1.3 A 2 kHz sound wave traveling in the x direction in air was observed to have a differential pressure $p(x,t) = 30$ N/m^2 at $x = 0$ and $t = 25$ μs. If the reference phase of $p(x,t)$ is 36°, find a complete expression for $p(x,t)$. The velocity of sound in air is 330 m/s.

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

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

where it is given that $\phi_0 = 36°$. From Eq. (1.26), $T = 1/f = 1/\left(2\times10^3\right) = 0.5$ ms. From Eq. (1.27),

$$\lambda = \frac{u_\text{p}}{f} = \frac{330}{2\times10^3} = 0.165 \text{ m}.$$

Also, since

$$\begin{aligned} p(x=0,\ t=50\ \mu\text{s}) = 30\ (\text{N/m}^2) &= A\cos\left(\frac{2\pi\times25\times10^{-6}}{5\times10^{-4}} + 36°\frac{\pi\ \text{rad}}{180°}\right) \\ &= A\cos(0.94\ \text{rad}) = 0.59A, \end{aligned}$$

it follows that $A = 30/0.59 = 51.04$ N/m^2. So, with t in (s) and x in (m),

$$\begin{aligned} p(x,t) &= 51.04\cos\left(2\pi\times10^6\frac{t}{500} - 2\pi\times10^3\frac{x}{165} + 36°\right) \qquad (\text{N/m}^2) \\ &= 51.04\cos(4\pi\times10^3 t - 12.12\pi x + 36°) \qquad (\text{N/m}^2). \end{aligned}$$