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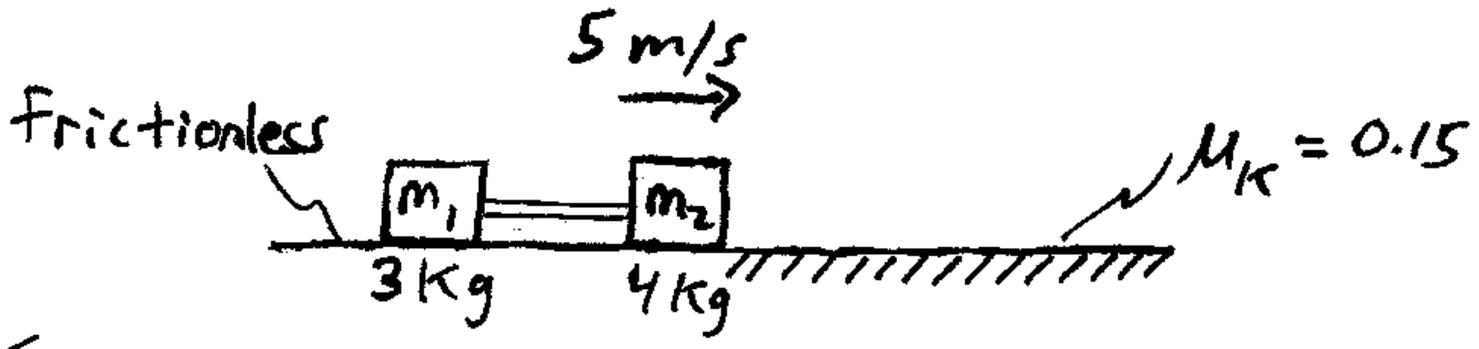
Oct. 3, 2020

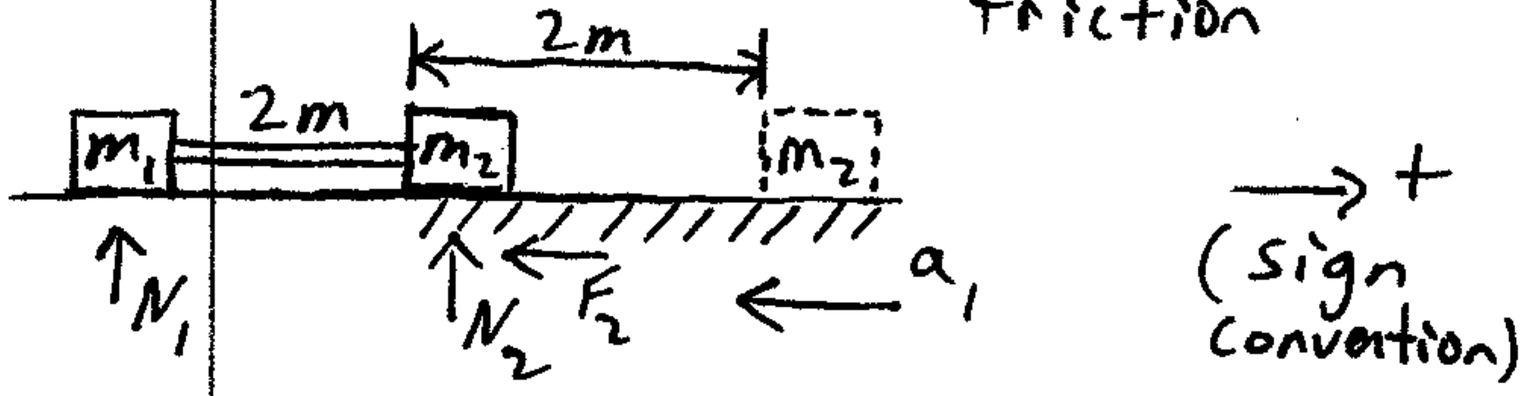
This is a force and motion problem involving friction.



Two masses, m_1 and m_2, are sliding on a frictionless surface at a speed of 5 m/s. The front mass, m_2, encounters a rough patch and experiences friction, and then the mass connected behind it, m_1, encounters the rough patch a short time later, and it too experiences friction. If the rod connecting the two masses has negligible mass, how far do both masses slide once the front mass encounters the rough patch? The rod is 2 m long. Ignore dimension of m_1 and m_2.

Solution:

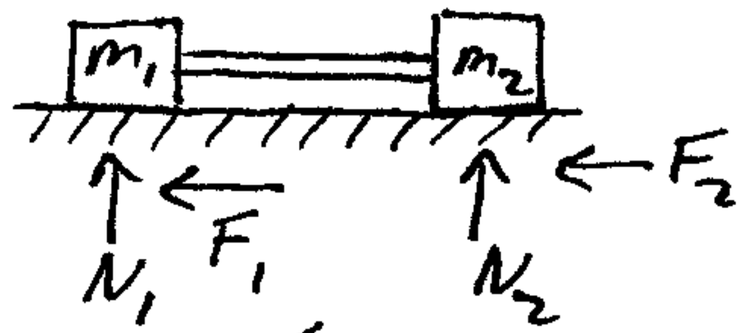
Phase I: Only m_2 experiences friction



$N_2 = m_2 g$

$F_2 = \mu_K N_2 = \mu_K m_2 g$

Phase II: Both m_1 and m_2 experience friction



$N_1 = m_1 g$

$F_1 = \mu_K N_1 = \mu_K m_1 g$

Phase I: Apply Newton's second law to the system:

$$-F_2 = (m_1 + m_2)a_1$$

$$-\mu_K m_2 g = (m_1 + m_2)a_1$$

$$a_1 = \frac{-\mu_K m_2 g}{m_1 + m_2}$$

substitute known values:

$$a_1 = \frac{-0.15(4)(9.8)}{3+4} = -0.84\ m/s^2$$

Phase II: Apply Newton's second law to the system:

$$-F_1 - F_2 = (m_1 + m_2)a_2$$

$$-\mu_K m_1 g - \mu_K m_2 g = (m_1 + m_2)a_2$$

$$a_2 = -\mu_K g$$

substitute known values:

$$a_2 = -0.15(9.8) = -1.47\ m/s^2$$

Apply kinematics equations to phase I and II:

Phase I: $V_f^2 = V_i^2 + 2a_1\Delta d$, $\Delta d = 2m$, $V_i = 5\ m/s$, $a_1 = -0.84\ m/s^2$

$V_f = 4.65\ m/s$

Phase II: $V_f^2 = V_i^2 + 2a_2\Delta d$, $V_i = 4.65\ m/s$, $V_f = 0$, $a_2 = -1.47\ m/s^2$

$\Delta d = 7.36\ m$

Total distance $= 2m + 7.36m = 9.36m$ (ans.)