Transmission of Electromagnetic Waves Through Multiple Materials
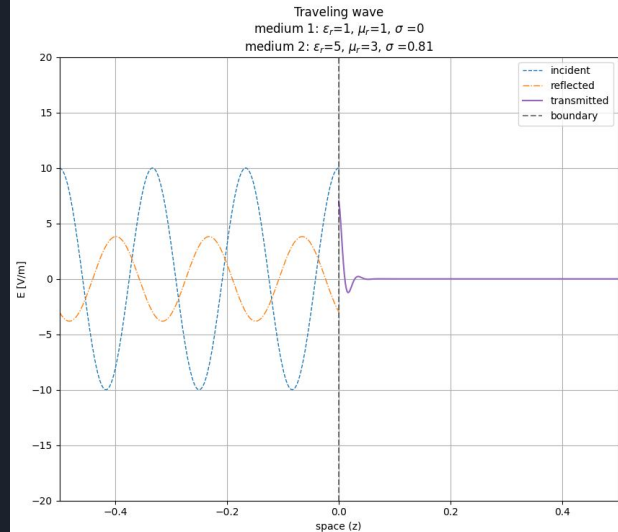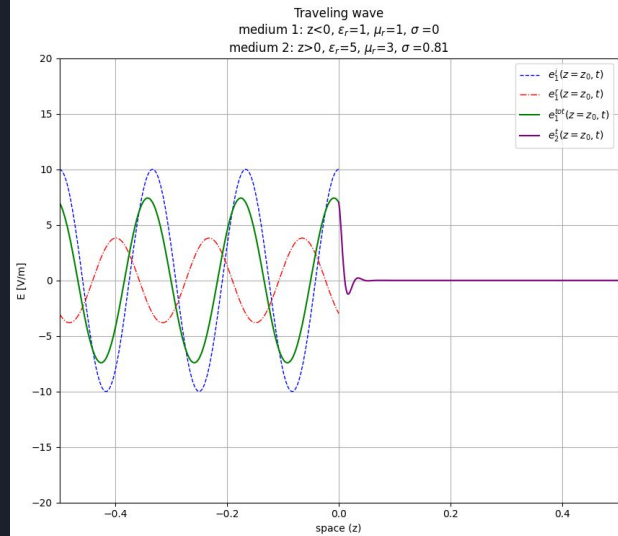
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Introduction

- EM waves undergo changes in different materials
  - Speed, wavelength, intensity
- Based on material properties (ε, μ, σ)
  - $$\zeta = \sqrt{\frac{\mu_{eq}}{\varepsilon_{eq}}}$$
- Can be modeled by reflection and transmission coefficients
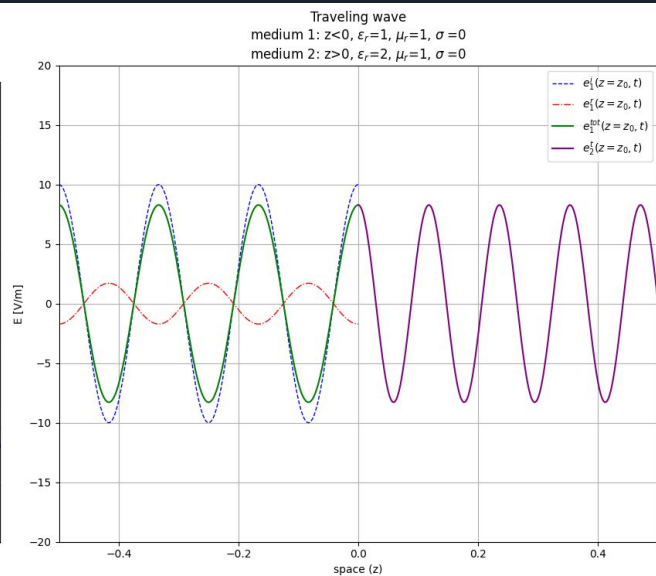 - $$\Gamma_{1,2} = \frac{\zeta_2 - \zeta_1}{\zeta_2 + \zeta_1}$$
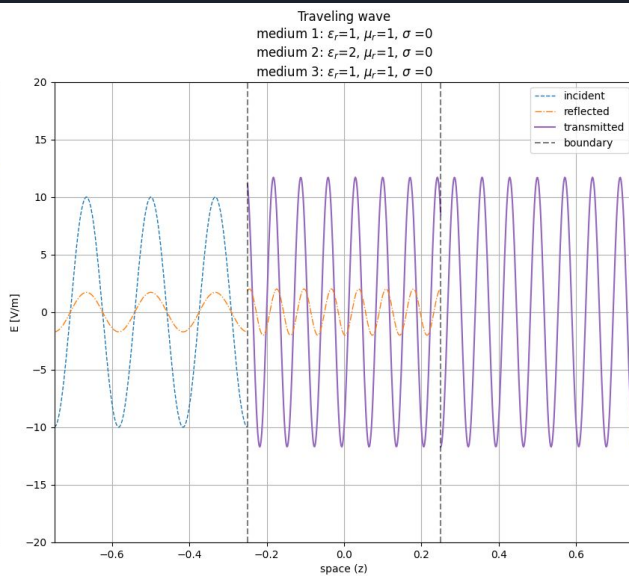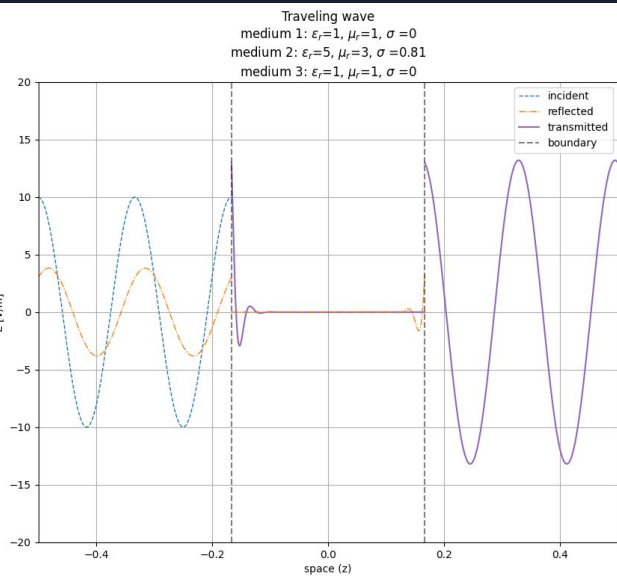
  - $$\tau_{1,2} = \frac{2\zeta_2}{\zeta_2 + \zeta_1}$$

Methods

- **em-waves package in python**
  - Numpy and matplotlib
  - Medium, wave, and sine classes
- **Modified package**
  - Relied on lists
  - Medium/sine classes unchanged
  - Methods to calculate constants changed
  - Animation function changed

Results

Traveling wave
medium 1: $\varepsilon_r=1$, $\mu_r=1$, $\sigma=0$
medium 2: $\varepsilon_r=5$, $\mu_r=3$, $\sigma=0.81$
medium 3: $\varepsilon_r=1$, $\mu_r=1$, $\sigma=0$

Traveling wave
medium 1: $\varepsilon_r=1$, $\mu_r=1$, $\sigma=0$
medium 2: $\varepsilon_r=2$, $\mu_r=1$, $\sigma=0$
medium 3: $\varepsilon_r=1$, $\mu_r=1$, $\sigma=0$

Traveling wave
medium 1: z<0, $\varepsilon_r=1$, $\mu_r=1$, $\sigma=0$
medium 2: z>0, $\varepsilon_r=2$, $\mu_r=1$, $\sigma=0$

Conclusions

- Substantial more work to make package usable for people in this industry
  - Fix amplitude calculations (position dependence centered at zero)
  - Thickness
  - Co-channel interference
  - Higher order transmission/reflection
- Currently good for introductions to the ideas using qualitative graphs