SAMPLE PROBLEM E

Overcoming Friction

PROBLEM

A student attaches a rope to a 20.0 kg box of books. He pulls with a force of 90.0 N at an angle of 30.0° with the horizontal. The coefficient of kinetic friction between the box and the sidewalk is 0.500. Find the acceleration of the box.

SOLUTION

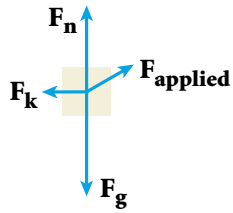
1. DEFINE

Given: $m = 20.0$ kg $\quad \mu_k = 0.500$

$\mathbf{F}_{applied} = 90.0$ N at $\theta = 30.0°$

Unknown: $\mathbf{a} = ?$

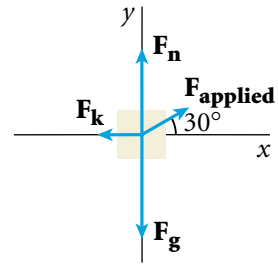
Diagram:



2. PLAN

Choose a convenient coordinate system, and find the *x* and *y* components of all forces.

The diagram at right shows the most convenient coordinate system, because the only force to resolve into components is $\mathbf{F}_{applied}$.



$F_{applied,y} = (90.0 \text{ N})(\sin 30.0°) = 45.0 \text{ N (upward)}$

$F_{applied,x} = (90.0 \text{ N})(\cos 30.0°) = 77.9 \text{ N (to the right)}$

Choose an equation or situation:

A. Find the normal force, F_n, by applying the condition of equilibrium in the vertical direction: $\Sigma F_y = 0$.

B. Calculate the force of kinetic friction on the box: $F_k = \mu_k F_n$.

C. Apply Newton's second law along the horizontal direction to find the acceleration of the box: $\Sigma F_x = ma_x$.

3. CALCULATE

Substitute the values into the equations and solve:

A. To apply the condition of equilibrium in the vertical direction, you need to account for all of the forces in the *y* direction: F_g, F_n, and $F_{applied,y}$. You know $F_{applied,y}$ and can use the box's mass to find F_g.

$F_{applied,y} = 45.0$ N

$F_g = (20.0 \text{ kg})(9.81 \text{ m/s}^2) = 196$ N