9.9. **Model:** Use the particle model for the sled, the model of kinetic friction, and the impulse-momentum theorem.

**Visualize:**

![Pictorial representation of sled and forces](image)

Note that the force of kinetic friction $f_k$ imparts a negative impulse to the sled.

**Solve:** Using $\Delta p_x = J_x$, we have

$$p_x(t_f) - p_x(t_i) = \int_{t_i}^{t_f} F_x(t) \, dt = -f_k \int_{t_i}^{t_f} \, dt = -f_k \Delta t \Rightarrow m v_x(t_f) - m v_x(t_i) = -f_k n \Delta t = -\mu_k mg \Delta t$$

We have used the model of kinetic friction $f_k = \mu_k n$, where $\mu_k$ is the coefficient of kinetic friction and $n$ is the normal (contact) force by the surface. The force of kinetic friction is independent of time and was therefore taken out of the impulse integral. Thus,

$$\Delta t = \frac{1}{\mu_k g} \frac{1}{0.25} \frac{1}{9.8 \text{ m/s}^2} (8.0 \text{ m/s} - 5.0 \text{ m/s}) = 1.22 \text{ s}$$