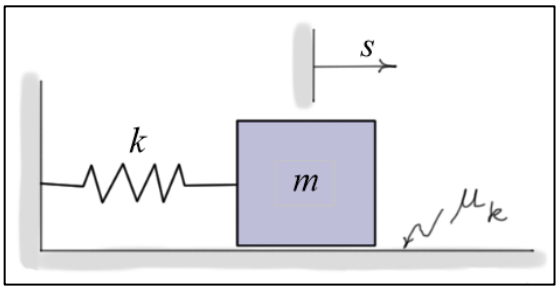
Elementary Dynamics Example #19: (Work & Energy)

Given: $m = 50$ (kg), $k = 35$ (kN/m), $\mu_k = 0.3$, spring is ***unstretched*** when $s = 0$, $v = 5$ (m/s) when $s = 0$



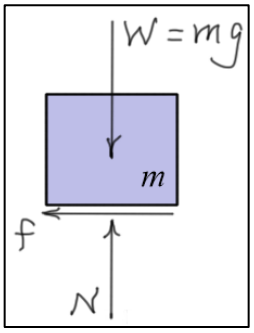
Find: s_{max}, the maximum displacement of the mass to the right.

Solution:

Newton's 2nd Law:

$$\boxed{+\uparrow \sum F = N - mg = 0} \quad \Rightarrow \quad \boxed{f = \mu_k N = 0.3mg}$$

Free body diagram



Work & Energy:

$$\boxed{K_1 + U_{1\to 2} = \underbrace{K_2}_{\text{zero}}}$$

where

$$K_1 = \tfrac{1}{2} m v_1^2 = \tfrac{50}{2}(5^2) = 25^2 = 625 \text{ (N-m)}$$

$$U_{1\to 2} = -\tfrac{1}{2} k s_{max}^2 - f\, s_{max} = -17500\, s_{max}^2 - 0.3mg\, s_{max} = -17500\, s_{max}^2 - 147.15\, s_{max}$$

Substituting into the work & energy equation

$$\boxed{17500\, s_{max}^2 + 147.15\, s_{max} - 625 = 0} \quad \Rightarrow \quad \boxed{s_{max} \approx \begin{cases} 0.185 \text{ (m)} \\ \cancel{-0.193 \text{ (m)}} \end{cases}} \quad \Rightarrow \quad \boxed{s_{max} \approx 0.185 \text{ (m)}}$$