**1.3** A 2 kHz sound wave traveling in the $x$-direction in air was observed to have a differential pressure $p(x,t) = 10$ N/m$^2$ at $x = 0$ and $t = 50$ $\mu$s. 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), $T = 1/f = 1/\left(2\times 10^3\right) = 0.5$ ms. From Eq. (1.27),

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

Also, since

$$\begin{aligned} p(x = 0,\ t = 50\ \mu\mathrm{s}) = 10\ (\mathrm{N/m^2}) &= A\cos\left(\frac{2\pi\times 50\times 10^{-6}}{5\times 10^{-4}} + 36°\frac{\pi \text{ rad}}{180°}\right) \\ &= A\cos(1.26 \text{ rad}) = 0.31A, \end{aligned}$$

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

$$\begin{aligned} p(x,t) &= 32.36\cos\left(2\pi\times 10^6\frac{t}{500} - 2\pi\times 10^3\frac{x}{165} + 36°\right) \qquad (\mathrm{N/m^2}) \\ &= 32.36\cos(4\pi\times 10^3 t - 12.12\pi x + 36°) \qquad (\mathrm{N/m^2}). \end{aligned}$$