1.1 A 2-kHz sound wave traveling in the x-direction in air was observed to have a differential pressure $\rho(x,t) = 10 \text{ N/m}^2$ at x = 0 and $t = 50 \,\mu\text{s}$. If the reference phase of $\rho(x,t)$ is 36°, find a complete expression for $\rho(x,t)$. The velocity of sound in air is 330 m/s.

Solution: The general form is given by Eq. (1.17),

$$\rho(x,t) = A\cos\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} + \phi_0\right),$$

where it is given that $\phi_0 = 36^\circ$. From Eq. (1.26), $T = 1/f = 1/(2 \times 10^5) = 0.5$ ms. From Eq. (1.27),

$$\lambda = \frac{u_p}{f} = \frac{330}{2 \times 10^3} = 0.165 \text{ m}.$$

Also, since

$$\rho(x = 0, t = 50 \text{ } \mu\text{s}) = 10 \text{ } (\text{N/m}^2) = A \cos\left(\frac{2\pi \times 50 \times 10^{-6}}{5 \times 10^{-4}} + 36^{\circ} \frac{\pi \text{ rad}}{180^{\circ}}\right)$$
$$= A \cos(1.26 \text{ md}) = 0.31A,$$

it follows that $A = 10/0.31 = 32.36 \text{ N/m}^2$. So, with r in (s) and x in (m),

$$\rho(x,t) = 32.36\cos\left(2\pi \times 10^6 \frac{t}{500} - 2\pi \times 10^3 \frac{x}{165} + 36^\circ\right) \quad \text{(N/m}^2)$$

= 32.36\cos(4\pi \times 10^3 t - 12.12\pi x + 36^\circ) \quad (N/m^2).

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M Carnoy

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