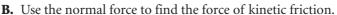Next, apply the equilibrium condition, $\Sigma F_y = 0$, and solve for F_n.

$$\Sigma F_y = F_n + F_{applied,y} - F_g = 0$$

$$F_n + 45.0\ N - 196\ N = 0$$

$$F_n = -45.0\ N + 196\ N = 151\ N$$

TIP *Remember to pay attention to the direction of forces. Here, F_g is subtracted from F_n and $F_{applied,y}$ because $\mathbf{F_g}$ is directed downward.*

B. Use the normal force to find the force of kinetic friction.

$$F_k = \mu_k\ F_n = (0.500)(151\ N) = 75.5\ N$$

C. Use Newton's second law to determine the horizontal acceleration.

TIP $\mathbf{F_k}$ *is directed toward the left, opposite the direction of* $\mathbf{F_{applied,\,x}}$. *As a result, when you find the sum of the forces in the x direction, you need to subtract F_k from $F_{applied,\,x}$.*

$$\Sigma F_x = F_{applied,\,x} - F_k = ma_x$$

$$a_x = \frac{F_{applied,\,x} - F_k}{m} = \frac{77.9\ N - 75.5\ N}{20.0\ kg} = \frac{2.4\ N}{20.0\ kg} = \frac{2.4\ kg \bullet m/s^2}{20.0\ kg}$$

$$\boxed{\mathbf{a} = 0.12\ m/s^2 \text{ to the right}}$$

4. EVALUATE   The normal force is not equal in magnitude to the weight because the y component of the student's pull on the rope helps support the box.

PRACTICE E

Overcoming Friction

1. A student pulls on a rope attached to a box of books and moves the box down the hall. The student pulls with a force of 185 N at an angle of 25.0° above the horizontal. The box has a mass of 35.0 kg, and μ_k between the box and the floor is 0.27. Find the acceleration of the box.

2. The student in item 1 moves the box up a ramp inclined at 12° with the horizontal. If the box starts from rest at the bottom of the ramp and is pulled at an angle of 25.0° with respect to the incline and with the same 185 N force, what is the acceleration up the ramp? Assume that $\mu_k = 0.27$.

3. A 75 kg box slides down a 25.0° ramp with an acceleration of 3.60 m/s^2.
   a. Find μ_k between the box and the ramp.
   b. What acceleration would a 175 kg box have on this ramp?

4. A box of books weighing 325 N moves at a constant velocity across the floor when the box is pushed with a force of 425 N exerted downward at an angle of 35.2° below the horizontal. Find μ_k between the box and the floor.