Answer on Question #49510, Physics, Mechanics | Kinematics | Dynamics

A 10g bullet is fired horizontally into a 300g wooden block initially at rest on a horizontal surface and becomes embedded in it. The coefficient of friction between block and surface is (0.50). The combined system slides 4.0m before stopping. With what speed did the bullet strike the block?

Solution:

We have an inelastic collision so only momentum is conserved.

The block goes from some speed v_B to zero in the space of 4.0m. The only net force on it during this time is friction. By finding the work done by friction, we will know how much energy the block had just after being struck by the bullet.

The friction force is

$$f = \mu F_N$$
$$F_N = mg$$
$$f = \mu mg = 0.5 * (0.30 + 0.01) * 9.8 = 1.519 \text{ N}$$

The work done is

$$W = fd \cos\theta$$
$$\theta = 180°$$

Thus,

$$W = 1.519 * 4.0 * \cos 180° = -6.076 \text{ J}$$

Now we know that the system had 6.08J of energy just as it started to move. We now can find the initial velocity of the block just after being struck by the bullet using the definition of kinetic energy.

$$KE = \frac{1}{2}mv^2 = -W$$

Hence,

$$v_B = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 * 6.076}{0.30 + 0.01}} = 6.26 \text{ m/s}$$

Since momentum is conserved, we find the momentum of the system block-bullet just after collision and then equate that to momentum of the bullet just before collision.

$$p_B = mv_B = m_{bull}v_x$$

Thus,

$$v_x = \frac{m}{m_{bull}}v_B = \frac{0.30 + 0.01}{0.01} * 6.26 = 194.06 \text{ m/s}$$

Answer: $v_x = 194.1 \text{ m/s}$