14.43. Model: The ball attached to a spring is in simple harmonic motion.

Solve: **(a)** Let $t = 0$ s be the instant when $x_0 = -5$ cm and $v_0 = 20$ cm/s. The oscillation frequency is

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{2.5\ \text{N/m}}{0.10\ \text{kg}}} = 5.0\ \text{rad/s}$$

Using Equation 14.27, the amplitude of the oscillation is

$$A = \sqrt{x_0^2 + \left(\frac{v_0}{\omega}\right)^2} = \sqrt{(-5\ \text{cm})^2 + \left(\frac{20\ \text{cm/s}}{5\ \text{rad/s}}\right)^2} = 6.40\ \text{cm}$$

(b) The maximum acceleration is $a_{\text{max}} = \omega^2 A = 160\ \text{cm/s}^2$.

(c) For an oscillator, the acceleration is most positive $(a = a_{\text{max}})$ when the displacement is most negative $(x = -x_{\text{max}} = -A)$. So the acceleration is maximum when $x = -6.40$ cm.

(d) We can use the conservation of energy between $x_0 = -5$ cm and $x_1 = 3$ cm:

$$\tfrac{1}{2}mv_0^2 + \tfrac{1}{2}kx_0^2 = \tfrac{1}{2}mv_1^2 + \tfrac{1}{2}kx_1^2 \Rightarrow v_1 = \sqrt{v_0^2 + \frac{k}{m}\left(x_0^2 - x_1^2\right)} = 0.283\ \text{m/s} = 28.3\ \text{cm/s}$$

Because k is known in SI units of N/m, the energy calculation *must* be done using SI units of m, m/s, and kg.