The distance between adjacent crests is one wavelength $\lambda$

$$\Rightarrow v = f \lambda = (145 \times 10^6 \text{ Hz}) (1.25 \text{ m})$$

$$= 1.81 \times 10^8 \text{ m/s} = 0.604 c$$
Problem

9. In Fig. 16-28 two boats are anchored offshore and are bobbing up and down on the waves at the rate of six complete cycles each minute. When one boat is up the other is down. If the waves propagate at 2.2 m/s, what is the minimum distance between the boats?

The boats are 180° out of phase ⇒ they are a minimum of \(\frac{1}{2}\)\(\lambda\) apart.

\[ \lambda = \frac{v}{\nu} \Rightarrow \frac{1}{2}\lambda = \frac{v}{2\nu} \]

\[ v = 2.2 \text{ m/s} \quad \nu = \frac{6}{60} = 0.1 \text{ Hz} \]

\[ \frac{\nu}{2\nu} = \frac{2.2 \text{ m/s}}{2(0.1 \text{ Hz})} = 11 \text{ m} \]
Problem

11. An ocean wave has period 4.1 s and wavelength 10.8 m. Find (a) its wave number and (b) its angular frequency.

\[
\text{a)} \quad k = \frac{2\pi}{\lambda} = \frac{2\pi}{10.8 \text{ m}} = 0.582 \text{ m}^{-1}
\]

\[
\omega = \frac{2\pi}{T} = \frac{2\pi}{4.1 \text{ s}} = 1.53 \text{ s}^{-1}
\]
Problem

15. What are (a) the amplitude, (b) the frequency in hertz, (c) the wavelength, and (d) the speed of a water wave whose displacement is \( y = 0.25 \sin(0.52x - 2.3t) \), where \( x \) and \( y \) are in meters and \( t \) in seconds?

\[ \text{a) } \quad A = 0.25 \text{ m} \]

\[ \text{b) } \quad f = \frac{\omega}{2\pi} = \frac{2.3 \text{ s}^{-1}}{2\pi} = 0.366 \text{ Hz} \]

\[ \text{c) } \quad \lambda = \frac{2\pi}{k} = \frac{2\pi}{0.52 \text{ m}^{-1}} = 12.1 \text{ m} \]

\[ \text{d) } \quad v = \frac{\omega}{k} = \frac{2.3 \text{ s}^{-1}}{0.52 \text{ m}^{-1}} = 4.42 \text{ m/s} \]
Problem

23. A transverse wave with 3.0-cm amplitude and 75-cm wavelength is propagating on a stretched spring whose mass per unit length is 170 g/m. If the wave speed is 6.7 m/s, find (a) the spring tension and (b) the maximum speed of any point on the spring.

\[ F = \mu v^2 = (0.17 \text{ kg/m}) (6.7 \text{ m/s})^2 \]
\[ = 7.63 \text{ N} \]

\[ u_{\text{max}} = \left( \frac{dy}{dt} \right)_{\text{max}} = \omega A = \left( \frac{2\pi v}{\lambda} \right) A \]
\[ = \frac{2\pi (6.7 \text{ m/s}) (3 \text{ cm})}{(75 \text{ cm})} = 1.68 \text{ m/s} \]
Problem

31. A steel wire can tolerate a maximum tension per unit cross-sectional area of 2.7 GN/m² before it undergoes permanent distortion. What is the maximum possible speed for transverse waves in a steel wire if it is to remain undistorted? Steel has a density of 7.9 g/cm³.

The linear density of the wire is: \( \mu = \rho \frac{1}{4\pi} d^2 \)

The tension is \( F = (2.7 \text{ GN/m}^2) \left( \frac{1}{4\pi} d^2 \right) \)

\[ \Rightarrow \quad v_{\text{max}} = \sqrt{\frac{F_{\text{max}}}{\mu}} = \sqrt{\frac{2.7 \text{ GN/m}^2}{7.9 \text{ g/cm}^3}} \]

\[ = 585 \text{ m/s} \]
Problem

35. A 600-g Slinky is stretched to a length of 10 m. You shake one end at the frequency of 1.8 Hz, applying a time-average power of 1.1 W. The resulting waves propagate along the Slinky at 2.3 m/s. What is the wave amplitude?

\[ P = \frac{1}{2} \mu \omega^2 A^2 \nu \]

\[ \Rightarrow A = \sqrt{\frac{2P}{\mu \omega^2 \nu}} \]

\[ = \sqrt{\frac{2 \times (1.1 \text{ W})}{(0.06 \text{ kg/m}) \times (2.3 \text{ m/s}) \times (2\pi \times 1.8 \text{ Hz})^2}} \]

\[ = 35.3 \text{ cm} \]
37. Figure 16-32 shows a wave train consisting of two cycles of a sine wave propagating along a string. Obtain an expression for the total energy in this wave train, in terms of the string tension $F$, the wave amplitude $A$, and the wavelength $\lambda$.

$$\vec{dE} = \overrightarrow{P} \, dt = \frac{1}{2} \mu w^2 A^2 \nu \, dt$$

$$= \frac{1}{2} \mu w^2 A^2 \, dx$$

$$\Rightarrow \frac{d\vec{E}}{dx} = \frac{1}{2} \mu w^2 A^2$$

for a wave train of length $l = 2\lambda$.

$$E = \frac{d\vec{E}}{dx} \cdot l = \frac{1}{2} \mu w^2 A^2 (2\lambda)$$

$$\Rightarrow E = \frac{1}{2} \left( \frac{F \nu^2}{\mu} \right) \left( \frac{2\pi \nu^2}{\lambda} \right) A^2 (2\lambda)$$

$$= 4 \frac{\pi^2 \nu^2 FA^2}{\lambda}$$