Worksheet 21: Mechanical Waves 1

Objectives

- Trace the movement of the medium in different mechanical waves.
- Relate the mathematical equation of a wave and its period, frequency, amplitude, speed, angular frequency, angular wavenumber, wavelength, and speed.

Summary

Limiting Types

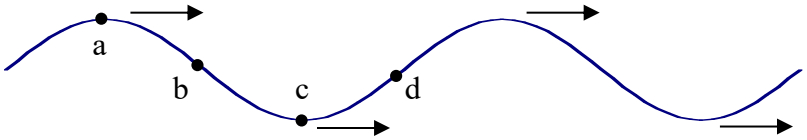
In a **transverse** wave, the medium oscillates in a direction perpendicular to the wave travel. In a **longitudinal** wave, the medium oscillates parallel to the wave travel.

Mathematical Description

The simplest description of a wave is the sinusoidal function $y(x, t) = A\cos(kx - \omega t + \phi)$, where y is the displacement of the medium, A is the maximum **amplitude** of oscillation, x is the rest position of the medium, t is time, the **angular wavenumber** $k = 2\pi/\lambda$, the **angular frequency** $\omega = 2\pi/T$, ϕ is the phase offset, λ is the **wavelength**, and T is the **period**. The **propagation speed** or **phase speed** of the wave is $v = \lambda/T = \omega/k$.

Problems

1. The transverse displacements in a stretched cord travel from left to right.



   a. In what direction is the rope at positions a, b, c, and d *accelerating*?

   b. In what direction is the rope at positions a, b, c, and d *moving*?

2. A wave has an angular frequency of 4π rad/s and a wavelength of 0.3 m.

   a. What is the angular wavenumber k of the wave?

   b. What is the period T of the wave?

   c. What is the propagation speed of the wave?

3. The speed of electromagnetic waves in vacuum is 3.0×10^8 m/s.

   a. In the United States, many cell phones employ carrier frequencies of 824–894 MHz. What are the wavelengths of these waves?

   b. Near the close of the 20th century, physicists found that light traveled through a Bose-Einstein condensate (BEC) at a mere 17 m/s. If sodium D-line light has a wavelength of 589 nm in vacuum, what would its wavelength be in the BEC? (The *speed* of the light changes in the BEC, but its *frequency* does not.)

4. The equation of a transverse wave traveling along a very long string is $y = 6.0 \text{ cm} \cos(0.020\pi x/\text{cm} - 4.0\ \pi t/\text{s})$. Determine:

   a. the amplitude

   b. the wavelength

   c. the frequency

   d. the speed of propagation

   e. the direction of propagation

   f. the maximum transverse speed of a particle in the string