y(t)$	
$\tilde{D}_z(t + \Delta t) = \frac{c_0 \Delta t}{1} C_z^{H}(t + \Delta t/2) + \tilde{D}_z(t)$	
$\tilde{E}_x^{i,j,k}(t + \Delta t) = \frac{1}{\epsilon_{xx}^{i,j,k}} \tilde{D}_x^{i,j,k}(t + \Delta t)$	
$\tilde{E}_y^{i,j,k}(t + \Delta t) = \frac{1}{\epsilon_{yy}^{i,j,k}} \tilde{D}_y^{i,j,k}(t + \Delta t)$	
$\tilde{E}_z^{i,j,k}(t + \Delta t) = \frac{1}{\epsilon_{zz}^{i,j,k}} \tilde{D}_z^{i,j,k}(t + \Delta t)$	

Boundary Conditions: https://youtu.be/f0orcF2ubIs?si=DO1kOVgE6b5TPSIn&t=1553

Full Finite Difference Equations	
Human Readable Math Form	Matlab Code Form
$H_x^{i,j,k}(t+\Delta t/2) = \frac{\Delta t}{\mu_{xx}}\left[\frac{\tilde{E}_z^{i,j+1,k}(t)-\tilde{E}_z^{i,j,k}(t)}{\Delta y} - \frac{\tilde{E}_y^{i,j,k+1}(t)-\tilde{E}_y^{i,j,k}(t)}{\Delta z}\right] + H_x(t-\Delta t/2)$	`% Calculate Magnetic field (for next integer half step)` `Hx(1:(Nz-1)) = Hx(1:(Nz-1)) + squeeze(mH(30,30,1:(Nz-1))) .* (Ey(2:Nz) - Ey(1:(Nz-1)));`
$H_y^{i,j,k}(t+\Delta t/2) = \frac{\Delta t}{\mu_{yy}}\left[\frac{\tilde{E}_x^{i,j,k+1}(t)-\tilde{E}_x^{i,j,k}(t)}{\Delta z} - \frac{\tilde{E}_z^{i+1,j,k}(t)-\tilde{E}_z^{i,j,k}(t)}{\Delta x}\right] + H_y(t-\Delta t/2)$	
$H_z^{i,j,k}(t+\Delta t/2) = \frac{\Delta t}{\mu_{zz}}\left[\frac{\tilde{E}_y^{i+1,j,k}(t)-\tilde{E}_y^{i,j,k}(t)}{\Delta x} - \frac{\tilde{E}_x^{i,j+1,k}(t)-\tilde{E}_x^{i,j,k}(t)}{\Delta y}\right] + H_z(t-\Delta t/2)$	
$\tilde{E}_x^{i,j,k}(t+\Delta t) = \frac{\Delta t}{\epsilon_{xx}}\left[\frac{H_z^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_z^{i,j-1,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta y} - \frac{H_y^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_y^{i,j,k-1}\left(t+\frac{\Delta t}{2}\right)}{\Delta z}\right] + \tilde{E}_x(t)$	
$\tilde{E}_y^{i,j,k}(t+\Delta t) = \frac{\Delta t}{\epsilon_{yy}}\left[\frac{H_x^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_x^{i,j,k-1}\left(t+\frac{\Delta t}{2}\right)}{\Delta z} - \frac{H_z^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_z^{i-1,j,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta x}\right] + \tilde{E}_y(t)$	
$\tilde{E}_z^{i,j,k}(t+\Delta t) = \frac{\Delta t}{\epsilon_{zz}}\left[\frac{H_y^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_y^{i-1,j,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta x} - \frac{H_x^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_x^{i,j-1,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta y}\right] + \tilde{E}_z(t)$	

Full Finite Difference Equations	
Human Readable Math Form	Matlab Code Form
$H_x^{i,j,k}(t+\Delta t/2) = \frac{\Delta t}{\mu_{xx}}\left[\frac{\tilde{E}_z^{i,j+1,k}(t)-\tilde{E}_z^{i,j,k}(t)}{\Delta y} - \frac{\tilde{E}_y^{i,j,k+1}(t)-\tilde{E}_y^{i,j,k}(t)}{\Delta z}\right] + H_x(t-\Delta t/2)$	`% Calculate Magnetic field (for next integer half step)` `Hx(1:(Nz-1)) = Hx(1:(Nz-1)) + squeeze(mH(30,30,1:(Nz-1))) .* (Ey(2:Nz) - Ey(1:(Nz-1)));`
$H_y^{i,j,k}(t+\Delta t/2) = \frac{\Delta t}{\mu_{yy}}\left[\frac{\tilde{E}_x^{i,j,k+1}(t)-\tilde{E}_x^{i,j,k}(t)}{\Delta z} - \frac{\tilde{E}_z^{i+1,j,k}(t)-\tilde{E}_z^{i,j,k}(t)}{\Delta x}\right] + H_y(t-\Delta t/2)$	
$H_z^{i,j,k}(t+\Delta t/2) = \frac{\Delta t}{\mu_{zz}}\left[\frac{\tilde{E}_y^{i+1,j,k}(t)-\tilde{E}_y^{i,j,k}(t)}{\Delta x} - \frac{\tilde{E}_x^{i,j+1,k}(t)-\tilde{E}_x^{i,j,k}(t)}{\Delta y}\right] + H_z(t-\Delta t/2)$	
$\tilde{D}_x^{i,j,k}(t+\Delta t) = \frac{\Delta t}{c_0}\left[\frac{H_z^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_z^{i,j-1,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta y} - \frac{H_y^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_y^{i,j,k-1}\left(t+\frac{\Delta t}{2}\right)}{\Delta z}\right] + \tilde{D}_x(t)$	
$\tilde{D}_y^{i,j,k}(t+\Delta t) = \frac{\Delta t}{c_0}\left[\frac{H_x^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_x^{i,j,k-1}\left(t+\frac{\Delta t}{2}\right)}{\Delta z} - \frac{H_z^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_z^{i-1,j,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta x}\right] + \tilde{D}_y(t)$	
$\tilde{D}_z^{i,j,k}(t+\Delta t) = \frac{\Delta t}{c_0}\left[\frac{H_y^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_y^{i-1,j,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta x} - \frac{H_x^{i,j,k}\left(t+\frac{\Delta t}{2}\right)-H_x^{i,j-1,k}\left(t+\frac{\Delta t}{2}\right)}{\Delta y}\right] + \tilde{D}_z(t)$	