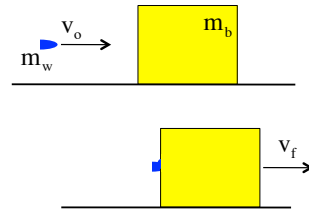


Problem 9.23

A .012 kg wad is thrown in the horizontal against a .100 kg block of wood initially at rest on a horizontal, frictional surface ($\mu_k = .650$). The two stick together travel 7.50 meters before coming to rest. What was the wad's initial velocity?



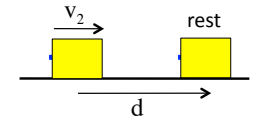
This problem is similar to Problem 9.19 in the sense that both are perfectly inelastic collision (the two become one after impact) and we are trying to determine the initial velocity of the striker. What is different is that we are not given the final velocity but, rather, information about friction in the system.

Again, an enormous amount of energy is going to be lost as the wad squashes itself against the block, so using *conservation of energy* through the collision isn't going to work (in fact, energy is NEVER conserved during a collision unless someone decides to animate never-never land and tells you to assume it). Again, what *is* conserved through the collision (along the line of motion) is *momentum*. Using that to get the after-collision speed, then using the *modified conservation of energy* relationship on the frictional motion that happens after, will allow us to solve the problem. That is:

1.)

Filling that relationship out, we get:

$$\begin{aligned} \sum KE_1 + \sum U_1 + \sum W_{\text{ext}} &= \sum KE_2 + \sum U_2 \\ \frac{1}{2}(m_w + m_b)v_2^2 + 0 + (-fd) &= 0 + 0 \\ \Rightarrow \frac{1}{2}(m_w + m_b)v_2^2 &= (\mu_k(m_w + m_b)g)d \\ \Rightarrow v_2 &= (2(\mu_k g)d)^{1/2} \end{aligned}$$



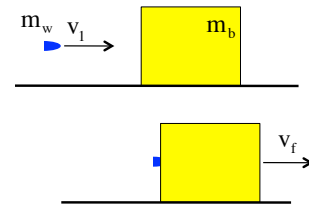
With that information, we can determine the original velocity of the wad using EQUATION A. That is:

$$\begin{aligned} v_1 &= \frac{(m_w + m_b)}{m_w} v_2 \\ &= \frac{(m_w + m_b)}{m_w} [(2\mu_k g d)^{1/2}] \\ &= \frac{((.0120 \text{ kg}) + (.100 \text{ kg}))}{(.0120 \text{ kg})} [(2(.650)(9.80 \text{ m/s}^2)(7.50 \text{ m}))^{1/2}] \\ &= 91.2 \text{ m/s} \end{aligned}$$

3.)

Through the collision:

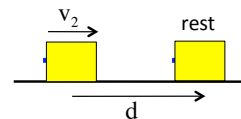
$$\begin{aligned} \sum p_{1,x} + \sum F_{\text{ext}} \Delta t_{\text{throughCollision}} &= \sum p_{2,x} \\ \Rightarrow m_w v_1 &= (m_w + m_b) v_2 \\ \Rightarrow v_1 &= \frac{(m_w + m_b)}{m_w} v_2 \quad \text{EQUATION A} \end{aligned}$$



N.S.L. would verify that "N = mg," so we are justified in writing " $f_k = \mu_k N = \mu_k mg$."

With that information, we can use the *modified conservation of energy* relationship to relate the after-collision velocity with the work friction did in bringing the body to rest. That is:

$$\begin{aligned} \sum KE_1 + \sum U_1 + \sum W_{\text{ext}} &= \sum KE_2 + \sum U_2 \\ \frac{1}{2}(m_w + m_b)v_2^2 + 0 + W_f &= 0 + 0 \end{aligned}$$



2.)

So what just happened?

- 1.) We used *conservation of momentum* through the collision to get a relationship between the *before collision* velocity of the wad and the *after collision* velocity of the wad/block system.
- 2.) We would have used N.S.L. to get a relationship for the frictional force if it hadn't been obvious.
- 3.) We used the *modified conservation of energy* for *AFTER* the collision was over to get a relationship between the *after collision* velocity of the wad/block system and the work friction did (which was known).
- 4.) We put the *after collision* velocity information derived in #3 back into our *conservation of momentum* relationship from #1, and voila, we had our solution.

Bottom line: This is a great example of a problem where you can use *conservation of momentum*, but not throughout, and *conservation of energy*, but not throughout. YOU NEED TO GET GOOD AT DETERMINING WHEN YOU CAN USE WHAT!

4.)