**Chapter-17**

1. Two waves on one string are described by the wave functions

y1 = 3.0 cos (4.0x - 1.6t) y2 = 4.0 sin (5.0x - 2.0t)

where x and y are in centimeters and t is in seconds. Find the values of y1 + y2 at the points (a) x = 1.00, t 5 1.00; (b) x 5 1.00, t 5 0.500; and (c) x 5 0.500, t 5 0. Note: Remember that the arguments of the trigonometric functions are in radians.

The superposition of the waves is given by



evaluated at the given x values.

(a) At x = 1.00, t = 1.00, the superposition of the two waves gives



(b) At x = 1.00, t = 0.500, the superposition of the two waves gives



(c) At x = 0.500, t = 0, the superposition of the two waves gives



1. A standing wave is established in a 120-cm-long string fixed at both ends. The string vibrates in four segments when driven at 120 Hz. (a) Determine the wavelength. (b) What is the fundamental frequency of the string?

We are given *L* = 120 cm, *f* = 120 Hz.

(a) For four segments, or 

(b)  

1. A taut string has a length of 2.60 m and is fixed at both ends. (a) Find the wavelength of the fundamental mode of vibration of the string. (b) Can you find the frequency of this mode? Explain why or why not

(a) Because the string is taut and is fixed at both ends, any standing waves will have nodes (which are multiples of *λ*/2 apart). The wavelengths of all possible modes on the string are:

 where *n* = 1, 2, 3,…

The fundamental (n = 1) wavelength must then have a wavelength *λ* exactly twice the string length, or



(b)  To obtain the frequencies on the string,



it is necessary to have either the wave velocity *v* or the tension T and mass density *µ* of the string. We do not know these; therefore, it is not possible to find the frequency of this mode on the string.

1. A string that is 30.0 cm long and has a mass per unit length of 9.00 3 1023 kg/m is stretched to a tension of 20.0 N. Find (a) the fundamental frequency and (b) the next three frequencies of possible standing-wave patterns on the string

The wave speed is



For a vibrating string of length *L* fixed at both ends, there are nodes at both ends. The wavelength of the fundamental is *λ* = 2*dNN* = 2*L* =   
0.600 m, and the frequency is



After NAN, the next three vibration possibilities read NANAN, NANANAN, and NANANANAN. Each has just one more node and one more antinode than the one before. Respectively, these string waves have wavelengths of one-half, one-third, and one-quarter of   
60.0 cm. The harmonic frequencies are







1. The windpipe of one typical whooping crane is 5.00 feet long. What is the fundamental resonant frequency of the bird’s trachea, modeled as a narrow pipe closed at one end? Assume a temperature of 378C

Assuming an air temperature of *T* = 37.0°C = 310 K, the speed of sound inside the pipe is



In the fundamental resonant mode, the wavelength of sound waves in a pipe closed at one end is  Thus, for the whooping crane,



and



1. A student holds a tuning fork oscillating at 256 Hz. He walks toward a wall at a constant speed of 1.33 m/s. (a) What beat frequency does he observe between the tuning fork and its echo? (b) How fast must he walk away from the wall to observe a beat frequency of 5.00 Hz?

The source moves toward the wall:

*v*s = +*v*student, *v*0 = 0, and 

The wall acts as stationary source, reflecting the wave of frequency  The observe moves toward the source: *v*s = 0, *v*0 = +*v*student, and



(a) When the student walks toward the wall  is larger than *f*; the beat frequency is





(b) When he is moving away from the wall, the sign of *v*student changes and  is smaller than f:



Solving for *v*student gives

