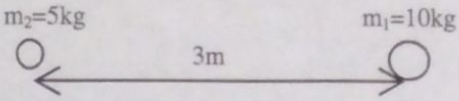
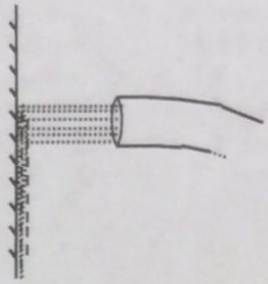
Physics Practice Problems: Center of Mass and Momentum

Center of mass: 1. The distance (center to center) between two balls, m_1=10kg and m_2=5kg, is 3 m as shown. How far from (the center of) m_1 is the center of mass of the m_1 and m_2 system?



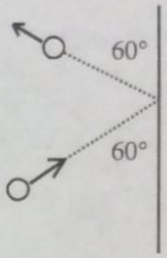
Collisions and explosions: (also problems 7 to 14)

2. A 700 kg cannon fires a 10 kg cannonball horizontally with a speed of 50 m/s. If the friction between the cannon and the ground is negligible, what is the cannon's recoil speed?
3. A 0.02 kg bullet traveling 450 m/s penetrates a 5-kg block of wood and emerges going 200 m/s. If the block is stationary on a frictionless surface when hit, how fast does it move after the bullet emerges?



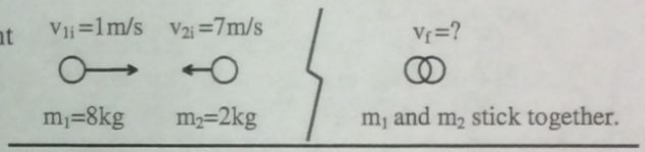
Impulse:

4. A 0.5 kg football is thrown and reaches a stationary receiver with a speed of 15 m/s. The receiver catches the ball brings it to rest in 0.2 s. a) What is the impulse delivered to the ball? b) What is the average force exerted on the receiver?
5. Calculate the force exerted on a wall, when water is shot out of a hose toward the wall at right angle, given that the water comes out at a rate of 100kg/min with a speed of 7 m/s. Assume that the water falls straight down after hitting the wall as shown in the figure to the right.
6. A 3 kg steel ball strikes a massive wall at 10 m/s at an angle of 60° with the plane of the wall. It bounces off with the same speed and angleas shown in the figure to the right. If the ball is in contact with the wall for 0.12 s, a) what is the impulse delivered to the ball? b) what is the average force exerted on the ball by the wall?

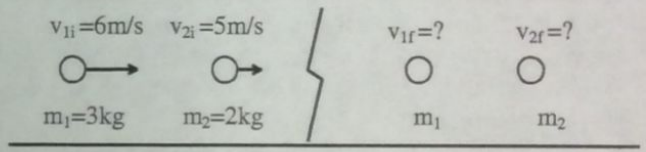


Collisions and explosions: (also problems 2, 3)

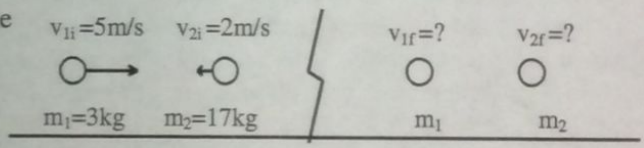
7. A ballistic pendulum is used to measure the speed of a 0.01 kg bullet. The bullet is fired into the 1.5-kg block and becomes embedded inside the block. As a result of the collision, the pendulum with the bullet inside swings up to a maximum height of 0.06 m. Determine the initial speed of the bullet.
8. Completely inelastic collision between m_1 and m_2 : Find the magnitude and direction (draw an arrow) of v_f.



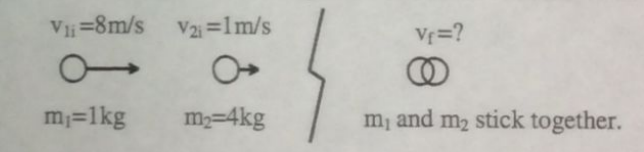
9. One-dimensional elastic collision between m_1 and m_2 : Find the magnitude and directions (draw arrows) of v_{1f} and v_{2f}. Also, find the total kinetic energy change in the system.



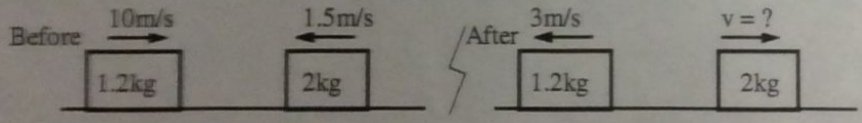
10. One-dimensional elastic collision between m_1 and m_2 : Find the magnitude and directions (draw arrows) of v_{1f} and v_{2f}.



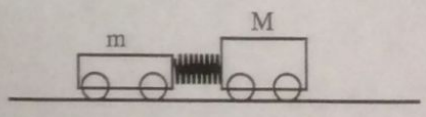
11. Completely inelastic collision between m_1 and m_2 : Find the magnitude and direction (draw arrows of v_f.



12. The blocks below slide without friction.
a) What is the velocity of the 2-kg block after the collision? b) Is this collision elastic?



13. In the following demonstration, the cars initially at rest begin to move after the compressed spring between the two cars is released. M is five times the m. If the total elastic potential energy released from the spring is 8 J, how much kinetic energy does each car acquire at the end? Ignore friction.



14. A shell moving with a southward horizontal velocity v_0 explodes in midair and breaks into 2 pieces. The larger broken piece has a mass 3 times that of the smaller piece. If the smaller piece has a horizontal velocity of $5v_0$ in the westward direction immediately after the explosion, what is the horizontal velocity of the larger piece immediately after the explosion?