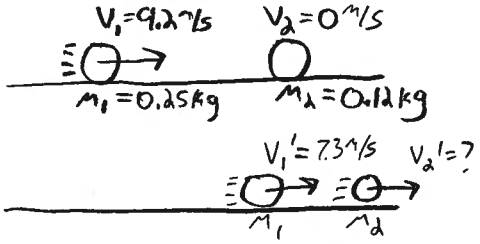
Name: KEY

Period: ____
Pre-AP Physics

# Conservation of Momentum Problems

*Answer each question in the space provided. Be sure to show all of your work and box your answer(s).*

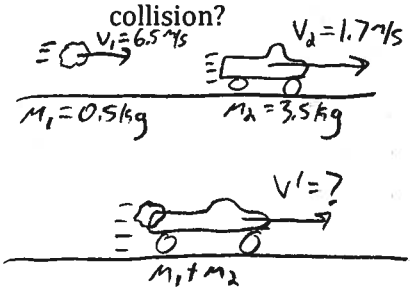
1. A 0.25 kg cue ball is traveling to the right at 9.2 m/s when it strikes the 0.12 kg 8-ball which is at rest. After the linear collision occurs, the cue ball continues to the right with a velocity of 7.3 m/s. What is the velocity of the 8-ball after the collision?




$$\Sigma p_i = \Sigma p_f$$
$$m_1 V_1 = m_1 V_1' + m_2 V_2'$$
$$V_2' = \frac{m_1 V_1 - m_1 V_1'}{m_2}$$
$$V_2' = \frac{(.25)(9.2) - (.25)(7.3)}{0.12}$$

$\boxed{V_2' = 3.96 \text{ m/s}}$

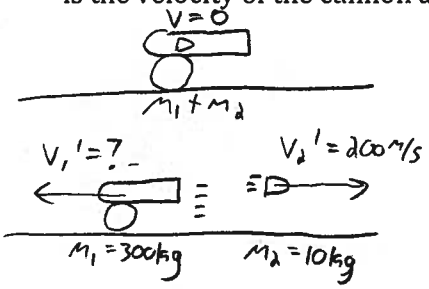
2. A 3.5 kg toy truck is moving to the right at 1.7 m/s when a 0.5 kg piece of clay is thrown to the right at 6.5 m/s. If the clay sticks to the truck, what is the final velocity of the system after the collision?




$$\Sigma p_i = \Sigma p_f$$
$$m_1 V_1 + m_2 V_2 = (m_1 + m_2) V'$$
$$V' = \frac{m_1 V_1 + m_2 V_2}{m_1 + m_2}$$
$$V' = \frac{(.5)(6.5) + (3.5)(1.7)}{(.5 + 3.5)}$$

$\boxed{V' = 2.3 \text{ m/s}}$

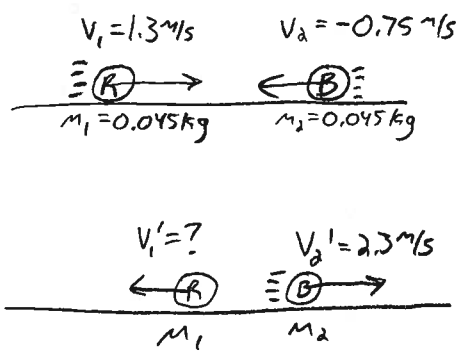
3. A loaded 300 kg cannon at rest fires a 10 kg projectile at a velocity of 200 m/s to the right. What is the velocity of the cannon as it recoils backwards?




$$\Sigma p_i = \Sigma p_f$$
$$0 = m_1 V_1' + m_2 V_2'$$
$$V_1' = \frac{-m_2 V_2'}{m_1}$$
$$V_1' = \frac{-(10)(200)}{300}$$

$\boxed{V_1' = -6.67 \text{ m/s}}$

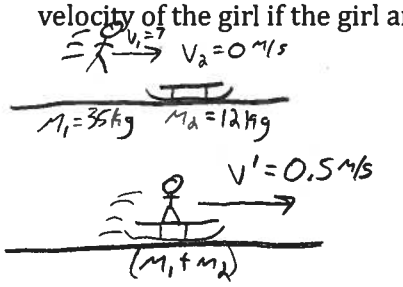
4. Two identical gumballs, each with a mass of 0.045 kg, are rolling toward each other on a flat surface. The red gumball is moving to the right with a velocity of 1.3 m/s, and the blue gumball is moving to the left with a velocity of 0.75 m/s when they collide in an elastic collision. If, after the collision, the blue gumball is traveling to the right with a velocity of 2.3 m/s, what is the final velocity of the red gumball?




$$\Sigma p_i = \Sigma p_f$$
$$m_1 V_1 + m_2 V_2 = m_1 V_1' + m_2 V_2'$$
$$V_1' = \frac{m_1 V_1 + m_2 V_2 - m_2 V_2'}{m_1}$$
$$V_1' = \frac{(.045)(1.3) + (.045)(-0.75) - (.045)(2.3)}{(.045)}$$

$\boxed{V_1' = -1.75 \text{ m/s}}$

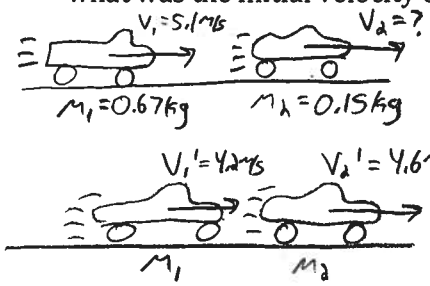
5. A 35 kg girl jumps on to a 12 kg sled that is resting on some frictionless ice. What was the initial velocity of the girl if the girl and sled move forward with a velocity of 0.5 m/s?




$$\Sigma p_i = \Sigma p_f$$
$$m_1 V_1 = (m_1 + m_2) V'$$
$$V_1 = \frac{(m_1 + m_2) V'}{m_1}$$
$$V_1 = \frac{(35+12)(.5)}{(35)}$$

$$\boxed{V_1 = 0.67 \text{ m/s}}$$

6. A toy truck with a mass of 0.67 kg is moving to the right with a velocity of 5.1 m/s when it strikes a toy car that has a mass of 0.15 kg and is also moving to the right. If, after the collision, the velocity of the truck is 4.2 m/s to the right and the velocity of the car is 4.6 m/s to the right, what was the initial velocity of the car?



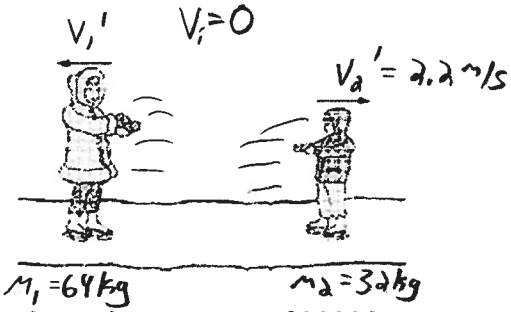

$$\Sigma p_i = \Sigma p_f$$
$$m_1 V_1 + m_2 V_2 = m_1 V_1' + m_2 V_2'$$
$$V_2 = \frac{m_1 V_1' + m_2 V_2' - m_1 V_1}{m_2}$$
$$V_2 = \frac{(.67)(4.2) + (.15)(4.6) - (.67)(5.1)}{(0.15)}$$

$$\boxed{V_2 = 0.58 \text{ m/s}}$$

7. A 64 kg woman and her 32 kg son are standing together at rest on some frictionless ice. The woman pushes on the boy, sending him moving to the right with a velocity of 2.2 m/s. What is the velocity of the woman after the push?

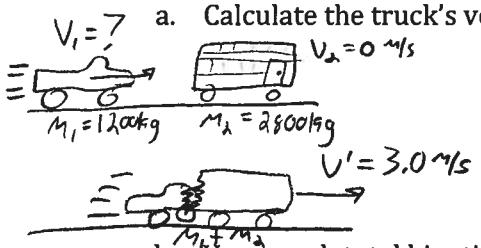
$$\Sigma p_i = \Sigma p_f$$
$$0 = m_1 V_1' + m_2 V_2'$$
$$V_1' = \frac{-m_2 V_2}{m_1}$$
$$V_1' = -\frac{(32)(2.2)}{(64)}$$

$$\boxed{V_1' = -1.1 \text{ m/s}}$$




8. The longest passenger buses in the world operate in Zaire. These buses have a mass of 2800 kg. Imagine a safety test involving one of these buses and a truck with a mass of 1200 kg. The truck with an unknown velocity travels to the right and hits a bus that is at rest so that the two vehicles move rightward together with a speed of 3.0 m/s.

a. Calculate the truck's velocity *prior* to the collision.




$$\Sigma p_i = \Sigma p_f$$
$$m_1 V_1 = (m_1 + m_2) V'$$
$$V_1 = \frac{(m_1 + m_2) V'}{m_1}$$
$$V_1 = \frac{(1200+2800)(3)}{1200}$$

$$\boxed{V_1 = 10 \text{ m/s}}$$

b. How much total kinetic energy was lost in the collision?

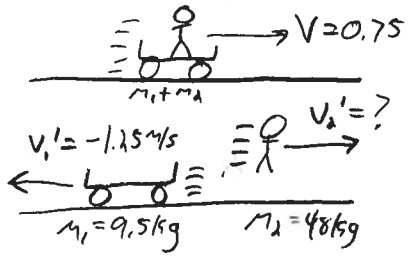
$$KE_i = \frac{1}{2} m_1 V_1^2 = \frac{1}{2}(1200)(10)^2 = 60{,}000 \text{ J}$$

$$KE_f = \frac{1}{2}(m_1 + m_2)(V')^2 = \frac{1}{2}(1200+2800)(3)^2 = 18{,}000 \text{ J}$$

$$KE_{lost} = 60{,}000 - 18{,}000$$

$$\boxed{KE_{lost} = 42{,}000 \text{ J}}$$

9. Betty has a mass of 48 kg and is riding in a 9.5 kg wagon with a velocity of 0.75 m/s when she jumps out of the front of the wagon. The wagon recoils backwards with a velocity of 1.25 m/s. What is Betty's velocity after she jumps?




$\Sigma p_i = \Sigma p_f$

$(m_1+m_2)V = m_1V_1' + m_2V_2'$

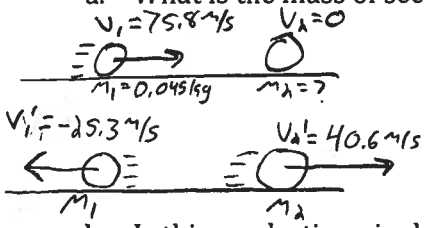
$V_2' = \dfrac{(m_1+m_2)V - m_1V_1'}{m_2}$

$V_2' = \dfrac{(9.5+48)(.75) - (9.5)(-1.25)}{(48)}$

$V_2' = 1.15 \text{ m/s}$

10. Suppose a 0.045 kg golf ball is moving to the right at 75.8 m/s and strikes another ball that is at rest. After collision the golf ball rebounds backwards at 25.3 m/s and the other ball moves forward at 40.6 m/s.

a. What is the mass of second ball?




$\Sigma p_i = \Sigma p_f$

$m_1V_1 = m_1V_1' + m_2V_2'$

$m_2 = \dfrac{m_1V_1 - m_1V_1'}{V_2'}$

$m_2 = \dfrac{(.045)(75.8) - (.045)(-25.3)}{(40.6)}$

$m_2 = 0.112 \text{ kg}$

b. Is this an elastic or inelastic collision? Justify your answer.

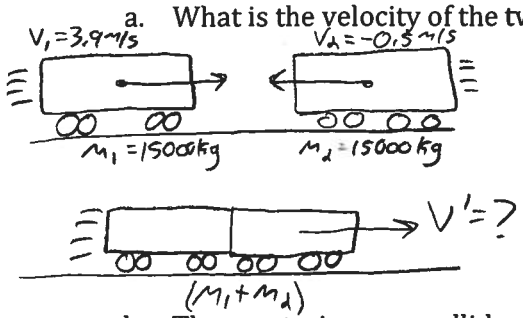
$\Sigma KE_i = \frac{1}{2}m_1V_1^2 = \frac{1}{2}(.045)(75.8)^2 = 129.3 \text{ J}$

$\Sigma KE_f = \frac{1}{2}m_1(V_1')^2 + \frac{1}{2}m_2(V_2')^2 = \frac{1}{2}(.045)(-25.3)^2 + \frac{1}{2}(0.112)(40.6)^2 = 106.7 \text{ J}$

It is inelastic, because KE is lost in the collision.

11. Two trains, each with a mass of 15,000 kg are moving toward each other. One train is moving with a velocity of 0.5 m/s to the left while the other is moving with a velocity of 3.9 m/s to the right. The two trains collide and lock together.

a. What is the velocity of the two trains after the collision?




$\Sigma p_i = \Sigma p_f$

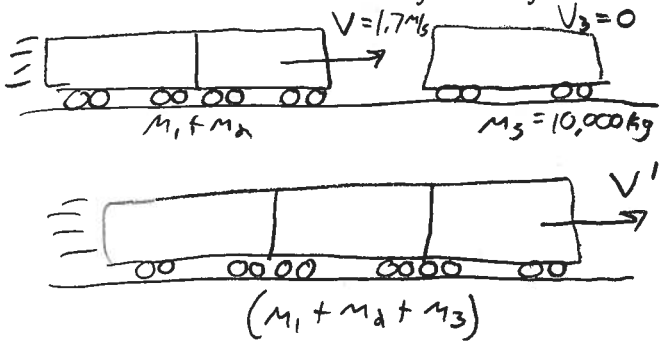
$m_1V_1 + m_2V_2 = (m_1+m_2)V'$

$V' = \dfrac{m_1V_1 + m_2V_2}{m_1+m_2}$

$V' = \dfrac{(15000)(3.9) + (15000)(-.5)}{(30000)}$

$V' = 1.7 \text{ m/s}$

b. The two trains now collide and connect with a third train of mass 10,000 kg that is at rest. What is the velocity of the system of trains after this collision?



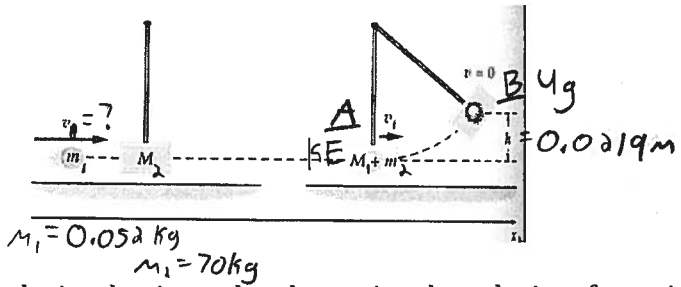

$\Sigma p_i = \Sigma p_f$

$(m_1+m_2)V = (m_1+m_2+m_3)V'$

$V' = \dfrac{(m_1+m_2)V}{(m_1+m_2+m_3)}$

$V' = \dfrac{(30{,}000)(1.7)}{(40{,}000)}$

$V' = 1.275 \text{ m/s}$




12. A ballistic pendulum is a device that is used to determine the velocity of a projectile, such as a bullet fired from a gun. The projectile is fired into a block of ballistic material that is suspended from a string, as in the diagram. The projectile comes to rest in the block and the system swings upward to a certain maximum height, which can be measured. Suppose a bullet with a mass of 52 grams is fired into a block that has a mass of 70 kg. The bullet comes to rest inside the block and the system swings upward to a maximum height of [redacted] centimeters above where it started. What was the initial velocity of the bullet? 2.19cm
*(hint: you will need to apply the law of conservation of energy as well as the law of conservation of momentum to solve this problem)*

$\Sigma p_i = \Sigma p_f$

$m_1 V_1 = (m_1 + m_2) V'$

$V_1 = \dfrac{(m_1 + m_2) V'}{m_1}$

$V_1 = \dfrac{(.052 + 70)(0.655)}{.052}$

$\boxed{V_1 = 883 \text{ m/s}}$

$\Sigma E_A = \Sigma E_B$

$KE_A = U_{gB}$

$\frac{1}{2}(m_1 + m_2)(V')^2 = (m_1 + m_2) g h_B$

$V' = \sqrt{2 g h_B}$

$V' = \sqrt{2(9.8)(.0219)}$

$V' = 0.655$ m/s