8.48

a) The kinetic energy of the mass is
\[ KE = \frac{1}{2} mv^2 = \frac{1}{2} (0.070 \text{ kg}) (7.0 \text{ m/s})^2 = 1.7 \text{ J}. \]

b) Use the CWE theorem. There are no nonconservative forces, so they do zero work. Take the initial position to be where the mass is resting against the compressed spring and the final position to be where the mass leaves the spring (at the equilibrium unstretched position of the spring).
\[ 0 \text{ J} = W_{\text{nonconservative}} = \Delta(KE + PE) = (KE_f + PE_f) - (KE_i + PE_i) = (1.7 \text{ J}) - (0 \text{ J} + PE_i) \implies PE_i = 1.7 \text{ J}. \]

c) The initial potential energy is associated with the spring, so letting \( x = -0.050 \text{ m} \) be the amount that it is compressed, and letting \( k \) be the spring constant,
\[ PE_i = \frac{1}{2} kx^2 \implies k = \frac{2PE_i}{x^2} = \frac{2(1.7 \text{ J})}{(-0.050 \text{ m})^2} = 1.4 \times 10^3 \text{ N/m}. \]

8.49

Choose a coordinate system with origin at the launch point, \( \hat{i} \) in the direction of the horizontal component of the projectile’s initial velocity, and \( \hat{j} \) pointing up.

Apply the CWE theorem with the initial position at the place where the projectile is launched, and the final position at the highest point of its trajectory. At the highest point, the velocity of the projectile is horizontal and, because there is no acceleration in the horizontal direction, its speed is equal to the magnitude of the \( x \)-component of the initial velocity, \( v_0 \cos \theta \).
\[ 0 \text{ J} = W_{\text{nonconservative}} = \Delta(KE + PE) = (KE + PE)_f - (KE + PE)_i = \left( \frac{m(v_0 \cos \theta)^2}{2} + mgy_f \right) - \left( \frac{mv_0^2}{2} + 0 \text{ J} \right) \implies mgy_f = \frac{mv_0^2}{2} - \frac{m v_0^2 \cos^2 \theta}{2} \implies y_f = \frac{v_0^2 (1 - \cos^2 \theta)}{2g} = \frac{v_0^2 \sin^2 \theta}{2g}. \]

8.50

a) The work done by the gravitational force is the negative of the change in the associated gravitational potential energy. For purposes of computing gravitational potential energy, choose the lower level section to be at zero height, so the cars start at an initial height of 2.00 m.
\[ W_{\text{gravity}} = -\Delta PE = -(PE_f - PE_i) = -(mgy_f - mgy_i) = mg(y_f - y_i) = (3.00 \times 10^4 \text{ kg})(9.81 \text{ m/s}^2)(2.00 \text{ m} - 0 \text{ m}) = 5.89 \times 10^5 \text{ J}. \]

b) The normal force does zero work because it is always perpendicular to the change in the position vector of the system.

c) Use the CWE theorem, with the initial situation where the boxcar is rolling at 1.50 m/s at the top of the incline, and the final situation where the boxcar is rolling along the level stretch at 0.500 m/s.
\[ W_{\text{other}} = \Delta(KE + PE) = (KE_f + PE_f) - (KE_i + PE_i) = \left( \frac{1}{2} mv_i^2 + mgy_i \right) - \left( \frac{1}{2} mv_i^2 + mgy_i \right) = m \left( \frac{1}{2} (v_f^2 - v_i^2) + g(y_f - y_i) \right) = (3.00 \times 10^4 \text{ kg}) \left( \frac{1}{2} ((0.500 \text{ m/s})^2 - (1.50 \text{ m/s})^2) + (9.81 \text{ m/s}^2)(0 \text{ m} - 2.00 \text{ m}) \right) = -6.18 \times 10^5 \text{ J}. \]