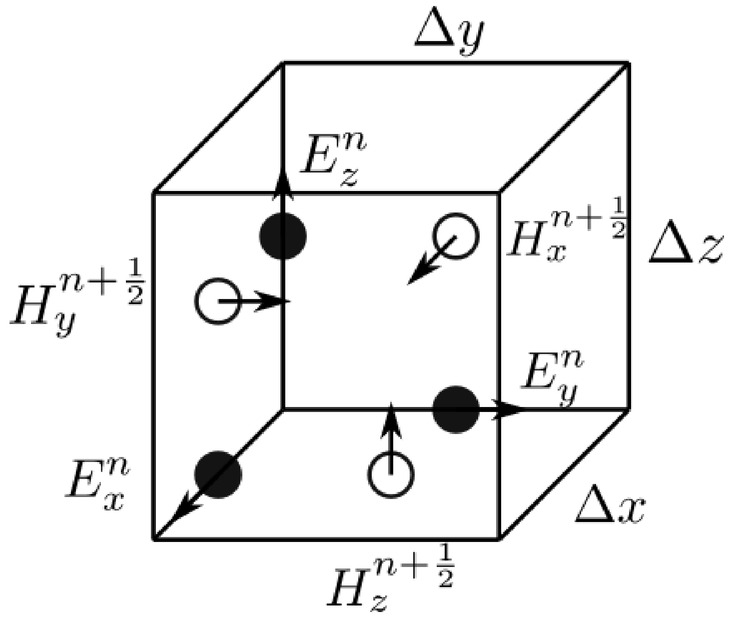
Solving Maxwell's equations numerically using a Yee Grid

Yee Grid



- Introduced by **Kane Yee** in 1966
- The curl equations are replaced by finite difference in both time and space in a staggered grid. (Both $\vec{E}$ and $\vec{H}$ fields)
- Divergence equations are satisfied by the grid placement
- For 2D simulations based on the direction of polarization there are two modes. TE and TM mode

Image source: wikipedia

Maxwell's equation

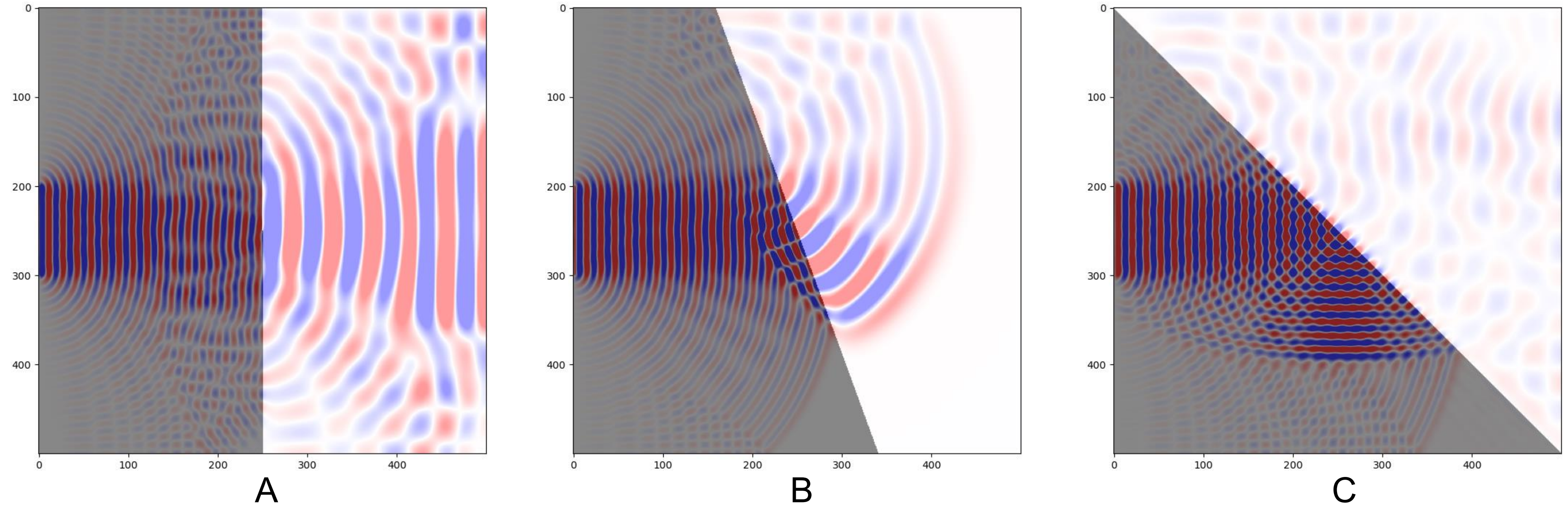
1. $\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon}$
2. $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
3. $\nabla \cdot \vec{B} = 0$
4. $\nabla \times \vec{B} = \mu_0 J + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$

Using finite difference for the curl equations update equations will give the following form,

$$H_y(x + 1/2, t + 1) = H_y(x + 1/2, t) - \left(\frac{\Delta t}{\mu}\right) \frac{[E_z(x + 1, t) - E_z(x, t)]}{\Delta x}$$

$$E_z(x, t + 1) = E_z(x, t) + \left(\frac{\Delta t}{\epsilon}\right) \frac{[H_y\left(x + \frac{1}{2}, t\right) - H_y(x - 1/2, t)]}{\Delta x}$$

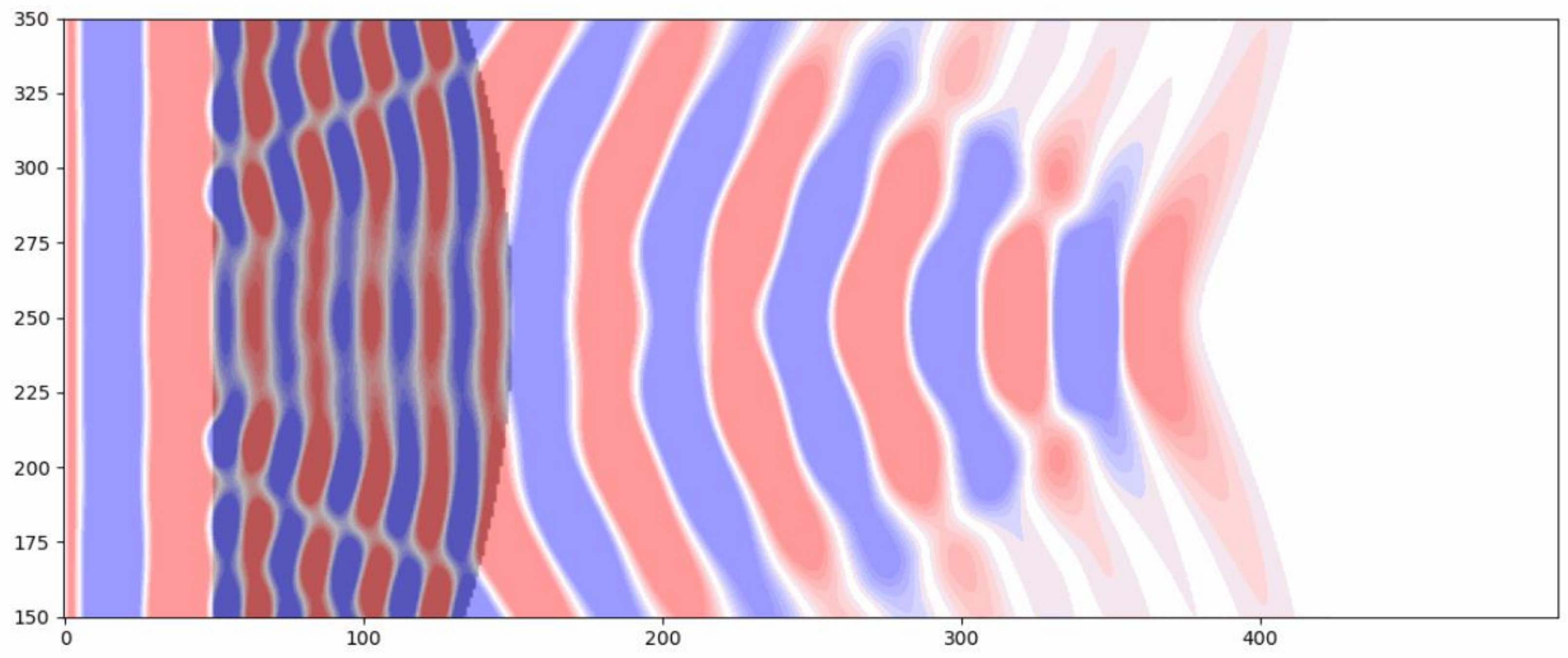
Simulation 1



The Electric field component of a simulation of a plane wave propagating from medium 1 (n=2, shown in gray) to medium 2(n=1). A, B,C shows simulations with angle 0^o,20^o,45^o. The critical angle is 30^o

Simulation 2 - lens

- A plano-convex lens made from a higher refractive index medium



Results and Discussion

- Implemented the FDTD algorithm for 1D and 2D (TM mode) to model constructed devices
- Confirmed known optical properties
  - Refraction from different media
  - Plano-convex lens
- One of the main advantages in the popularity of this method is the ability to derive the frequency response using a single simulations