## SAMPLE PROBLEM C

### Work–Kinetic Energy Theorem

**PROBLEM**

**On a frozen pond, a person kicks a 10.0 kg sled, giving it an initial speed of 2.2 m/s. How far does the sled move if the coefficient of kinetic friction between the sled and the ice is 0.10?**

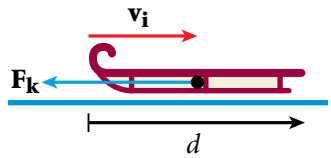
**SOLUTION**

**1. DEFINE**

**Given:** $m = 10.0\ \text{kg} \quad v_i = 2.2\ \text{m/s} \quad v_f = 0\ \text{m/s} \quad \mu_k = 0.10$

**Unknown:** $d = ?$

**Diagram:**




**2. PLAN**

**Choose an equation or situation:**

This problem can be solved using the definition of work and the work–kinetic energy theorem.

$$W_{net} = F_{net} d \cos\theta$$

The net work done on the sled is provided by the force of kinetic friction.

$$W_{net} = F_k d \cos\theta = \mu_k mgd \cos\theta$$

The force of kinetic friction is in the direction opposite $d$, so $\theta = 180°$. Because the sled comes to rest, the final kinetic energy is zero.

$$W_{net} = \Delta KE = KE_f - KE_i = -\tfrac{1}{2} m v_i^2$$

Use the work-kinetic energy theorem, and solve for $d$.

$$-\tfrac{1}{2} m v_i^2 = \mu_k mgd \cos\theta$$

$$d = \frac{-v_i^2}{2\mu_k g \cos\theta}$$

**3. CALCULATE**

**Substitute values into the equation:**

$$d = \frac{-(2.2\ \text{m/s})^2}{2(0.10)(9.81\ \text{m/s}^2)(\cos 180°)}$$

$$\boxed{d = 2.5\ \text{m}}$$

**4. EVALUATE**

According to Newton's second law, the acceleration of the sled is about $-1\ \text{m/s}^2$ and the time it takes the sled to stop is about 2 s. Thus, the distance the sled traveled in the given amount of time should be less than the distance it would have traveled in the absence of friction.

$$2.5\ \text{m} < (2.2\ \text{m/s})(2\ \text{s}) = 4.4\ \text{m}$$