Mechanical Waves

- Introduction to Waves
- Types of Waves
- Traveling Waves
- Waves on a String
- Homework
Introduction to Waves

- Wave motion appears in almost every branch of physics, e.g. sound, light, radio and other electromagnetic waves.
- A wave is a disturbance that travels at a definite speed \( v = \lambda f \) and transfers energy and momentum.
- Mechanical waves travel in elastic media (e.g. sound).
- Electromagnetic waves are oscillating electromagnetic fields and do not require a medium (the speed of EM waves in a vacuum is \( c = 3 \times 10^8 \) m/s).
Types of Waves

- Transverse waves - displacement is perpendicular to direction of propagation
  - Traveling wave on a string

- Longitudinal wave - displacement is parallel to direction of propagation
  - Traveling wave in a spring Sound
Transverse Waves

- Displacement is perpendicular to direction of propagation

- Traveling wave on a string
Longitudinal Waves

- Displacement is parallel to direction of propagation
  - Traveling wave in a spring
  - Sound
Traveling Waves

- The wavefunction for a wave traveling in the +x direction has the form

\[ y(x, t) = f(x - vt) \]

- The wavefunction for a wave traveling in the -x direction has the form

\[ y(x, t) = f(x + vt) \]
Sinusoidal Waves

\[ y(x, t) = A \sin \left( \frac{2\pi}{\lambda} (x - vt) \right) \]
Sinusoidal Waves (cont’d)

- **Wavelength** ($\lambda$) is the distance between two adjacent points in the wave having the same phase.

- The period ($T$) is the time required for the wave to travel one wavelength, $\lambda = vT$

$$y(x, t) = A \sin \left[ 2\pi \left( \frac{x}{\lambda} - \frac{t}{T} \right) \right]$$
The wavefunction can also be written as
\[ y = A \sin \left( kx - \omega t \right) \]
where \( k = \frac{2\pi}{\lambda} \) is the wave number and \( \omega = \frac{2\pi}{T} = 2\pi f \) is the angular frequency.

The speed of the wave is
\[ v = \frac{\lambda}{T} = \frac{\omega}{k} = \lambda f \]

If \( y \neq 0 \) at \( x = 0 \) and \( t = 0 \)
\[ y = A \sin \left( kx - \omega t + \phi \right) \]
where \( \phi \) is the phase constant
Speed of Waves on a String

\[ F_r = 2T \sin \theta \approx 2T \theta \]

\[ m = \mu \Delta s = 2\mu R \theta \]

\[ F_r = m \frac{v^2}{R} \]

\[ 2T \theta = \frac{2\mu R \theta v^2}{R} \]

\[ v = \sqrt{\frac{T}{\mu}} \]
Homework Set 24 - Due Wed. Nov. 10

- Read Sections 13.1-13.4
- Answer Questions 13.2, 13.9, 13.10 & 13.11