5. ***REASONING AND SOLUTION*** From Equation 16.1, we have $\lambda = v/f$. But $v = x/t$, so we find

$$\lambda = \frac{v}{f} = \frac{x}{tf} = \frac{2.5\ \text{m}}{(1.7\ \text{s})(3.0\ \text{Hz})} = \boxed{0.49\ \text{m}}$$

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8. ***REASONING AND SOLUTION*** The period of the waves is T = 7.0 s/3 = 2.3 s. The frequency is then f = 1/T = 0.43 Hz. The wavelength is λ = 4.0 m. The speed is

$$v = \lambda f = (4.0\ \text{m})(0.43\ \text{Hz}) = \boxed{1.7\ \text{m/s}}$$

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12. ***REASONING AND SOLUTION*** The speed of the wave is

$$v = \sqrt{\frac{F}{m/L}} = f\lambda \qquad (16.2)$$

Solving for the mass *m* of the string gives

$$m = \frac{FL}{f^2\lambda^2} = \frac{(2.3\ \text{N})(0.75\ \text{m})}{(150\ \text{Hz})^2\,(0.40\ \text{m})^2} = \boxed{4.8\times 10^{-4}\ \text{kg}}$$

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15. SSM WWW ***REASONING*** According to Equation 16.2, the linear density of the string is given by $(m/L) = F/v^2$, where the speed v of waves on the middle C string is given by Equation 16.1, $v = \lambda f = \lambda / T$.

SOLUTION Combining Equations 16.2 and 16.1 and using the given data, we obtain

$$m/L = \frac{F}{v^2} = \frac{FT^2}{\lambda^2} = \frac{(944\ \text{N})(3.82\times 10^{-3}\ \text{s})^2}{(1.26\ \text{m})^2} = \boxed{8.68\times 10^{-3}\ \text{kg/m}}$$

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31. ***REASONING AND SOLUTION***

$$\lambda = v/f = (343\ \text{m/s})/(4185.6\ \text{Hz}) = \boxed{8.19\times 10^{-2}\ \text{m}} \qquad (16.1)$$

49. SSM WWW ***REASONING AND SOLUTION*** Since the sound radiates uniformly in all directions, at a distance r from the source, the energy of the sound wave is distributed over the area of a sphere of radius r. Therefore, according to Equation 16.9 [$I = P/(4\pi r^2)$] with $r = 3.8$ m, the power radiated from the source is

$$P = 4\pi I r^2 = 4\pi(3.6\times10^{-2}\ \text{W/m}^2)(3.8\ \text{m})^2 = \boxed{6.5\ \text{W}}$$

---

62. ***REASONING AND SOLUTION***

a. $\beta = (10\ \text{dB})\log(P_A/P_B) = (10\ \text{dB})\log[(250\ \text{W})/(45\ \text{W}) = \boxed{7.4\ \text{dB}}$

b. No , A will not be twice as loud as B since it requires an increase of 10 dB to double the loudness.

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63. SSM ***REASONING*** According to Equation 16.10, the sound intensity level β in decibels (dB) is related to the sound intensity I according to $\beta = (10\ \text{dB})\log(I/I_0)$, where the quantity I_0 is the reference intensity. Since the sound is emitted uniformly in all directions, the intensity, or power per unit area, is given by $I = P/(4\pi r^2)$. Thus, the sound intensity at position 1 can be written as $I_1 = P/(4\pi r_1^2)$, while the sound intensity at position 2 can be written as $I_2 = P/(4\pi r_2^2)$. Therefore, the difference in the sound intensity level β_{21} between the two positions is

$$\beta_{21} = \beta_2 - \beta_1 = (10\ \text{dB})\log\left(\frac{I_2}{I_0}\right) - (10\ \text{dB})\log\left(\frac{I_1}{I_0}\right) = (10\ \text{dB})\log\left(\frac{I_2/I_0}{I_1/I_0}\right) = (10\ \text{dB})\log\left(\frac{I_2}{I_1}\right)$$

$$\beta_{21} = (10\ \text{dB})\log\left[\frac{P/(4\pi r_2^2)}{P/(4\pi r_1^2)}\right] = (10\ \text{dB})\log\left(\frac{r_1^2}{r_2^2}\right) = (10\ \text{dB})\log\left(\frac{r_1}{r_2}\right)^2$$

$$= (20\ \text{dB})\log\left(\frac{r_1}{r_2}\right) = (20\ \text{dB})\log\left(\frac{r_1}{2r_1}\right) = (20\ \text{dB})\log(1/2) = \boxed{-6.0\ \text{dB}}$$

The negative sign indicates that the sound intensity level decreases.

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68. ***REASONING AND SOLUTION*** The intensity level at each point is given by

$$I = \frac{P}{4\pi r^2}$$

Therefore,

$$\frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$$

Since the two intensity levels differ by 2.00 dB, the intensity ratio is

$$\frac{I_1}{I_2} = 10^{0.200} = 1.58$$

Thus,

$$\left(\frac{r_2}{r_1}\right)^2 = 1.58$$

We also know that $r_2 - r_1 = 1.00$ m. We can then solve the two equations simultaneously by substituting, i.e., $r_2 = r_1\sqrt{1.58}$ gives

$$r_1\sqrt{1.58} - r_1 = 1.00 \text{ m}$$

so that

$$r_1 = (1.00 \text{ m})/[\sqrt{1.58} - 1] = \boxed{3.9 \text{ m}}$$

and

$$r_2 = 1.00 \text{ m} + r_1 = \boxed{4.9 \text{ m}}$$

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70. ***REASONING*** In this situation, the observer is moving toward a stationary source of waves. The frequency f_o detected by the moving observer is related to the frequency f_s emitted by the source by

$$f_o = f_s\left(1 + \frac{v_o}{v}\right) \quad (16.13)$$

where v_o is the speed of the observer and v is the speed of the waves. The frequency f_s is related to the speed v of the waves and their wavelength λ by Equation 16.1, $f_s = v/\lambda$. Substituting this value for f_s into Equation 16.13 gives

$$f_o = \left(\frac{v}{\lambda}\right)\left(1 + \frac{v_o}{v}\right)$$

SOLUTION The frequency of the waves, as detected by the moving observer, is

$$f_o = \left(\frac{v}{\lambda}\right)\left(1 + \frac{v_o}{v}\right) = \left(\frac{6.70 \text{ m/s}}{13.4 \text{ m}}\right)\left(1 + \frac{4.20 \text{ m/s}}{6.70 \text{ m/s}}\right) = \boxed{0.813 \text{ Hz}}$$

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