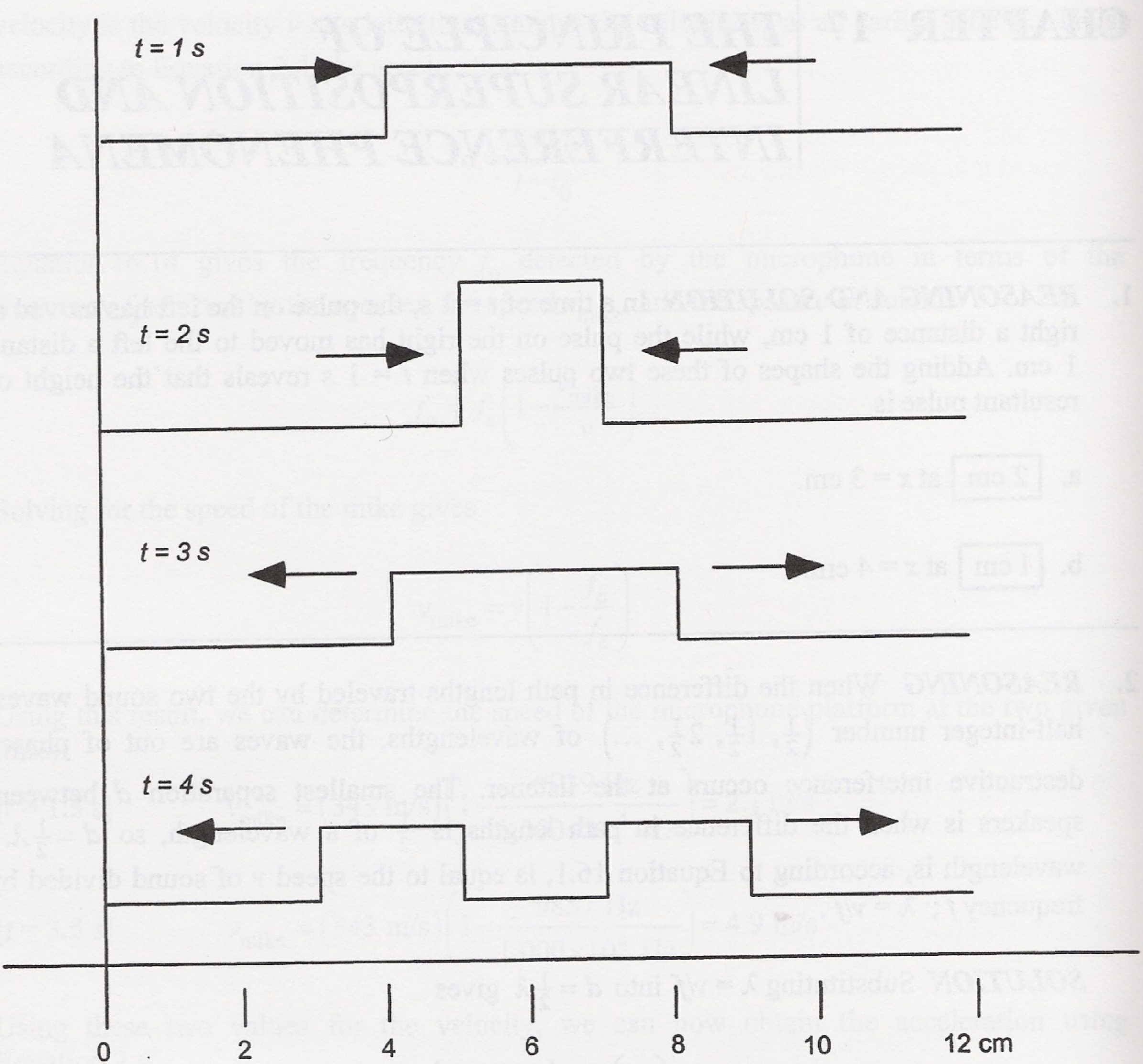
4. ***REASONING AND SOLUTION*** If the width of the speakers is D, then sound of wavelength λ will diffract more readily if the ratio λ / D is large. Since longer wavelengths correspond to lower frequencies, we see that lower-frequency sounds diffract more readily from a given speaker than higher-frequency sounds. Since the frequencies of the sounds of the female vocalists are higher than the frequencies of the sounds of the rhythmic bass, the sounds of the female vocalists will not diffract to the same extent as the sounds of the rhythmic bass. Thus, diffraction allows the bass tones to penetrate the regions to either side of the stage, but it does not permit the same help to the sounds of the female vocalists.

3. SSM ***REASONING AND SOLUTION*** According to the principle of linear superposition, when two or more waves are present simultaneously at the same place, the resultant wave is the sum of the individual waves. Therefore, the shape of the string at the indicated times looks like the following:



t = 1 s
t = 2 s
t = 3 s
t = 4 s
0
2
4
6
8
10
12 cm

15. ***REASONING AND SOLUTION*** At 0 °C the speed of sound is air is given as 331 m/s in Table 16.1 in the text. This corresponds to a wavelength of

$$\lambda_1 = v/f = (331 \text{ m/s})/(3.00 \times 10^3 \text{ Hz}) = 0.1103 \text{ m}$$

The diffraction angle is given by Equation 17.2 as

$$\theta_1 = \sin^{-1}\left(\frac{1.22\,\lambda}{\text{D}}\right) = \sin^{-1}\left[\frac{1.22(0.1103 \text{ m})}{0.175 \text{ m}}\right] = 50.3°$$

For an ideal gas, the speed of sound is proportional to the square root of the Kelvin temperature, according to Equation 16.5. Therefore, the speed of sound at 29 °C is

$$v = (331 \text{ m/s})\sqrt{\frac{302 \text{ K}}{273 \text{ K}}} = 348 \text{ m/s}$$

The wavelength at this temperature is $\lambda_2 = (348 \text{ m/s})/(3.00 \times 10^3 \text{ Hz}) = 0.116 \text{ m}$. This gives a diffraction angle of $\theta_2 = 54.0°$. The change in the diffraction angle is thus

$$\Delta\theta = 54.0° - 50.3° = \boxed{3.7°}$$

20. ***REASONING AND SOLUTION*** The beat frequency is $f_{beat} = 529 \text{ Hz} - 524 \text{ Hz} = 5 \text{ Hz}$.
The period of the beats is then

$$T_{beat} = 1/f_{beat} = 1/(5\ \text{Hz}) = \boxed{0.2\ \text{s}}$$