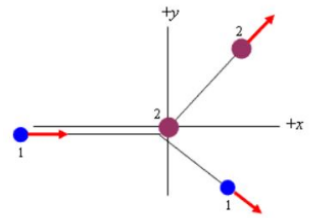
AP Physics 1
5.3 – Collisions
Assessment

Name: _____ Period: _____

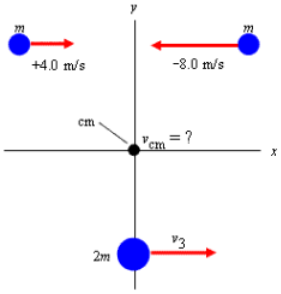
Concepts

1) Object 1 is moving along the x-axis with an initial momentum of +16 kg-m/s. It collides with a second object initially at rest. The collision is not head-on, so the objects move off in different directions after the collision. There are no net external forces acting on the system. After the collision, object 1 has a momentum whose y-component is -5 kg-m/s. What is the y-component of the momentum of object 2 after the collision? Justify your answer.

   a. 0 kg-m/s
   b. +16 kg-m/s
   c. +5 kg-m/s
   d. -16 kg-m/s
   e. Cannot be determined.
   f. Is the same as its initial momentum.



2) The diagram shows three particles that are moving with different velocities. Two of the particles have mass m, and the third has a mass of 2m and a velocity of +6.0 m/s. At the instant shown, the center of mass of the three particles is at the coordinate origin. What is the velocity, v_{cm} (magnitude and direction) of the center of mass?

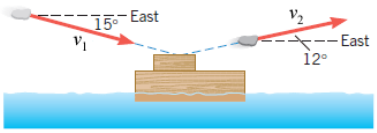


Problems

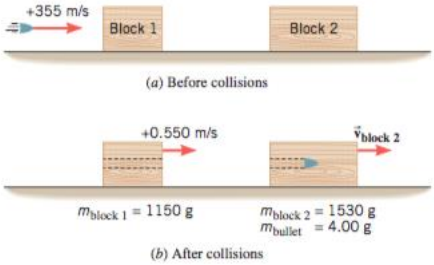
3) Joanne is riding on a sled across a level snowfield after sliding down a hill. Her velocity is +2.7 m/s. Her friend Becky runs after Joanne with a velocity of +4.5 m/s and jumps onto the sled. Becky has a mass of 58 kg, 13 kg less than that of Joanne, and the mass of the sled may be ignored. If the friction between the sled and the snow is negligible, how fast do the two of them slide together on the sled?
4) Two objects collide in a completely inelastic collision in one-dimension. Let the masses of the two objects be 3.0 kg and 8.0 kg. If the speed of the first object is initially 25 m/s, determine the final speed of the system when:
   a. the larger-mass object is the one initially in motion; and,
   b. the lower-mass object is the one initially in motion.
5) A large SUV is traveling in a straight line (m = 2500 kg). A car, traveling at 32 m/s and traveling in the opposite direction, slams into the front of the SUV in a head-on collision. The mass of the car is 1100 kg. In the collision, the two vehicles come to a halt. With what speed was the SUV traveling?
6) A 5000 g puck is moving to the right on a frictionless air hockey table with a velocity of +2.0 m/s. It collides head-on with a stationary 7.5 kg puck. Find the velocities of the pucks if the collision is
   a) elastic. b) perfectly (completely) inelastic.
7) It is another busy night for Spiderman! A diabolical criminal is trying to flee on a boat (m = 510 kg) moving at +11 m/s. Spiderman jumps straight down from a bridge onto the boat to apprehend the criminal. If Spiderman has a mass of 91 kg, what is the final velocity of the boat after he lands on it?
8) Two objects collide in a completely inelastic collision. The first object, A, is moving due east, and the second, Object B, is moving due north. The mass of object A is 17.0 kg and the mass of B is 29.0 kg, while the velocity of A is 8.0 m/s and that of B is 5.0 m/s. Find the momentum (magnitude and direction) of the system after the collision.

9) An automobile is moving under its own power with a velocity of +17 m/s. Its mass, including fuel, is 2.1 x 10^3 kg. At a red light, this car hits a 1900 kg stationary car. The cars lock bumpers and skid off together with both their brakes locked.
   a. What is the velocity of the two-car system after the collision?
   b. Find the impulse (magnitude and direction) that acts on the cars just after the collision until they come to a halt.
   c. If the coefficient of kinetic friction between the wheels of the cars and the pavement is $\mu_k = 0.68$, determine how far the cars skid before coming to rest.

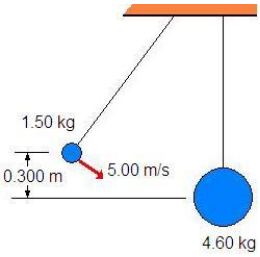
10) A toy boat is at rest in a pool. In this problem, you may assume that the water offers no resistance to the boat's motion because it its shape and mass. A girl on the side of the pool is skipping stones off the surface of the water and one of them accidentally strikes the top of the toy boat. This stone, which has a mass of 72 g, strikes the toy boat with a velocity of 13 m/s due east at an angle of 15° below the horizontal and ricochets off at a velocity of 11 m/s due east, 12° above the horizontal. After being struck by this stone, the toy boat has a velocity of 2.1 m/s east. What is the mass of the boat?



11) A bullet is moving horizontally to the right, which will be considered to be the positive direction. The mass of the bullet is 4.0 g. It is approaching two blocks that are at rest on a frictionless, horizontal table. Air resistance, heat, and noise are all negligible. The bullet passes completely through the first block (an inelastic collision) but does get embedded in the second block. Both blocks are now in motion. The first block (m = 1.150 kg) has a velocity of +0.550 m/s after the bullet passes through it. The mass of the second block is 1.530 kg.
   a. What is the velocity of the second block after the bullet embeds itself?
   b. Find the ratio of the total kinetic energy after the collision to that before the collision.



Problem 11



Problem 12

12) Consider the diagram above. In it, a 1.50 kg ball, initially at a height of 0.30 m with an initial velocity of 5.0 m/s, swings downward and strikes a 4.60 kg ball hanging at rest.
   a. Use the Principle of Conservation of Mechanical Energy (that is, assume no nonconservative forces are present) to find the speed of the 1.50 kg ball just before impact.
   b. Assuming that the collision is elastic, find the velocities (vectors!) of both balls just after the collision.
   c. Again ignoring nonconservative forces (air resistance), how high does each ball swing after the collision?

13) A binary star system is one in which two stars orbit each other around a center of mass. In one such system, the centers of the two stars (their individual centers of mass) are 7.17 x 10^{11} m apart. The larger of the two stars has a mass of 3.7 x 10^{30} kg with its center being 2.08 x 10^{11} m from the system's center of mass. What is the mass of the smaller star?

14) Consider two dancers at a barn dance, Billy Bob and Daisy May. Billy Bob has a mass of 86 kg, while Daisy May's mass is only 55 kg. At the beginning of a song, Billy Bob is standing at a point +9 m from a wall, while Daisy May is only +2 m from the same wall. Let the wall be the origin on a number line. They then switch positions as they dance. How far and in which direction does their center of mass move as a result of the switch?

15) Consider a molecule of sulfur dioxide, which is composed of two oxygen atoms and one sulfur atom. An oxygen atom is ½ the mass of a sulfur atom. Using the information provided in the diagram below, find the x- and y-components of the center of mass of a sulfur dioxide molecule. Express your answer in nanometers.