Worksheet 23: Combining Waves

Objectives

- Identify the partition and transfer of energy in mechanical waves.
- Evaluate the superposition of mechanical waves.

Summary

Superposition and Interference

When waves meet, their resulting displacement is often the sum of the displacements predicted for the component waves. **Standing waves** result from the combination of otherwise identical waves propagating in opposite directions: $y(x, t) = 2A \sin(kx) \sin(\omega t)$.

Problems

1. Two transverse waves in a string of phase speed 3.0 m/s, amplitude 20 cm, wavelength 2.0 m, and opposite directions of propagation encounter each other. The waves have opposite displacements of +20 cm and –20 cm at $x = 0$, $t = 0$.

a. Write down the wave parameters A, v, λ, T, f, ω, and k.

b. Find the equations of displacement for both waves $y_1(x, t)$ and $y_2(x, t)$. (It's probably easiest to begin with the symbols. In fact, you can stay there.)

b. Find the equation of displacement for the superposition $y_1 + y_2$ of the two waves. (Again, it's probably best to do this symbolically first. Perhaps last, too.)

c. Find the maximum amplitude of the superposition of the two waves.

d. Find the locations of the nodes and antinodes of the superposition of the two waves.

2. A string that is stretched between fixed supports separated by 75.0 cm has resonant frequencies of 4.20 Hz and 3.15 Hz, with no intermediate resonant frequencies.

a. What is the lowest resonant frequency?

b. What is the wave speed?

3. Find the Doppler frequencies at the detector f_d for the following scenarios:

a. $v_s = v_d = 0$

b. $v_s = 0$; $v_d = -0.1\ v$

c. $v_s = +0.1\ v$; $v_d = 0$

d. $v_s = 0$; $v_d = +0.1\ v$

e. $v_s = -0.1\ v$; $v_d = 0$

f. $v_s = +0.1\ v$; $v_d = +0.1\ v$

g. $v_s = +v$; $v_d = 0$

h. $v_s = -v$; $v_d = 0$

i. $v_s = 0$; $v_d = +v$

j. $v_s = 0$; $v_d = -v$