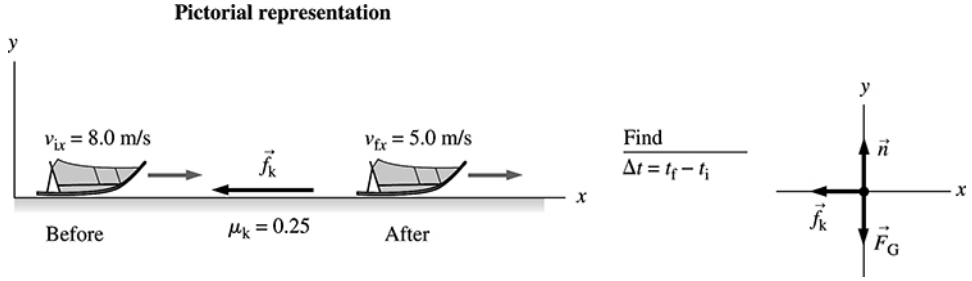
9.9. Model: Use the particle model for the sled, the model of kinetic friction, and the impulse-momentum theorem.

Visualize:



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

$$p_{fx} - p_{ix} = \int_{t_i}^{t_f} F_x(t)\,dt = -f_k \int_{t_i}^{t_f} dt = -f_k \Delta t \Rightarrow mv_{fx} - mv_{ix} = -\mu_k n \Delta t = -\mu_k mg \Delta t$$

We have used the model of kinetic friction $f_k = \mu_k n$, where μ_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,

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