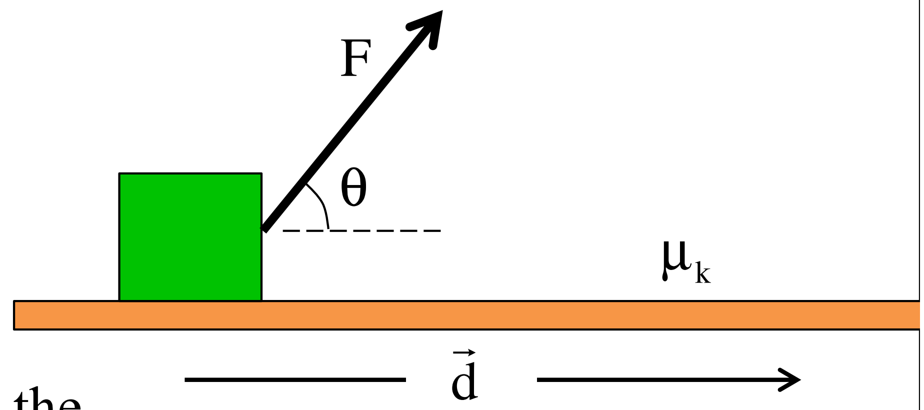
General announcements

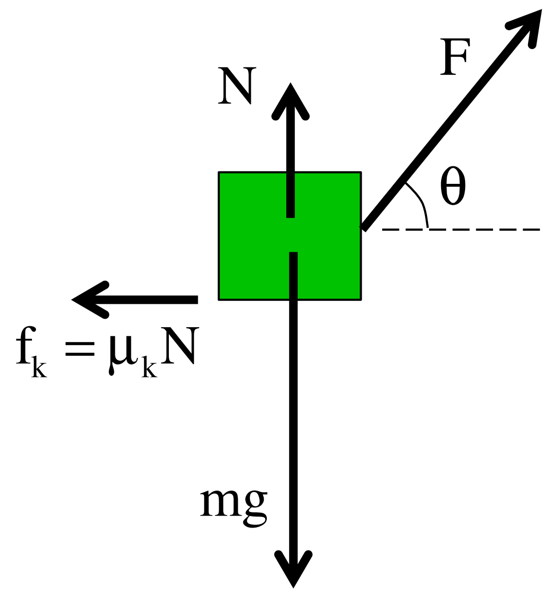
Consider: a 100-N force F applied at 60° above the horizontal drags a 20-kg box 3.0 meters across a rough surface whose *coefficient of kinetic friction* is $\mu_k = .15$.



Derive an expression for the work done by the various forces acting on the box.

gavity:

$$
\begin{aligned}
W_g &= \vec{F}_g \bullet \vec{d} \\
&= \left|\vec{F}_g\right|\left|\vec{d}\right|\cos\phi \\
&= (mg)d\left(\cos 90^{\circ}\right) \\
&= 0
\end{aligned}
$$

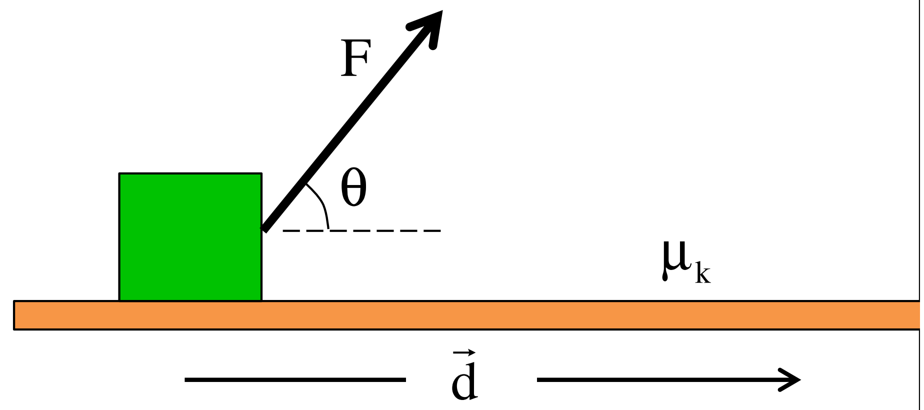


normal:

$$
\begin{aligned}
W_N &= \vec{F}_N \bullet \vec{d} \\
&= \left|\vec{F}_N\right|\left|\vec{d}\right|\cos\phi \\
&= (N)d\left(\cos 90^{\circ}\right) \\
&= 0
\end{aligned}
$$

friction:

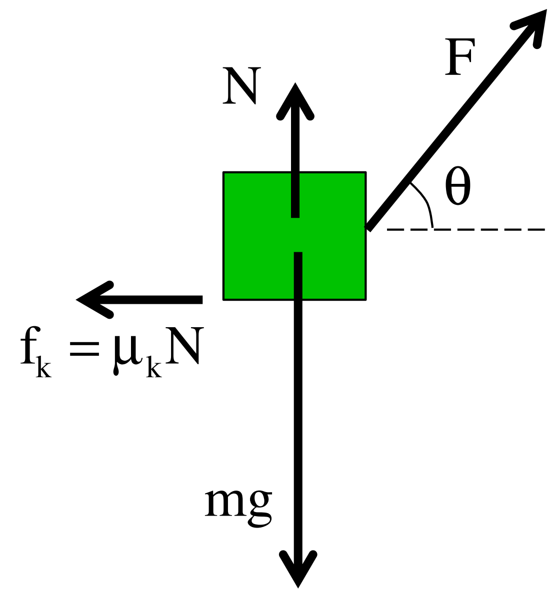
To deal with friction, we need the normal force. Using N.S.L. in the vertical:



$$\sum F_y :$$

$$N - mg + F\sin\theta = m\overset{0}{\cancel{a_y}}$$

$$\Rightarrow \quad N = mg - F\sin\theta$$



So $\quad W_f = \vec{F}_f \bullet \vec{d}$

$$= \left|\vec{F}_f\right|\left|\vec{d}\right|\cos\phi$$

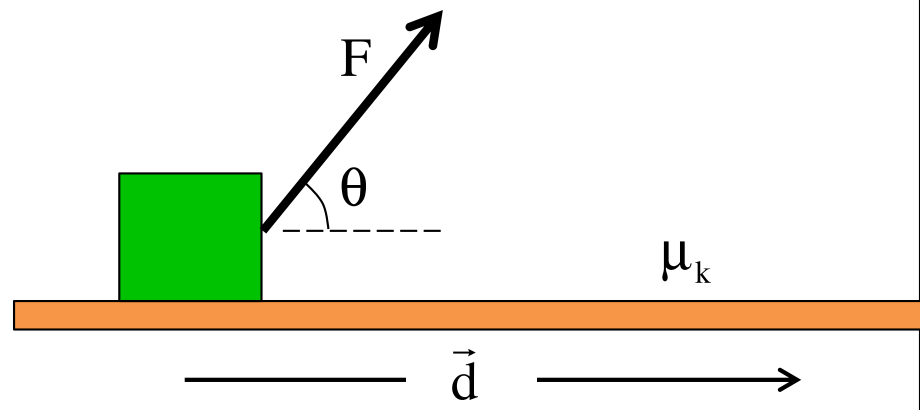
$$= \left(\mu_k N\right)d\left(\cos 180^\circ\right)$$

$$= \left(\mu_k\left(mg - F\sin\theta\right)\right)d\left(\overset{-1}{\cancel{\cos 180^\circ}}\right)$$

$$= -\left((.15)\left((20\text{ kg})\left(9.8\text{ m/s}^2\right) - (100\text{ N})\sin 60^\circ\right)\right)(3.0\text{ m})$$

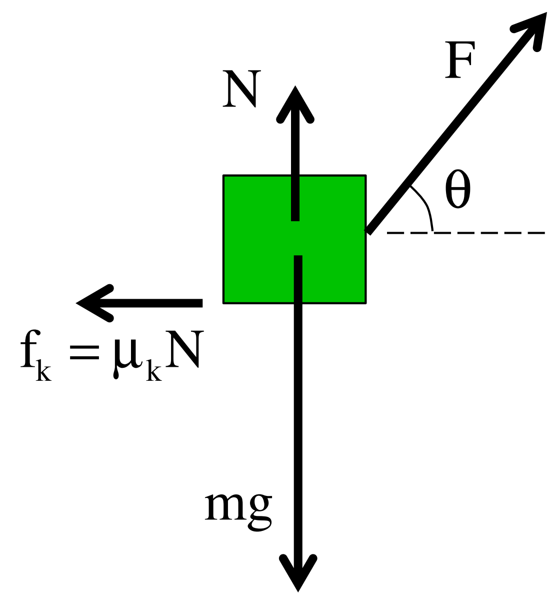
$$= -49.23\text{ nt}\bullet\text{m}$$

$$= -49.23\text{ joules}$$



Notice the units of work are *newton-meters*, which are *joules*, an energy quantity. So what must the significance of a negative work calculation like friction's be?

Negative work acts to *pull energy out of the system* (which means that positive work must act to put energy *into* a system).

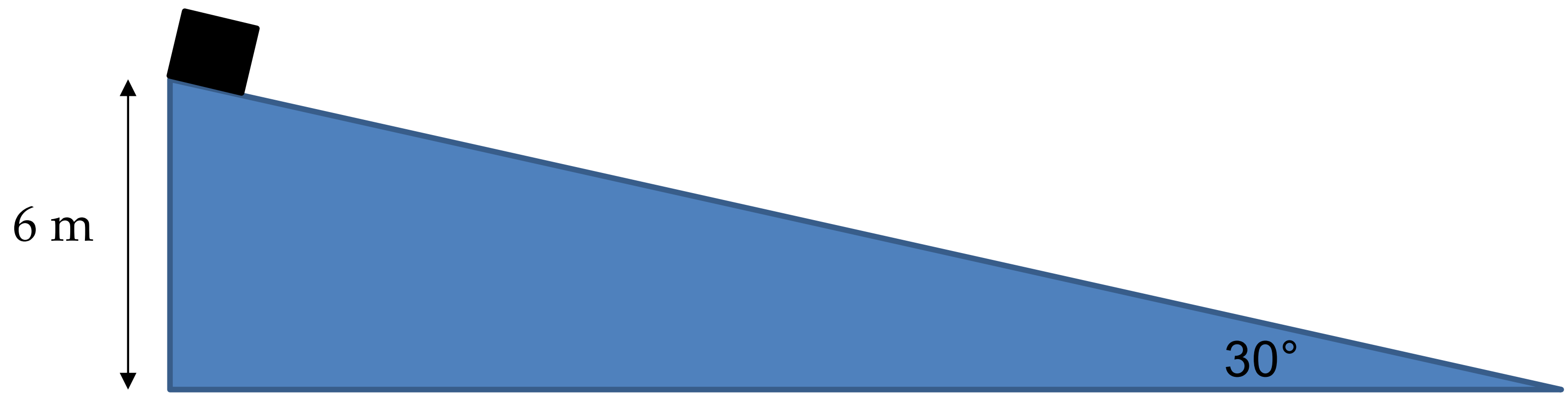


F's work:

$$
\begin{aligned}
W_F &= \vec{F} \bullet \vec{d} \\
&= |\vec{F}||\vec{d}|\cos\phi \\
&= (F)d(\cos 60^\circ) \\
&= (100\ \text{N})(3\ \text{m})(\cos 60^\circ) \\
&= 150\ \text{joules}
\end{aligned}
$$

Box on an incline...

- A 5-kg box sits at the top of a 6-m high ramp that is inclined at 30° above the horizontal. For this ramp, $\mu_s = 0.3$ and $\mu_k = 0.15$.



  - Does the box stay in place or slide?

Gravity is pulling down with force: $mg\sin\theta = (5\text{ kg})(9.8\text{ m/s}^2)\sin 30^\circ = 24.5\text{ nts}$

Maximum static frictional force is:

$$\mu_s N = \mu_s(mg\cos\theta) = (.3)(5\text{ kg})(9.8\text{ m/s}^2)\cos 30^\circ = 12.73\text{ nts}$$

Clearly gravity wins out and the body slides!

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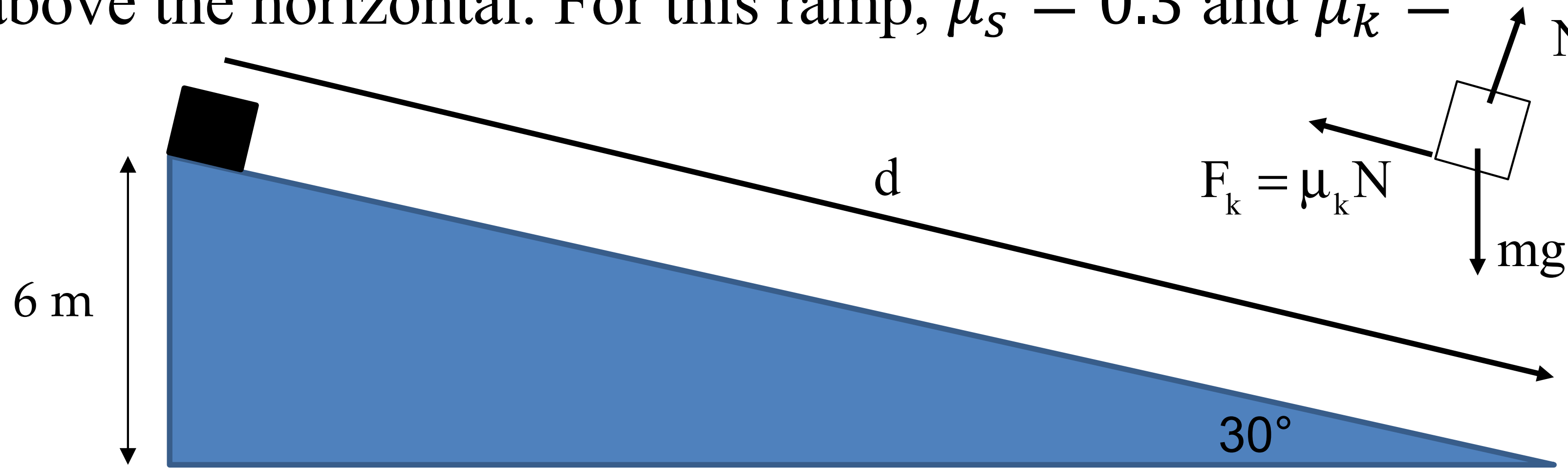

Assuming it slides, how much work is done by each force acting on the box by the time it reaches the bottom of the ramp? Also, what is the net work done during the motion?

$$
\begin{aligned}
W_{net} &= W_f + W_{grav} + W_N \\
&= \vec{f}_k \bullet \vec{d} + F_g \bullet \vec{d} + F_N \bullet \vec{d} \\
&= [\mu_k \quad N]\, d \cos\varphi + (m g)(d)\cos\phi + N d \cos 90^\circ \\
&= [\mu_k (m g \cos\theta)]\, d \cos 180^\circ + (m g)(d)\cos\phi + 0 \\
&= [(.15)(5\text{ kg})(9.8\text{ m/s}^2)\cos 30^\circ]\left(\frac{6}{\sin 30^\circ}\right)(-1) + (5\text{ kg})(9.8\text{ m/s}^2)(6\text{ m})\cos 60^\circ \\
&= 70.6\text{ J}
\end{aligned}
$$

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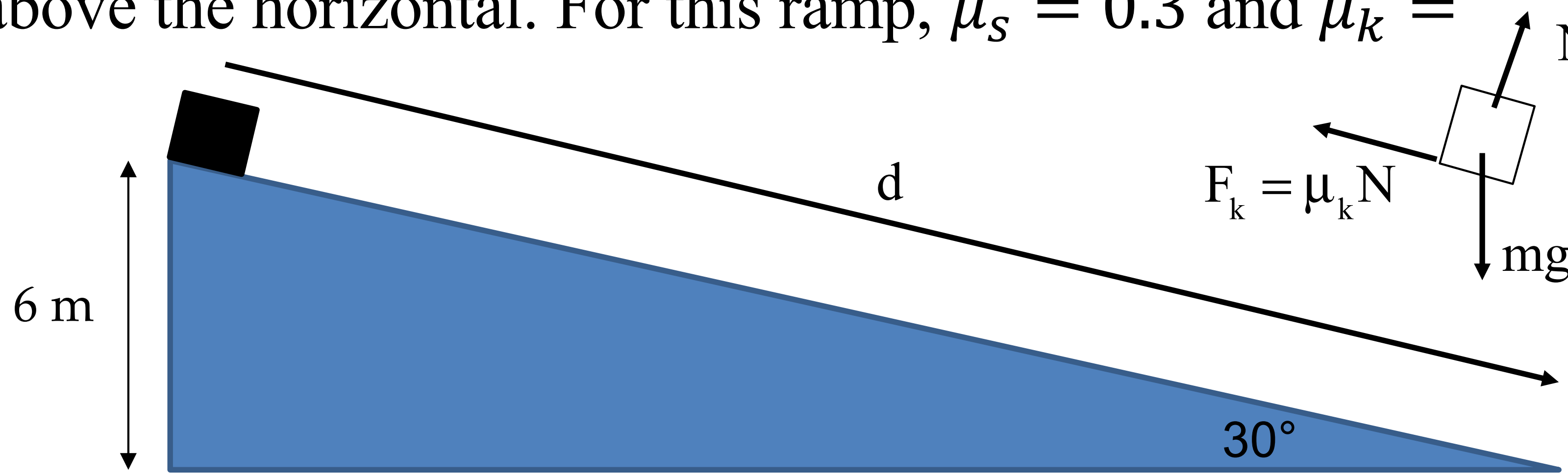

How fast is the block traveling when it gets to the bottom of the incline?

AND HERE IS WHERE WE NEED A LITTLE HELP . . .