Part N Problems

Waves on Strings

1. A 4.00-meter rope has a mass of 0.70 kg. It is tied at both ends with a tension of 70 N. What is the speed of pulses on this rope?

2. The wave speed on a string is 4.0 m/s. What would be the new wave speed if the tension were increased to a value that is 25 times what is was before?

3. The frequency of a wave on a wire is 40 Hz, and the distance between consecutive “peaks” (“maxima”) is 0.15 m. What is the wave speed?

4. The frequency of oscillation of a string is 25 Hz. If the wave speed is 2.0 m/s, what is the wavelength?

5. If the frequency of oscillation of a string is tripled, what happens to the wavelength?

6. If the frequency of oscillation is quadruped, what happens to the wave speed?

7. A resonance on a 1.2-meter string has two anti-nodes. The frequency of the oscillator creating the wave is 40 hertz. What is the wave speed?

8. What is the frequency of a resonance on a 1.2-meter string that has five anti-nodes? The tension in the string is 288 N, and the mass per meter of the string is 2 kg/m.

9. The wave speed on a certain string is unknown, but when its tension is quadrupled, the wave speed is measured to be 10 m/s. What was the original wave speed before the tension was changed?

10. One end of a rope 1.92 meters long is hanging vertically. The top of the rope is being oscillated at small amplitude (small swings) back and forth by hand, and the other end is free to whip back and forth. A resonance is created with three anti-nodes. The speed of pulses on this rope is 1.2 m/s. What is the frequency at which the hand is oscillating the rope?

Sound Waves

1. The distance between consecutive regions of “normal” pressure (P_o) in a sound wave is 0.10 meter. What is the frequency of this wave?

2. The “amplitude” of a sound wave is the maximum departure from atmospheric pressure. It’s the difference between the condensation pressure and atmospheric pressure. Given that atmospheric pressure is 1010 mb (milli-bars), what is the pressure when a “condensation” of a sound wave of 2 mb amplitude arrives at the eardrum? What is the pressure when a “rarefaction” of 2 mb amplitude arrives there?

3. The doctor reports she plans to use 50,000 Hz ultrasound waves to disintegrate a tumor in a patient's kidney. Given that the speed of sound in human tissue is about 1500 m/s, what is the approximate diameter of the tumor, in millimeters?

4. A siren broadcasting 3000 Hz sound is racing at 30 m/s toward an automobile traveling at 45 m/s toward the siren. What frequency does the driver of the automobile hear?

5. A police car moving at 35 m/s and emitting 2400 Hz sound is chasing an automobile attempting to escape the police. The driver of the automobile hears 2200 Hz sound. What is the automobile's speed?

6. A sound wave resonance exists in a tube that is open at one end, closed at the other end. Sound waves of 400-Hz frequency create a resonating sound wave in the tube with five anti-nodes. What is the length of the tube?

7. What is the frequency of the resonating sound wave resonating with two anti-nodes in a 2.2-meter tube that is open at both ends?

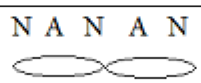
8. What would have to be the length of a tube, open at each end, whose lowest resonance frequency is 3000 Hz?

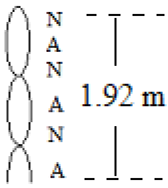
9. What are the lowest three frequencies that resonate in a 0.30-meter tube closed at one end, open at the other?

10. What frequency of sound will create a resonating sound wave with three nodes in a 0.80-m tube closed at one end, open at the other?

String Waves Solutions

1. $\mu = 0.70/4.00$ $= 0.18$ kg/m $v = [70/0.18]^{1/2}$ $= 19.7$ m/s	**2.** $v_1 = (T_1/\mu)^{1/2}$ $= 4.0$ m/s $T_2 = 25\ T_1$ $v_2 = (T_2/\mu)^{1/2}$ $= [(25T_1)/\mu]^{1/2}$ $= 5(T_1/\mu)^{1/2}$ $= 5\ v_1$ $= 5\ (4.0)$ $= 20$ m/s	**3.** $\lambda = 0.15$ m $v = 0.15(40)$ $= 6.0$ m/s

4. $v = \lambda f$ $2.0 = \lambda(25)$ $\lambda = 2.0/25$ $= 0.08$ m	**5.** $\lambda f = v$ v is a constant, so the product of λ and f doesn't change. If one goes up, the others goes down. To preserve the product when the frequency is tripled, the wavelength becomes one-third as large.	**6.** $v = \sqrt{(T/\mu)}$ The *only* way to change v is to change T, or change μ, or change both. Quadrupling the frequency cannot change v; all it does is cause the wavelength to be quartered (reduced to one-fourth of its previous value).
7.  $2\ (\lambda/2) = 1.2$ $\lambda = 1.2$ m $v = 1.2\ (40)$ $= 48$ m/s	**8.** $v = (288/2)^{1/2}$ $= 12$ m/s  5 loops $5(\lambda/2) = 1.2$ $\lambda = 0.48$ m $\lambda f = v$ $0.48f = 12$ $f = 25$ Hz	**9.** $v = (T/\mu)^{1/2}$ Quadrupling the tension quadruples the quantity inside the radial sign, which doubles the square root, which doubles the speed. If the new speed is 10 m/s, the old one must have been 5 m/s.

10. v = 1.2 m/s  2.5(λ/2) = 1.92 λ = 1.54 m λf = v 1.54 f = 1.2 f = 0.78 Hz	

Sound Waves Solutions

1. λ/2 = 0.10 m λ = 0.20 m f = 340/0.20 = 1700 Hz	**2.** 1010 + 2 = 1012 mb 1010 - 2 = 1008 mb	**3.** λ = v/f = 1500/50000 = 0.030 m
4. f_o = 3000 (340+45)/(340-30) = 3726 Hz	**5.** 2400(340-x)/(340-35) = 2200 x = 60.42 m/s	**6.** λ = 340/400 = 0.85 m ANANANANAN L = 9 (0.85/4) = 1.91 m
7. ANA : 2(λ/4) = 2.2 λ = 4.4 m f = v/λ f = 340/4.4 = 77.3 Hz	**8.** λ = v/f = 340/3000 = 0.113 m ANA L = 2(λ/4) = 2 (0.113/4) = 0.057 m (5.7 cm)	

9. A N:	**10.**
$\lambda/4 = 0.30$ $\lambda = 1.20$ m f = 340/1.20 = **283 Hz** A N A N: $3(\lambda/4) = 0.30$ $\lambda = 0.40$ f = 340/0.40 = **850 Hz** A N A N A N: $5(\lambda/4) = 0.30$ $\lambda = 0.24$ m: f =340/0.24 = **1417 Hz**	A N A N A N $5 (\lambda/4) = 0.80$ $\lambda = 0.64$ m f = 340/0.64 = 531 Hz