Quick Notes

Tuesday, April 27, 2021 12:24 PM

31. ‖ During takeoff, the sound intensity level of a jet engine is 140 dB at a distance of 30 m. What is the sound intensity level at a distance of 1.0 km?

20.31. Model: Assume the intensity scales inversely with the square of the distance.

Visualize: $\beta = (10\text{ dB})\log_{10}\left(\frac{I}{I_0}\right)$.

Solve: The intensity at 1.0 km is $I' = \left(\frac{30\text{ m}}{1000\text{ m}}\right)^2 I$.

$$\beta = (10\text{ dB})\log_{10}\left(\frac{I'}{I_0}\right) = (10\text{ dB})\log_{10}\left(\frac{\left(\frac{30\text{ m}}{1000\text{ m}}\right)^2 I}{I_0}\right)$$

$$= (10\text{ dB})\log_{10}\left(\frac{30\text{ m}}{1000\text{ m}}\right)^2 + (10\text{ dB})\log_{10}\left(\frac{I}{I_0}\right) = -30\text{ db} + 140\text{ dB} = 110\text{ dB}$$

Assess: 110 dB is still loud, but not as damaging.

41. ‖ A 300 g oscillator has a speed of 95.4 cm/s when its displacement is 3.0 cm and 71.4 cm/s when its displacement is 6.0 cm. What is the oscillator's maximum speed?

14.41. Model: The oscillator is in simple harmonic motion. Energy is conserved.

Solve: The energy conservation equation $E_1 = E_2$ is

$$\tfrac{1}{2}mv_1^2 + \tfrac{1}{2}kx_1^2 = \tfrac{1}{2}mv_2^2 + \tfrac{1}{2}kx_2^2$$

$$\frac{1}{2}(0.30\text{ kg})(0.954\text{ m/s})^2 + \frac{1}{2}k(0.030\text{ m})^2 = \frac{1}{2}(0.30\text{ kg})(0.714\text{ m/s})^2 + \frac{1}{2}k(0.060\text{ m})^2$$

$$\Rightarrow k = 44.48\text{ N/m}$$

The total energy of the oscillator is

$$E_{\text{total}} = \frac{1}{2}mv_1^2 + \frac{1}{2}kx_1^2 = \frac{1}{2}(0.30\text{ kg})(0.954\text{ m/s})^2 + \frac{1}{2}(44.48\text{ N/m})(0.030\text{ m})^2 = 0.1565\text{ J}$$

Because $E_{\text{total}} = \frac{1}{2}mv_{\max}^2$,

$$0.1565\text{ J} = \frac{1}{2}(0.300\text{ kg})v_{\max}^2 \Rightarrow v_{\max} = 1.02\text{ m/s}$$

Assess: A maximum speed of 1.02 m/s is reasonable.

24. | a. Telephone signals are often transmitted over long distances by microwaves. What is the frequency of microwave radiation with a wavelength of 3.0 cm?
b. Microwave signals are beamed between two mountaintops 50 km apart. How long does it take a signal to travel from one mountaintop to the other?

20.24. Model: Microwaves are electromagnetic waves that travel with a speed of 3×10^8 m/s.

Solve: **(a)** The frequency of the microwave is

$$f_{\text{microwaves}} = \frac{c}{\lambda} = \frac{3.0\times10^8\text{ m/s}}{3.0\times10^{-2}\text{ m}} = 1.0\times10^{10}\text{ Hz} = 10\text{ GHz}$$

(b) The refractive index of air is 1.0003, so the speed of microwaves in air is $v_{\text{air}} = c/1.00 = c$. The time for the microwave signal to travel is

$$t = \frac{50\text{ km}}{v_{\text{air}}} = \frac{50\times10^3\text{ m}}{(3.0\times10^8\text{ m}/1.00)} = 0.167\text{ ms} = 0.17\text{ ms}$$

Assess: A small time of 0.17 ms for the microwaves to cover a distance of 50 km shows that the electromagnetic waves travel very fast.