
Reading: Sec. 4.1–4.8 sec. 10.1–10.6
Ref: Saleh and Teich, "Fundamental of Photonics," Ch. 5 Wiley

* Use geometrical optics when \( \lambda < d \).
  If \( \lambda \geq d \), use wave optics

* 1-D Wave Equation (study Sec. 4-1)
  - How to describe a traveling wave mathematically?
    \[ y = f(x \pm vt) \] represents traveling towards \( +x \) direction
  - Examples:
    \[ y = A \sin(x - vt) \]
    \[ y = A(x + vt)^2 \]
    \[ y = e^{k(x - vt)} \]
  - Satisfy 1-D wave equation:
    \[ \frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 y}{\partial t^2} \]
  - Quiz:
    \[ y = 2.85 \left( 0.75x + 2\pi t \right) \] "\( x \)" direction.
    \[ v = \frac{\pi}{3} \]
    \[ y = e^{-(0.009x^2 + 0.02e^{xt} - 4.9t^2)} \] "\( -x \)" direction
    \[ v = 7/0.3 \]
    \[ y(x,t) = A \left( Bx^2 - t \right) \]
    \( x \) Not a traveling wave.

* Exercise: Lorentzian pulse
  \[ y(x,t) = \frac{b^2}{a^2 + (x - x_0)^2} \]
  At later time \( t \):
  \[ y(x,t) = \frac{b^2}{a^2 + [x + v(t-t_0) - x_0]^2} \]
  \[ \approx \frac{b^2}{a^2 + [x - x_0 + v(t-t_0)]^2} \]
* Harmonic Waves (study Sec. 4.2.1)

\[ y = A \sin \left( k(x \pm vt) + \phi_0 \right) \] or \[ A \cos \left( k(x \pm vt) + \phi_0 \right) \]

\[ k = \frac{2\pi}{\lambda} \] : Propagation constant

General form of harmonic waves:

\[ y = A \sin \left( kx + \omega t + \phi_0 \right) \] or \[ A \cos \left( kx + \omega t + \phi_0 \right) \]

\[ \omega = 2\pi f = \frac{2\pi}{T} \] : Angular frequency

* Complex Harmonic Wave Functions

(study Sec. 4.3 to 4.7)

- \[ \sin (A + B) \neq \sin A + \sin B \] or \[ \sin A \cdot \sin B \]

\[ e^{i(A+B)} = e^{iA} \cdot e^{iB} \]

- Express a harmonic wave by \[ Y(x,t) \]

\[ Y = A e^{i(kx - \omega t)} \]

\[ \text{Re} (Y) = A \cos (kx - \omega t) \]

\[ \text{Im} (Y) = A \sin (kx - \omega t) \]

Take real or imaginary part for physical quantities

- Plane wave.

In \( x \)-direction, \[ Y = A \sin (kx - \omega t) \]

In any direction,

\[ Y = A \sin (k \cdot \mathbf{r} - \omega t) \]

In complex form,

\[ Y = A e^{i(k \cdot \mathbf{r} - \omega t)} \]

- Spherical wave.