Problem 14.105

A 30-g bullet is fired with a velocity of 480 m/s into block A, which has a mass of 5 kg. The coefficient of kinetic friction between block A and cart BC is 0.05. Knowing that the cart has a mass of 4 kg and can roll freely, determine (a) the final velocity of the cart and block, (b) the final position of the block on the cart.
A 30-g bullet is fired with a velocity of 480 m/s into block $A$, which has a mass of 5 kg. The coefficient of kinetic friction between block $A$ and cart $BC$ is 0.05. Knowing that the cart has a mass of 4 kg and can roll freely, determine (a) the final velocity of the cart and block, (b) the final position of the block on the cart.

1. Conservation of linear momentum of a system of particles is used to determine the final velocity of the system of particles. Conservation of linear momentum occurs when the resultant of the external forces acting on the particles of the system is zero.
A 30-g bullet is fired with a velocity of 480 m/s into block $A$, which has a mass of 5 kg. The coefficient of kinetic friction between block $A$ and cart $BC$ is 0.05. Knowing that the cart has a mass of 4 kg and can roll freely, determine (a) the final velocity of the cart and block, (b) the final position of the block on the cart.

2. Conservation of linear momentum during impact is used to determine the kinetic energy immediately after impact. The kinetic energy $T'$ immediately after the collision is computed from $T = \frac{1}{2} \sum m_i v_i^2$. 
Solving Problems on Your Own

A 30-g bullet is fired with a velocity of 480 m/s into block A, which has a mass of 5 kg. The coefficient of kinetic friction between block A and cart BC is 0.05. Knowing that the cart has a mass of 4 kg and can roll freely, determine (a) the final velocity of the cart and block, (b) the final position of the block on the cart.

3. The work-energy principle is applied to determine how far the block slides. The final kinetic energy of the system $T_f$ is determined knowing the final velocity of the system of particles (from step 1). The work is done by the friction force.
Conservation of linear momentum of a system of particles is used to determine the final velocity of the system of particles.

\[ m_O v_O = (m_O + m_A + m_C) \ v_f \]

\[ 0.03(480) = (0.03 + 5 + 4) \ v_f \]

\[ v_f = 1.595 \text{ m/s} \]
Conservation of linear momentum during impact is used to determine the kinetic energy immediately after impact.

Conservation of linear mementum:

\[ m_O v_O = (m_O + m_A) v' \]

\[ 0.03(480) = (0.03 + 5) v' \]

\[ v' = 2.86 \text{ m/s} \]

Kinetic energy after impact = \( T' \):

\[ T' = \frac{1}{2} (m_O + m_A)(v')^2 = 0.5(5.03)(2.86)^2 = 20.61 \text{ N-m} \]
\[ v_f = 1.595 \text{ m/s} \]

**Problem 14.105 Solution**

The work-energy principle is applied to determine how far the block slides.

\[ T' = 20.61 \text{ N-m} \]

Final kinetic energy = \( T_f \):

\[ T_f = \frac{1}{2} (m_O + m_A + m_C)(v_f)^2 = 0.5(9.03)(1.595)^2 = 11.48 \text{ N-m} \]

The only force to do work is the friction force \( F \).

\[ T' + U_{1\rightarrow 2} = T_f: \quad 20.61 - \mu (mg)(x) = 11.48 \]

\[ 20.61 - 0.5(5.03)(9.81)(x) = 11.48 \]

\[ x = 0.370 \text{ m} \]