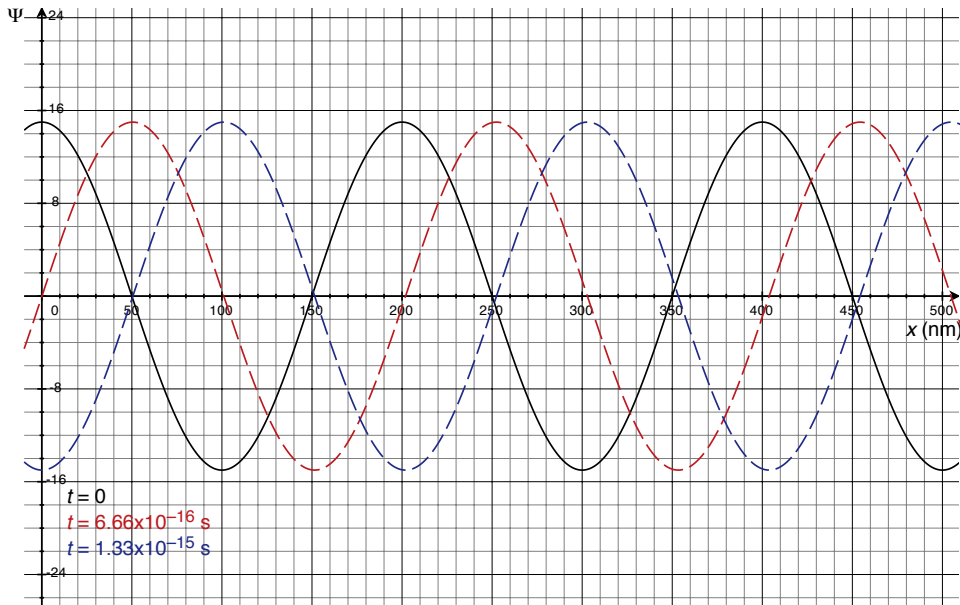


1. A wave**(4 pts)**

Figure 1 shows three snapshots of a harmonic wave.



(a) Write down expressions for this wave as a trig function and in exponential notation.

$$\Psi(x, t) = A \cdot \cos(kx - \omega t) \text{ and}$$

$$\Psi(x, t) = A \cdot e^{i(kx - \omega t)}$$

With $\lambda = 200 \text{ nm}$ from diagram, $T = 2.66 \cdot 10^{-15} \text{ s}$ from shift of cos function in diagram, retrieve

$$k = 2\pi/\lambda = 3.14 \cdot 10^5 \text{ cm}^{-1}, \quad \omega = 2\pi/T = \frac{\pi \text{ rad}}{1.33 \cdot 10^{-15} \text{ s}} = 0.75 \cdot \pi \cdot 10^{15} \frac{\text{rad}}{\text{s}}$$

(b) Determine its wavelength λ , phase velocity, frequency ν and temporal period T .

$\lambda = 200 \text{ nm}$ from diagram. $T = 2.66 \cdot 10^{-15} \text{ s}$ from shift of the cos function in the diagram.

$$\nu = \omega/k = \frac{0.75 \cdot \pi \cdot 10^{15} \text{ s}^{-1}}{\pi \cdot 10^5 \text{ cm}^{-1}} = 0.75 \cdot 10^{10} \frac{\text{cm}}{\text{s}}$$

$$\nu = \omega/2\pi = 3.75 \cdot 10^{14} \text{ Hz}$$

2. Sound wave**(3 pts)**

A sound wave with a frequency $\nu = 1.65$ kHz travels at a speed of 340 m/s in dry air.

(a) Determine its angular frequency ω and wavelength λ .

$$\omega = 2\pi\nu = 3.3 \cdot \pi \cdot 10^3 \text{ rad/s}$$

$$\lambda = c/\nu = (340 \text{ m/s}) / (1650 \text{ s}^{-1}) = 0.206 \text{ m}$$

(b) What is the phase difference in radians of two points on the wave separated by 100 mm?

$$\Delta\phi = (0.1 \text{ m}) / (0.206 \text{ m}) \cdot 2\pi = 3.05 \text{ rad}$$

3. Light wave**(3 pts)**

A light wave with a phase velocity of 3×10^8 m/s has a frequency $\nu = 5 \times 10^{14}$ Hz. What phase shift on this wave at a given point in space occurs in 100 ns? How many full wavelengths have passed by in this time interval?

$$\Delta x = 3 \cdot 10^8 \text{ m/s} \cdot 10^{-7} \text{ s} = 30 \text{ m}$$

$$\Delta\phi = 2\pi \frac{\Delta x}{\lambda} = 2\pi \frac{\Delta x \nu}{c} = 2\pi \frac{30 \text{ m} \cdot 5 \cdot 10^{14} \text{ s}^{-1}}{3 \cdot 10^8 \text{ m/s}} = 2\pi \cdot 5 \cdot 10^7 : \text{no phase shift; } 5 \cdot 10^7 \text{ passes.}$$