Characteristics of “Waves”

- Amplitude, $A$:

- Wavelength, $\lambda$:

- Frequency, $f$ or $\omega$:

- Wave speed, $v$: 
Types of Waves

• There are three general types of mechanical waves:
  – Transverse – particle motion is perpendicular to wave motion.
  – Longitudinal – particle motion is in the same direction as wave motion.
  – Combined – sea waves.

**CAUTION** Wave motion vs. particle motion Don’t confuse the motion of the transverse wave along the string and the motion of a particle of the string. The wave moves with constant speed \( v \) along the length of the string, while the motion of the particle is simple harmonic and transverse (perpendicular) to the length of the string.
Transverse Waves

- Particle motion is perpendicular to wave motion.

- Notice that it takes one period of time for the wave to move one wavelength in distance:

\[ v = \frac{\lambda}{T} = f \lambda = 2\pi f \frac{\lambda}{2\pi} = \frac{\omega}{k} \]

\[ \omega = 2\pi f, \quad k = \frac{2\pi}{\lambda} \]
Longitudinal Waves

• Particle motion is in the same direction as wave motion.

• Again, notice that it takes one period of time for the wave to move one wavelength in distance:

\[ v = \frac{\lambda}{T} = f \lambda = 2\pi f \frac{\lambda}{2\pi} = \frac{\omega}{k} \]

\[ \omega = 2\pi f, \quad k = \frac{2\pi}{\lambda} \]
Combined Waves

• Water waves...
Combined Waves

• Water waves...

Which way are the waves moving?
It is important to differentiate wave and particle motion!!!
2-Dimensional Waves

• Waves can, of course, move in more than one dimension:
2-Dimensional Waves

• Waves can, of course move in more than one dimension:

Diffraction!!!
Periodic vs. Non-periodic Waves

• Periodic means that it repeats itself:

• Non-periodic can be, e.g., a pulse:
• Displacement for a fixed position as a function of time:

\[ y(x = 0, t) = A \cos(\omega t) \]

\[ \omega = \frac{2\pi}{T} = 2\pi f \]
Periodic Wave Description

- Displacement for a fixed time as a function of position:

\[ y(x, t = 0) = A \cos(kx) \quad \text{Or, in this case, } \sin(kx) \]

\[ k = \frac{2\pi}{\lambda} \]
Periodic Wave Description

- We can put these together:

\[ y(x, t) = A \sin(kx - \omega t) \]

\[ k = \frac{2\pi}{\lambda}, \quad \omega = \frac{2\pi}{T}, \quad v = \frac{\omega}{k} \]

What is A? k? ω? v?
Periodic Wave Description

- Look at just one point at a time on the medium:

\[
y(x = 2.5, t) = \cos(\omega t + \phi) \\
y(x = 2.9, t) = \cos(\omega t - \delta \phi + \phi) \\
y(x = 3.3, t) = \cos(\omega t - 2\delta \phi + \phi) \\
y(x = 2.5 + \lambda, t) = \cos(\omega t - 2\pi + \phi)
\]
Periodic Wave Description

Wave travelling to the left

\[ Z(x, t) = 1.5 + A \cos(kx + \omega t) \]

What is \( A \), \( k \), \( \omega \), \( v \)?

\[ k = \frac{2\pi}{\lambda}, \quad \omega = \frac{2\pi}{T}, \quad v = \frac{\omega}{k} \]
Periodic Wave Description

• How fast is the wave moving?

\[ y(x,t) = 0 = A \cos(kx - \omega t) \]

\[ kx - \omega t = \frac{\pi}{2} \Rightarrow \]

\[ x = \frac{\pi}{2k} + \frac{\omega}{k} t \Rightarrow \]

\[ v = \frac{dx}{dt} = 0 + \frac{\omega}{k} = \frac{\omega}{k} = \frac{2\pi f}{\lambda} = f \lambda \]

\[ v_p = f \lambda = \frac{\omega}{k} \]

This is known as the phase velocity, for reasons that will become clearer later.