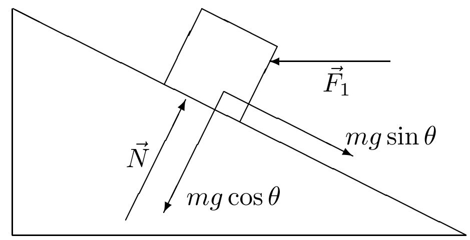
72. The free-body diagram for the trunk is shown.

The x and y applications of Newton's second law provide two equations:

$$\begin{aligned} F_1\cos\theta - f_k - mg\sin\theta &= ma \\ N - F_1\sin\theta - mg\cos\theta &= 0 \ . \end{aligned}$$



(a) The trunk is moving up the incline at constant velocity, so $a = 0$. Using $f_k = \mu_k N$, we solve for the push-force F_1 and obtain

$$F_1 = \frac{mg(\sin\theta + \mu_k\cos\theta)}{\cos\theta - \mu_k\sin\theta} \ .$$

The work done by the push-force $\vec{F}_1$ as the trunk is pushed through a distance ℓ up the inclined plane is therefore

$$\begin{aligned} W_1 &= F_1\ell\cos\theta = \frac{(mg\ell\cos\theta)(\sin\theta + \mu_k\cos\theta)}{\cos\theta - \mu_k\sin\theta} \\ &= \frac{(50\,\mathrm{kg})(9.8\,\mathrm{m/s^2})(6.0\,\mathrm{m})(\cos 30°)\,(\sin 30° + (0.20)\cos 30°)}{\cos 30° - (0.20)\sin 30°} \\ &= 2.2 \times 10^3\ \mathrm{J} \ . \end{aligned}$$

(b) The increase in the gravitational potential energy of the trunk is

$$\Delta U = mg\ell\sin\theta = (50\,\mathrm{kg})\left(9.8\,\mathrm{m/s^2}\right)(6.0\,\mathrm{m})\sin 30° = 1.5 \times 10^3\ \mathrm{J} \ .$$

Since the speed (and, therefore, the kinetic energy) of the trunk is unchanged, Eq. 8-31 leads to

$$W_1 = \Delta U + \Delta E_{\mathrm{th}} \ .$$

Thus, using more precise numbers than are shown above, the increase in thermal energy (generated by the kinetic friction) is $2.24 \times 10^3 - 1.47 \times 10^3 = 7.7 \times 10^2$ J. An alternate way to this result is to use $\Delta E_{\mathrm{th}} = f_k\ell$ (Eq. 8-29).