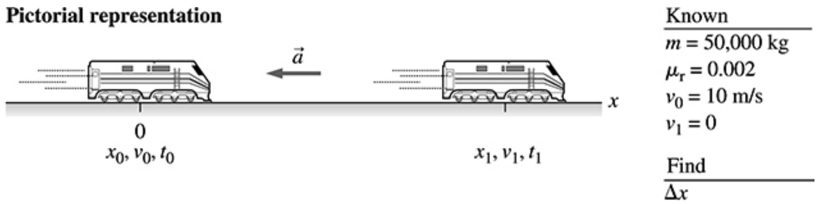
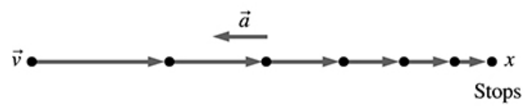
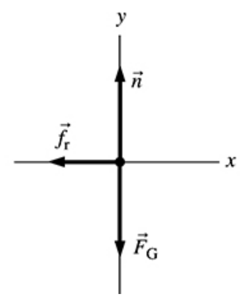
6.23. Model: We treat the train as a particle subject to rolling friction but not to drag (because of its slow speed and large mass). We can use the one-dimensional kinematic equations.

Visualize:







Solve: The locomotive is not accelerating in the vertical direction, so the free-body diagram shows us that $n = F_G = mg$. Thus,

$$f_r = \mu_r mg = (0.002)(50{,}000 \text{ kg})(9.80 \text{ m/s}^2) = 980 \text{ N}$$

From Newton's second law for the decelerating locomotive,

$$a_x = \frac{-f_r}{m} = \frac{-980 \text{ N}}{50{,}000 \text{ kg}} = -0.01960 \text{ m/s}^2$$

Since we're looking for the distance the train rolls, but we don't have the time:

$$v_1^2 - v_0^2 = 2a_x(\Delta x) \Rightarrow \Delta x = \frac{v_1^2 - v_0^2}{2a_x} = \frac{(0 \text{ m/s})^2 - (10 \text{ m/s})^2}{2(-0.01960 \text{ m/s}^2)} = 2.55 \times 10^3 \text{ m}$$

Assess: The locomotive's enormous inertia (mass) and the small coefficient of rolling friction make this long stopping distance seem reasonable.