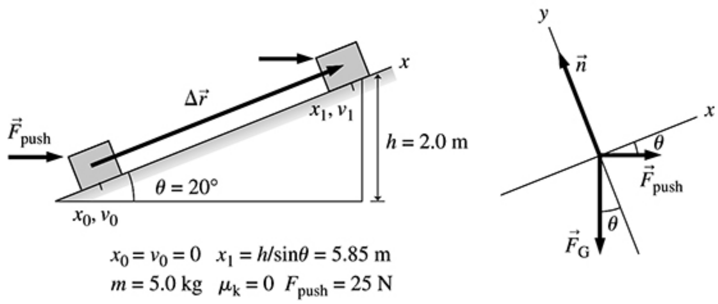
**11.43. Model:** Model the crate as a particle, and use the work-kinetic energy theorem.
**Visualize:**




**Solve: (a)** The work-kinetic energy theorem is $\Delta K = \frac{1}{2}mv_1^2 - \frac{1}{2}mv_0^2 = \frac{1}{2}mv_1^2 = W_{total}$. Three forces act on the box, so $W_{total} = W_{grav} + W_n + W_{push}$. The normal force is perpendicular to the motion, so $W_n = 0$ J. The other two forces do the following amount of work:

$$W_{push} = \vec{F}_{push} \cdot \Delta\vec{r} = F_{push}\Delta x \cos 20° = 137.4 \text{ J} \qquad W_{grav} = \vec{F}_G \cdot \Delta\vec{r} = \left(F_G\right)_x \Delta x = (-mg\sin 20°)\Delta x = -98.0 \text{ J}$$

Thus, $W_{total} = 39.4$ J, leading to a speed at the top of the ramp equal to

$$v_1 = \sqrt{\frac{2W_{total}}{m}} = \sqrt{\frac{2(39.4 \text{ J})}{5.0 \text{ kg}}} = 4.0 \text{ m/s}$$

**(b)** The $x$-component of Newton's second law is

$$a_x = a = \frac{(F_{net})_x}{m} = \frac{F_{push}\cos 20° - F_G \sin 20°}{m} = \frac{F_{push}\cos 20° - mg\sin 20°}{m} = 1.35 \text{ m/s}^2$$

Constant-acceleration kinematics with $x_1 = h/\sin 20° = 5.85$ m gives the final speed

$$v_1^2 = v_0^2 + 2a(x_1 - x_0) = 2ax_1 \Rightarrow v_1 = \sqrt{2ax_1} = \sqrt{2(1.35 \text{ m/s}^2)(5.85 \text{ m})} = 4.0 \text{ m/s}$$