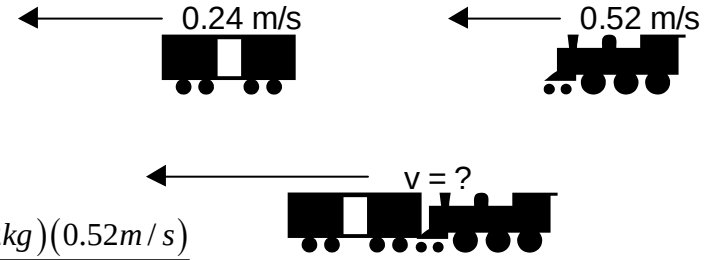
Physics 151 Class Exercise: Momentum

1. (a) A 0.20-kg model railroad car moving with a speed of 0.24 m/s is struck from behind by an 0.42-kg model locomotive moving along the same line with a speed of 0.52 m/s. If they stick together after the collision, what is their velocity? (Make sure your draw a picture of the situation and indicate your coordinate system.



$$p_{initial} = p_{final}$$

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_1 v_2'$$

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v'$$

$$\frac{(m_1 v_1 + m_2 v_2)}{(m_1 + m_2)} = v' = \frac{(0.20kg)(0.24m/s) + (0.42kg)(0.52m/s)}{(0.20kg + 0.42kg)}$$

$$v' = 0.43\, m/s$$

(b) Redo the above problem assuming that train 2 is traveling in the opposite direction as train 1 and there is a head-on collision (they still stick together).

$$p_{initial} = p_{final}$$

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_1 v_2'$$

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v'$$

$$\frac{(m_1 v_1 + m_2 v_2)}{(m_1 + m_2)} = v' = \frac{(0.20kg)(0.24m/s) + (0.42kg)(-0.52m/s)}{(0.20kg + 0.42kg)}$$

$$v' = -0.275\, m/s$$

Answer:	

2. To make a bounce pass, a player throws a 0.60-kg basketball toward the floor. The ball hits the floor with a speed of 5.4 m/s at an angle of 65° to the vertical.

(a) If the ball rebounds with the same speed and angle, what was the impulse delivered to it by the floor? (Hint: Think of the velocity of the ball in terms of components that are parallel and perpendicular to the floor.)

The impulse is equal to the change in the y-component of the momentum of the ball – the x-component of momentum remains constant. Note the y-axis points upward so that the basketball's initial velocity is negative.

$$I = \Delta p_y = m\Delta v_y = m[v_0 \cos 65° - (-v_0 \cos 65°)] = (0.60\ \text{kg})\left(5.4\ \frac{\text{m}}{\text{s}}\right)(2\cos 65°) = \boxed{2.7\ \text{kg}\cdot\text{m/s}}$$

(b) If the ball was in contact with the floor for 38 ms, what was the average force exerted by the floor during that time.

$$\overline{F}\Delta t = \Delta p$$

$$\overline{F} = \frac{\Delta p}{\Delta t} = \frac{2.7\ \frac{kg\cdot m}{s}}{38\times 10^{-3} s} = 71N$$