5.46. Model: We will model the box as a particle, and use the models of kinetic and static friction.

Visualize: The pushing force is along the $+x$-axis, but the force of friction acts along the $-x$-axis. A component of the box’s weight acts along the $-x$-axis as well. The box will move up if the pushing force is at least equal to the sum of the friction force and the component of the weight in the $x$-direction.

Solve: Let’s determine how much pushing force you would need to keep the box moving up the ramp at steady speed. Newton’s second law for the box in dynamic equilibrium is

$$F_{\text{net}} = \sum F_i = n_i + w_i + (f_k)_i + (F_{\text{push}})_i = 0 \text{ N}$$

The $x$-component equation and the model of kinetic friction yield:

$$F_{\text{push}} = mg \sin \theta + f_k = mg \sin \theta + \mu n$$

Let us obtain $n$ from the $y$-component equation as $n = mg \cos \theta$, and substitute it in the above equation to get

$$F_{\text{push}} = mg \sin \theta + \mu mg \cos \theta = mg (\sin \theta + \mu \cos \theta) = 888 \text{ N}$$

The force is less than your maximum pushing force of 1000 N. That is, once in motion, the box could be kept moving up the ramp. However, if you stop on the ramp and want to start the box from rest, the model of static friction applies. The analysis is the same except that the coefficient of static friction is used and we use the maximum value of the force of static friction. Therefore, we have

$$F_{\text{push}} = mg (\sin \theta + \mu \cos \theta) = (100 \text{ kg})(9.80 \text{ m/s}^2)(\sin 20^\circ + 0.90 \cos 20^\circ) = 1160 \text{ N}$$

Since you can push with a force of only 1000 N, you can’t get the box started. The big static friction force and the weight are too much to overcome.