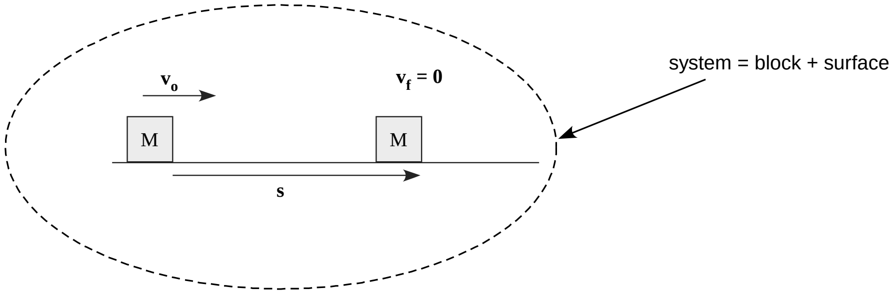
Conservation of Energy Involving Friction

Consider a block that is given an initial velocity V_o on a horizontal surface where $\mu = \mu_k$. The block comes to a stop due to the frictional force acting on it. Let's define the isolated system to be the block + surface.



Recall that the work done by all the external forces acting on a system is given by:

(1) $\boxed{W_{ext} = \Delta E_{mech} = \Delta K_{sys} + \Delta U_{sys}}$

Because $W_{ext} = 0$ (there are **NO** external forces acting on the system) and $\Delta U_{sys} = 0$, then this implies that $\Delta K_{sys} = 0$. However we know that $\Delta K_{sys} = -\frac{1}{2}Mv_o^2$. Since we have an isolated system there is no transfer of energy into or out of system and since energy cannot be created or destroyed, where did the decrease in energy (kinetic) of the system go? The decrease in energy (kinetic) of the system shows up as an increase in a new form of energy called internal energy of the block + surface system. This increase in internal energy shows up as an increase in the temperature of the system. Thus, Eq. (1) needs to be extended to include this new form of energy - internal energy.

(2) $$\boxed{\begin{aligned} W_{ext} &= \Delta E_{mech} + \Delta E_{\text{int}} \\ W_{ext} &= \Delta K_{sys} + \Delta U_{sys} + \Delta E_{\text{int}} \end{aligned}}$$

Applying (2) to the same system above we have:

$$\Delta K_{sys} + \Delta U_{sys} + \Delta E_{\text{int}} = 0$$
$$-f_k s + 0 + \Delta E_{\text{int}} = 0$$

$$\boxed{\Delta E_{\text{int}} = f_k s}$$

Thus, (2) can be written as:

$$\boxed{\begin{aligned} W_{ext} &= \Delta E_{mech} + f_k s \\ W_{ext} &= \Delta K_{sys} + \Delta U_{sys} + f_k s \end{aligned}}$$

For an isolated system (W_{ext} =0):

$0 = \Delta E_{mech} + f_k$
$0 = \Delta E_{mech} + \Delta U_{sys} + f_k$