14.74 A barge is in a rectangular lock on a freshwater river. The lock is 60.0 m long and 20.0 m wide, and the steel doors on each end are closed. With the barge floating in the lock, a 2.50×10^6 N load of scrap metal is put onto the barge. The metal has density 9000 kg/m^3. a) When the load of scrap metal, initially on the bank, is placed onto the barge, what vertical distance does the water in the lock rise? b) The scrap metal is now pushed overboard into the water. Does the water level in the lock rise, fall, or remain the same? If it rises or falls, by what vertical distance does it change?

14.74: a) The change in height Δy is related to the displaced volume ΔV by $\Delta y = \frac{\Delta V}{A}$, where A is the surface area of the water in the lock. ΔV is the volume of water that has the same weight as the metal, so

$$\Delta y = \frac{\Delta V}{A} = \frac{w/\rho_{\text{water}}g}{A} = \frac{w}{\rho_{\text{water}}gA}$$

$$= \frac{(2.50 \times 10^6 \text{ N})}{(1.00 \times 10^3 \text{ kg/m}^3)(9.80 \text{ m/s}^2)((60.0 \text{ m})(20.0 \text{ m}))} = 0.213 \text{ m}.$$

b) In this case, ΔV is the volume of the metal; in the above expression, ρ_{water} is replaced by $\rho_{\text{metal}} = 9.00\rho_{\text{water}}$, which gives $\Delta y' = \frac{\Delta y}{9}$, and $\Delta y - \Delta y' = \frac{8}{9}\Delta y = 0.189$ m; the water sinks by this amount.

15.44 a) A horizontal string tied at both ends is vibrating in its fundamental mode. The traveling waves have speed v, frequency f, amplitude A, and wavelength λ. Calculate the maximum transverse velocity and maximum transverse acceleration of points located at i) $x = \lambda/2$, ii) $x = \lambda/4$, and iii) $x = \lambda/8$ from the left-hand end of the string. b) At each of the points in part (a), what is the amplitude of the motion? c) At each of the points in part (a), how much time does it take the string to go from its largest upward displacement to its largest downward displacement?

15.44: a) (i) $x = \frac{\lambda}{2}$ is a node, and there is no motion. (ii) $x = \frac{\lambda}{4}$ is an antinode, and $v_{\max} = A(2\pi f) = 2\pi fA$, $a_{\max} = (2\pi f)v_{\max} = 4\pi^2 f^2 A$. (iii) $\cos\frac{\pi}{4} = \frac{1}{\sqrt{2}}$, and this factor multiplies the results of (ii), so $v_{\max} = \sqrt{2}\pi fA$, $a_{\max} = 2\sqrt{2}\pi^2 f^2 A$. b) The amplitude is $A\sin kx$, or (i) 0, (ii) A, (iii) $A/\sqrt{2}$. c) The time between the extremes of the motion is the same for any point on the string (although the period of the zero motion at a node might be considered indeterminate) and is $\frac{1}{2f}$.