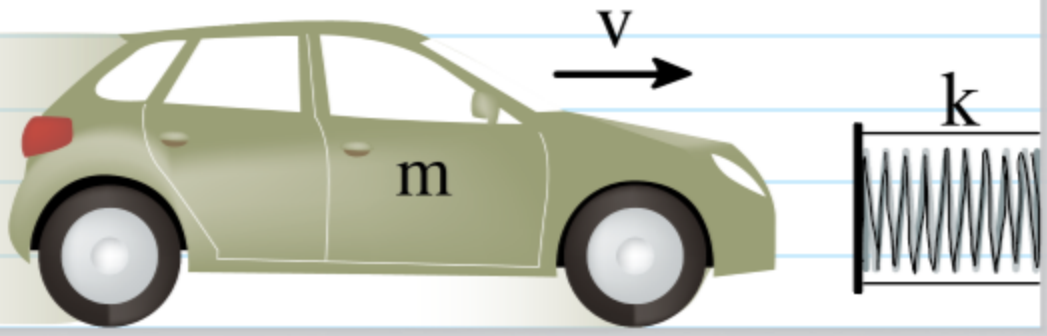
21-P-WE-GD-009



During a crash test for a new car, the car is driven at high speed toward a large pre-compressed spring mounted on a wall.

The spring is initially compressed $\underline{L}$ m when the $\underline{m}$ kg car hits the spring while applying the brakes, causing the spring to further compress $\underline{s}$ m, stopping the car.

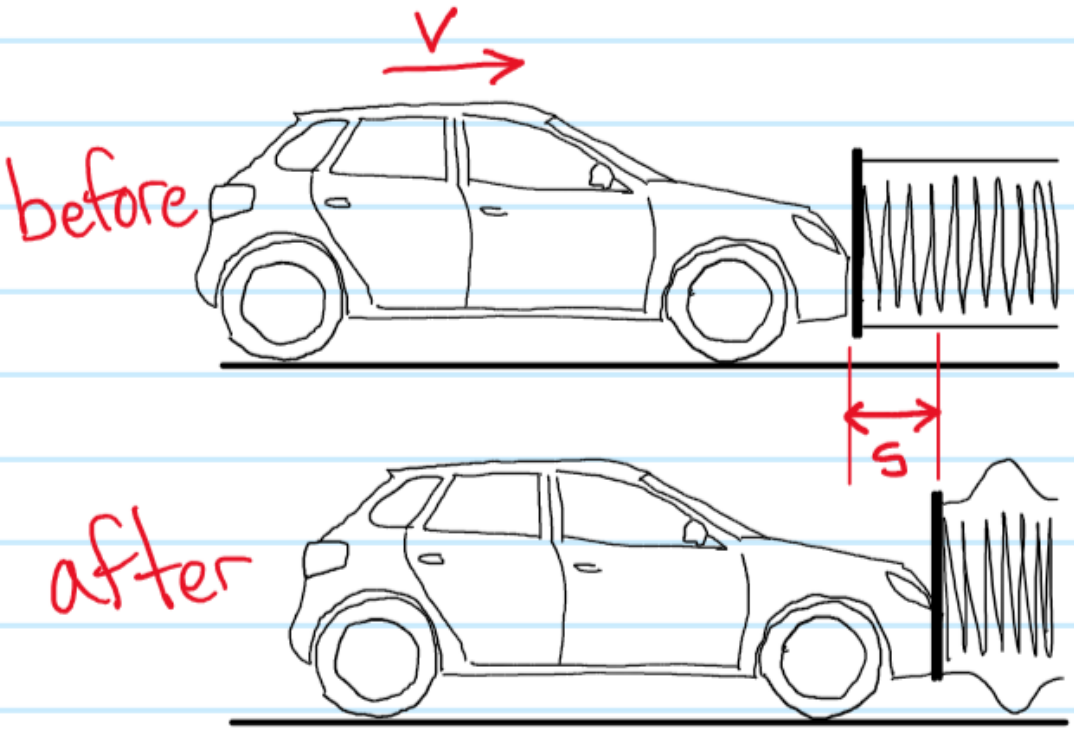
If $K = \underline{K}$ N/m and the coefficient of kinetic friction the wheels and the road is $\underline{\mu_k}$, what was the car's initial velocity?

given

L, m, s, K

find

v



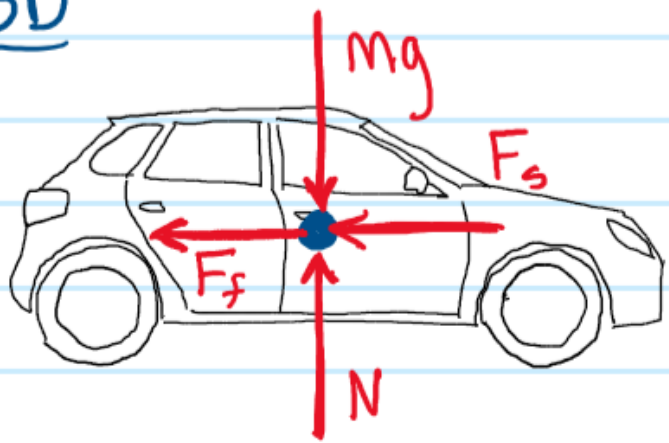
Force Equilibrium

$$\Sigma F_x = ma = -F_f - F_s$$

$$\Sigma F_y = 0 = N - mg$$

$$F_f = \mu_k N = \mu_k mg$$

FBD



Work & Energy

$$T_1 + \Sigma U_{1-2} = T_2$$

$$\tfrac{1}{2}mv^2 - U_f - U_s = 0$$

work from spring

$$-\int_L^{L+s} kx\,dx$$

$$-\tfrac{1}{2}kx^2\Big|_L^{L+s}$$

$$-\left[\tfrac{1}{2}k(L+s)^2 - \tfrac{1}{2}k(L)^2\right]$$

$$\tfrac{1}{2}mv^2 - \mu_k mgs - \left[\tfrac{1}{2}k(L+s)^2 - \tfrac{1}{2}k(L)^2\right] = 0$$

$$v = \sqrt{\frac{2\mu_k mgs + \left[k(L+s)^2 - k(L)^2\right]}{m}}$$