ME 2210 Dynamics Handout #4: Homework: 14.2, 14.4, 14.8, 14.10, 14.16, 14.22, 14.34, 14.40, 14.42, 14.48, 14.54

14.1 An airline employee tosses two suitcases, of mass 15 kg and 20 kg, respectively, onto a 25-kg baggage carrier in rapid succession. Knowing that the carrier is initially at rest and that the employee imparts a 3-m/s horizontal velocity to the 15-kg suitcase and a 2-m/s horizontal velocity to the 20-kg suitcase, determine the final velocity of the baggage carrier if the first suitcase tossed onto the carrier is (*a*) the 15-kg suitcase, (*b*) the 20-kg suitcase.

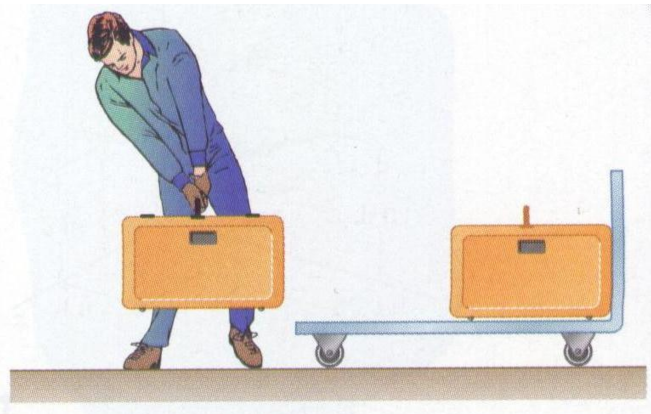

Fig. P14.1 and P14.2

14.2 An airline employee tosses two suitcases in rapid succession, with a horizontal velocity of 2.4 m/s, onto a 25-kg baggage carrier which is initially at rest. (*a*) Knowing that the final velocity of the baggage carrier is 1.2 m/s and that the first suitcase the employee tosses onto the carrier has a mass of 15 kg, determine the mass of the other suitcase. (*b*) What would be the final velocity of the carrier if the employee reversed the order in which he tosses the suitcases?

14.3 A 180-lb man and a 120-lb woman stand side by side at the same end of a 300-lb boat, ready to dive, each with a 16-ft/s velocity relative to the boat. Determine the velocity of the boat after they have both dived, if (*a*) the woman dives first, (*b*) the man dives first.

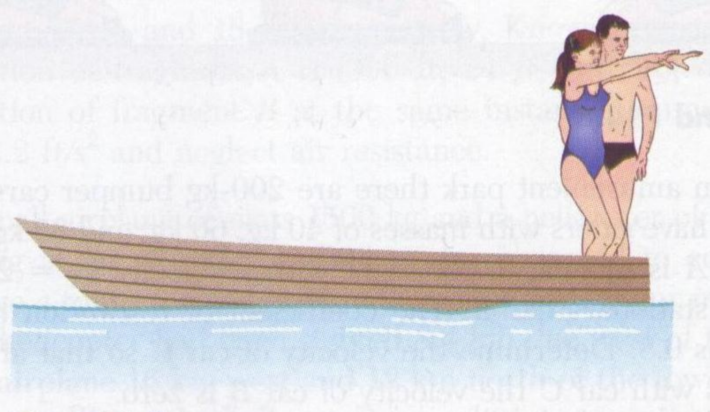

Fig. P14.3

14.4 A 180-lb man and a 120-lb woman stand at opposite ends of a 300-lb boat, ready to dive, each with a 16-ft/s velocity relative to the boat. Determine the velocity of the boat after they have both dived, if (*a*) the woman dives first, (*b*) the man dives first.

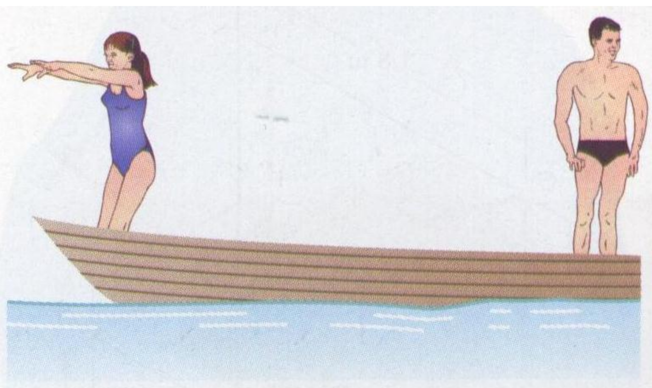

Fig. P14.4

14.5 A bullet is fired with a horizontal velocity of 1500 ft/s through a 6-lb block *A* and becomes embedded in a 4.95-lb block *B*. Knowing that blocks *A* and *B* start moving with velocities of 5 ft/s and 9 ft/s, respectively, determine (*a*) the weight of the bullet, (*b*) its velocity as it travels from block *A* to block *B*.

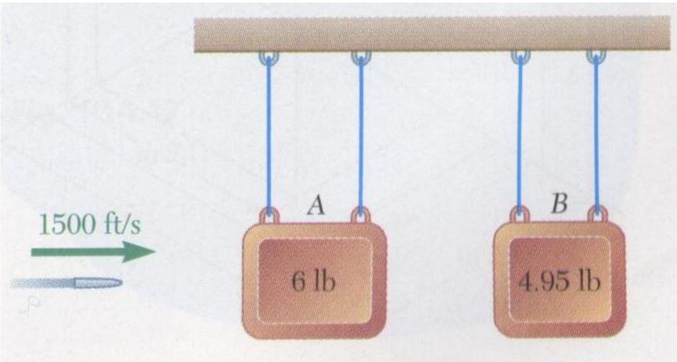

Fig. P14.5

14.7 At an amusement park there are 200-kg bumper cars *A*, *B*, and *C* that have riders with masses of 40 kg, 60 kg, and 35 kg respectively. Car *A* is moving to the right with a velocity $\mathbf{v}_A = 2$ m/s and car *C* has a velocity $\mathbf{v}_B = 1.5$ m/s to the left, but car *B* is initially at rest. The coefficient of restitution between each car is 0.8. Determine the final velocity of each car, after all impacts, assuming (*a*) cars *A* and *C* hit car *B* at the same time, (*b*) car *A* hits car *B* before car *C* does.

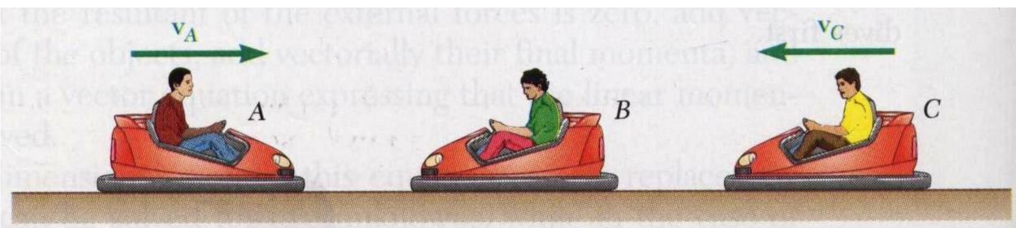

Fig. P14.7 and P14.8

14.8 At an amusement park there are 200-kg bumper cars *A*, *B*, and *C* that have riders with masses of 40 kg, 60 kg, and 35 kg respectively. Car *A* is moving to the right with a velocity $\mathbf{v}_A = 2$ m/s when it hits stationary car *B*. The coefficient of restitution between each car is 0.8. Determine the velocity of car *C* so that after car *B* collides with car *C* the velocity of car *B* is zero.

14.9 A system consists of three particles *A*, *B*, and *C*. We know that $m_A = 3$ kg, $m_B = 4$ kg, and $m_c = 5$ kg and that the velocities of the particles expressed in m/s are, respectively, $\mathbf{v}_A = -4\mathbf{i} + 4\mathbf{j} + 6\mathbf{k}$, $\mathbf{v}_B = -6\mathbf{i} + 8\mathbf{j} + 4\mathbf{k}$, and $\mathbf{v}_C = 2\mathbf{i} - 6\mathbf{j} - 4\mathbf{k}$. Determine the angular momentum $\mathbf{H}_O$ of the system about *O*.

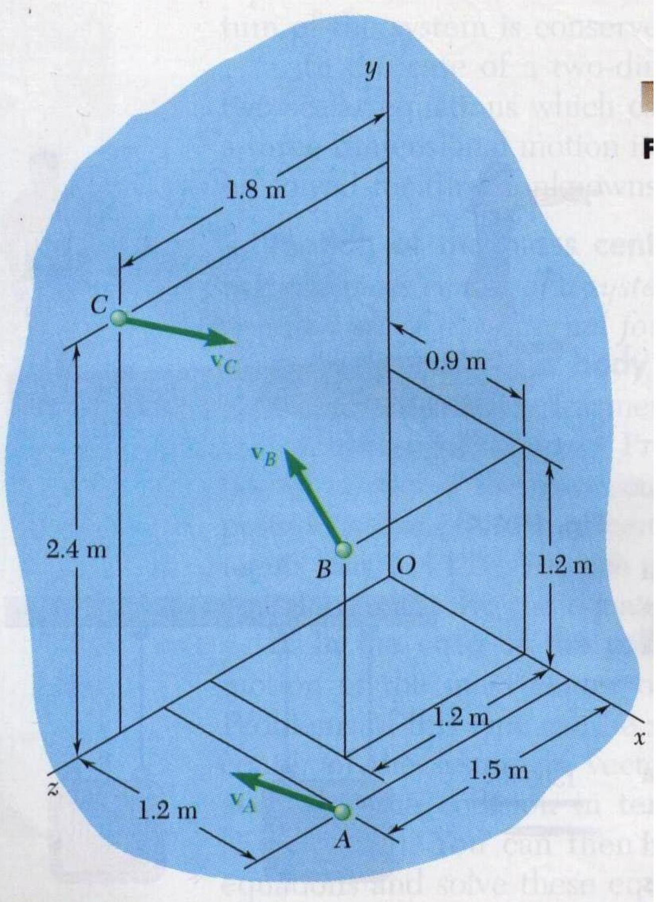

Fig. P14.9 and *P14.11*

14.10 For the system of particles of Prob. 14.9, determine (*a*) the position vector $\bar{\mathbf{r}}$ of the mass center *G* of the system, (*b*) the linear momentum $m\bar{\mathbf{v}}$ of the system, (*c*) the angular momentum $\mathbf{H}_G$ of the system about *G*. Also verify that the answers to this problem and to Prob. 14.9 satisfy the equation given in Prob. 14.27.

14.15 A 900-lb space vehicle traveling with a velocity $\mathbf{v}_0 = (1200 \text{ ft/s})\mathbf{i}$ passes through the origin *O* at $t = 0$. Explosive charges then separate the vehicle into three parts *A*, *B*, and *C*, weighing, respectively, 450 lb, 300 lb, and 150 lb. Knowing that at $t = 4$ s, the positions of parts *A* and *B* are observed to be *A* (3840 ft, −960 ft, −1920 ft) and *B* (6480 ft, 1200 ft, 2640 ft), determine the corresponding position of part *C*. Neglect the effect of gravity.

14.16 A 30-lb projectile is passing through the origin O with a velocity $\mathbf{v}_0 = (120 \text{ ft/s})\mathbf{i}$ when it explodes into two fragments A and B, of weight 12 lb and 18 lb, respectively. Knowing that 3 s later the position of fragment A is (300 ft, 24 ft, −48 ft), determine the position of fragment B at the same instant. Assume $a_y = -g = -32.2 \text{ ft/s}^2$ and neglect air resistance.

14.17 A small airplane of mass 1500 kg and a helicopter of mass 3000 kg flying at an altitude of 1200 m are observed to collide directly above a tower located at O in a wooded area. Four minutes earlier the helicopter had been sighted 8.4 km due west of the tower and the airplane 16 km west and 12 km north of the tower. As a result of the collision the helicopter was split into two pieces, H_1 and H_2, of mass $m_1 = 1000$ kg and $m_2 = 2000$ kg, respectively; the airplane remained in one piece as it fell to the ground. Knowing that the two fragments of the helicopter were located at points H_1 (500 m, −100 m) and H_2 (600 m, −500 m), respectively, and assuming that all pieces hit the ground at the same time, determine the coordinates of the point A where the wreckage of the airplane will be found.

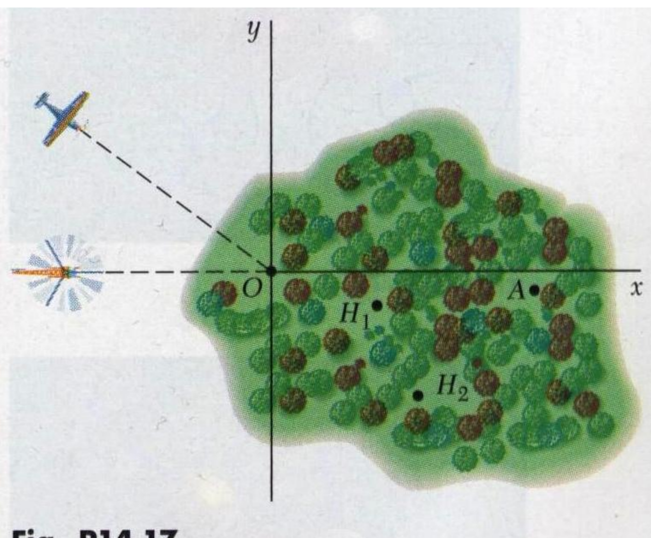

Fig. P14.17

14.18 In Problem 14.17, knowing that the wreckage of the small airplane was found at point A (1200 m, 80 m) and the 1000-kg fragment of the helicopter at point H_1 (400 m, −200 m), and assuming that all pieces hit the ground at the same time, determine the coordinates of the point H_2 where the other fragment of the helicopter will be found.

14.21 and 14.22 In a game of pool, ball A is moving with a velocity $\mathbf{v}_0$ when it strikes balls B and C which are at rest and aligned as shown. Knowing that after the collision the three balls move in the directions indicated and that $v_0 = 12$ ft/s and $v_C = 6.29$ ft/s, determine the magnitude of the velocity of (*a*) ball A, (*b*) ball B.

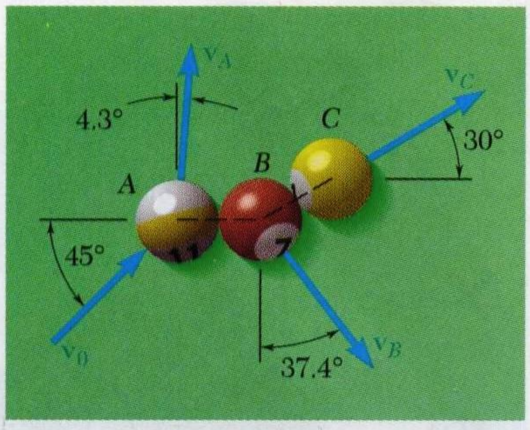

Fig. P14.21

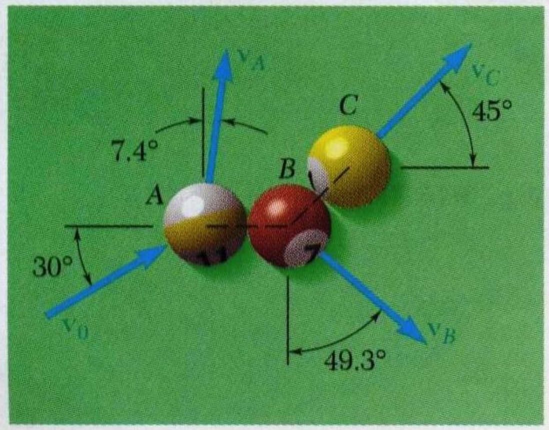

Fig. P14.22

14.25 A 12-lb shell moving with a velocity $\mathbf{v}_0 = (40 \text{ ft/s})\mathbf{i} - (30 \text{ ft/s})\mathbf{j} - (1200 \text{ ft/s})\mathbf{k}$ explodes at point D into three fragments A, B, and C weighing, respectively, 5 lb, 4 lb, and 3 lb. Knowing that the fragments hit the vertical wall at the points indicated, determine the speed of each fragment immediately after the explosion.

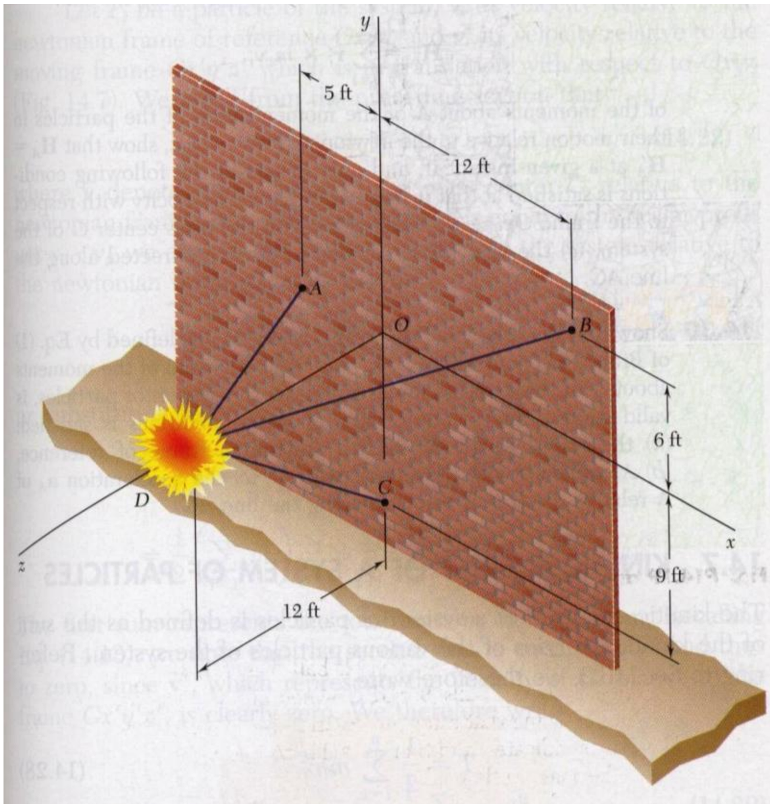

Fig. P14.25 and P14.26

14.26 A 12-lb shell moving with a velocity $\mathbf{v}_0 = (40\text{ ft/s})\mathbf{i} - (30\text{ ft/s})\mathbf{j} - (1200\text{ ft/s})\mathbf{k}$ explodes at point *D* into three fragments *A*, *B*, and *C* weighing, respectively, 4 lb, 3 lb, and 5 lb. Knowing that the fragments hit the vertical wall at the points indicated, determine the speed of each fragment immediately after the explosion.

14.31 Assuming that the airline employee of Prob. 14.1 first tosses the 15-kg suitcase on the baggage carrier, determine the energy lost (*a*) as the first suitcase hits the carrier, (*b*) as the second suitcase hits the carrier.

14.32 Determine the energy loss as a result of the series of collisions described in Prob. 14.7.

14.33 In Prob. 14.3, determine the work done by the woman and by the man as each dives from the boat, assuming that the woman dives first.

14.34 In Prob. 14.5, determine the energy lost as the bullet (*a*) passes through block *A*, (*b*) becomes embedded in block *B*.

14.37 Solve Sample Prob. 14.4, assuming that cart *A* is given an initial horizontal velocity $\mathbf{v}_0$ while ball *B* is at rest.

14.38 In a game of pool, ball *A* is moving with the velocity $\mathbf{v}_0 = v_0\mathbf{i}$ when it strikes balls *B* and *C*, which are at rest side by side. Assuming frictionless surfaces and perfectly elastic impact (i.e., conservation of energy), determine the final velocity of each ball, assuming that the path of *A* is (*a*) perfectly centered and that *A* strikes *B* and *C* simultaneously, (*b*) not perfectly centered and that *A* strikes *B* slightly before it strikes *C*.

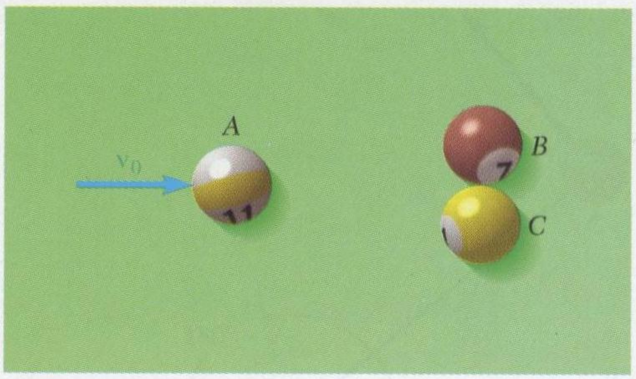

Fig. P14.38

14.39 and 14.40 In a game of pool, ball *A* is moving with a velocity $\mathbf{v}_0$ of magnitude $v_0 = 15$ ft/s when it strikes balls *B* and *C*, which are at rest and aligned as shown. Knowing that after the collision the three balls move in the directions indicated and assuming frictionless surfaces and perfectly elastic impact (i.e., conservation of energy), determine the magnitudes of the velocities $\mathbf{v}_A$, $\mathbf{v}_B$, and $\mathbf{v}_C$.

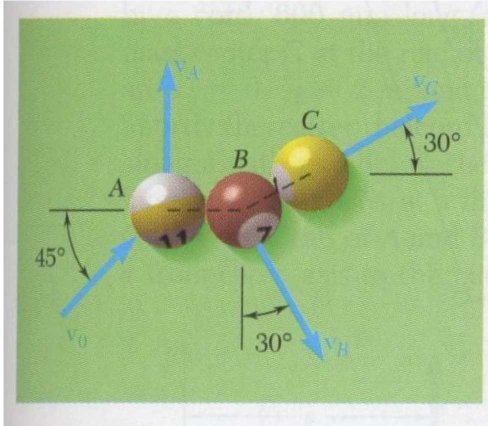

Fig. P14.39

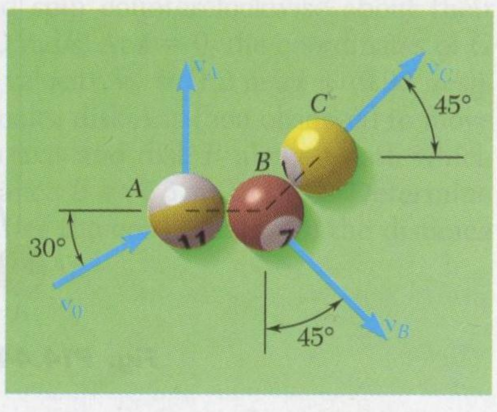

Fig. P14.40

14.41 Two hemispheres are held together by a cord which maintains a spring under compression (the spring is not attached to the hemispheres). The potential energy of the compressed spring is 120 J and the assembly has an initial velocity $\mathbf{v}_0$ of magnitude $v_0 = 8$ m/s. Knowing that the cord is severed when $\theta = 30°$, causing the hemispheres to fly apart, determine the resulting velocity of each hemisphere.

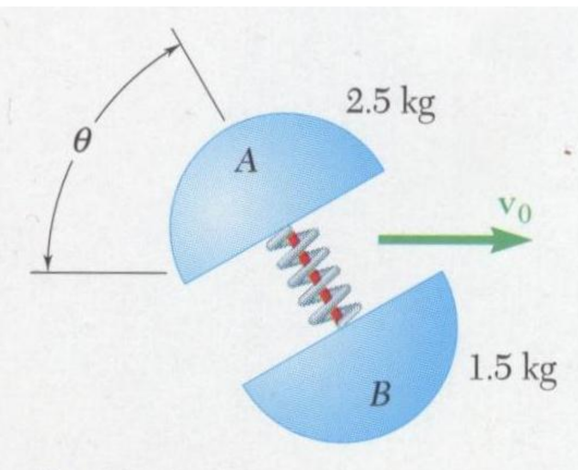

Fig. P14.41

14.42 Solve Prob. 14.41, knowing that the cord is severed when $\theta = 120°$.

14.43 A 40-lb block B is suspended from a 6-ft cord attached to a 60-lb cart A, which may roll freely on a frictionless, horizontal track. If the system is released from rest in the position shown, determine the velocities of A and B as B passes directly under A.

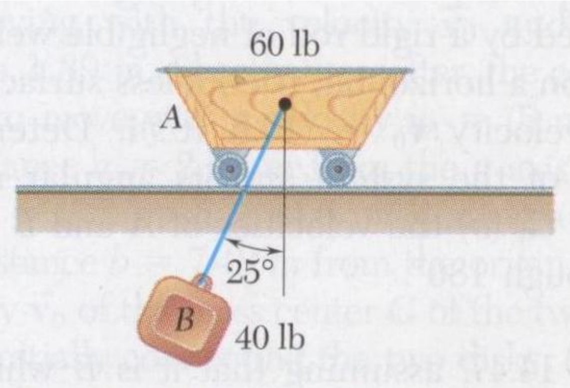

Fig. P14.43

14.45 A 360-kg space vehicle traveling with a velocity $\mathbf{v}_0 = (450\text{ m/s})\mathbf{k}$ passes through the origin O. Explosive charges then separate the vehicle into three parts A, B, and C, with masses of 60 kg, 120 kg, and 180 kg, respectively. Knowing that shortly thereafter the positions of the three parts are, respectively, $A(72, 72, 648)$, $B(180, 396, 972)$, and $C(-144, -288, 576)$, where the coordinates are expressed in meters, that the velocity of B is $\mathbf{v}_B = (150\text{m/s})\mathbf{i} + (330\text{ m/s})\mathbf{j} + (660\text{ m/s})\mathbf{k}$, and that the x component of the velocity of C is -120 m/s, determine the velocity of part A.

14.47 Two small spheres A and B, weighing 5 lb and 2 lb, respectively, are connected by a rigid rod of negligible weight. The two spheres are resting on a horizontal, frictionless surface when A is suddenly given the velocity $\mathbf{v}_0 = (10.5\text{ ft/s})\mathbf{i}$. Determine (*a*) the linear momentum of the system and its angular momentum about its mass center G, (*b*) the velocities of A and B after the rod AB has rotated through 180°.

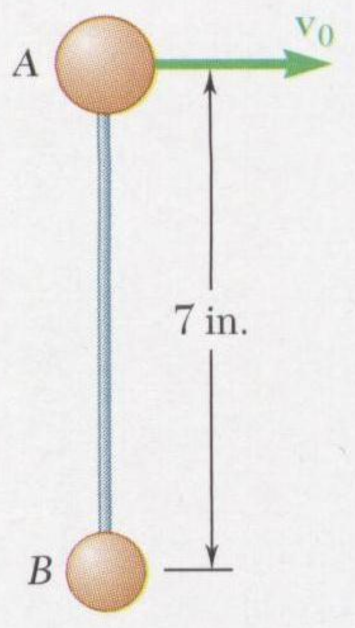

Fig. P14.47

14.48 Solve Prob. 14.47, assuming that it is B which is suddenly given the velocity $\mathbf{v}_0 = (10.5 \text{ ft/s})\mathbf{i}$.

14.51 Two small disks A and B, of mass 3 kg and 1.5 kg, respectively, may slide on a horizontal, frictionless surface. They are connected by a cord, 600 mm long, and spin counterclockwise about their mass center G at the rate of 10 rad/s. At $t = 0$, the coordinates of G are $\bar{x}_0 = 0$, $\bar{y}_0 = 2$ m, and its velocity $\bar{\mathbf{v}}_0 = (1.2 \text{ m/s})\mathbf{i} + (0.96 \text{ m/s})\mathbf{j}$. Shortly thereafter the cord breaks; disk A is then observed to move along a path parallel to the y axis and disk B along a path which intersects the x axis at a distance $b = 7.5$ m from O. Determine (*a*) the velocities of A and B after the cord breaks, (*b*) the distance a from the y axis to the path of A.

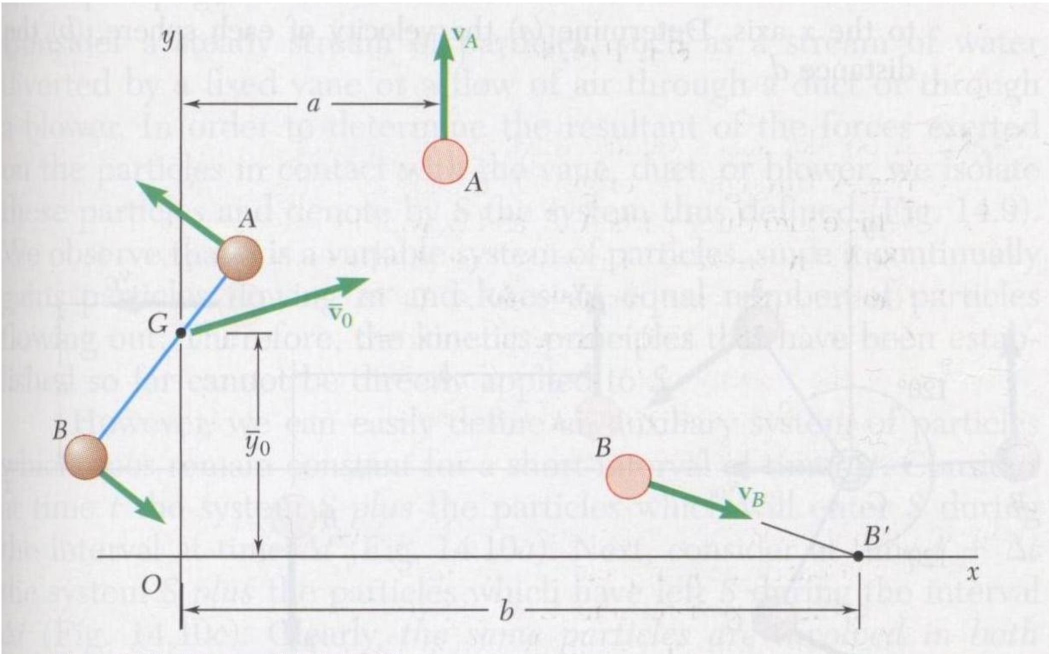

Fig. P14.51 and P14.52

14.52 Two small disks A and B, of mass 2 kg and 1 kg, respectively, may slide on a horizontal and frictionless surface. They are connected by a cord of negligible mass and spin about their mass center G. At $t = 0$, G is moving with the velocity $\overline{\mathbf{v}}_0$ and its coordinates are $\bar{x}_0 = 0$, $\bar{y}_0 = 1.89$ m. Shortly thereafter, the cord breaks and disk A is observed to move with a velocity $\mathbf{v}_A = (5 \text{ m/s})\mathbf{j}$ in a straight line and at a distance $a = 2.56$ m from the y axis, while B moves with a velocity $\mathbf{v}_B = (7.2 \text{ m/s})\mathbf{i} - (4.6 \text{ m/s})\mathbf{j}$ along a path intersecting the x axis at a distance $b = 7.48$ m from the origin O. Determine (*a*) the initial velocity $\overline{\mathbf{v}}_0$ of the mass center G of the two disks, (*b*) the length of the cord initially connecting the two disks, (*c*) the rate in rad/s at which the disks were spinning about G.

14.53 In a game of billiards, ball A is given an initial velocity $\mathbf{v}_0$ along the longitudinal axis of the table. It hits ball B and then ball C, which are both at rest. Balls A and C are observed to hit the sides of the table squarely at A' and C', respectively, and ball B is observed to hit the side obliquely at B'. Knowing that $v_0 = 12$ ft/s, $v_A = 5.76$ ft/s, and $a = 66$ in., determine (*a*) the velocities $\mathbf{v}_B$ and $\mathbf{v}_C$ of balls B and C, (*b*) the point C' where ball C hits the side of the table. Assume frictionless surfaces and perfectly elastic impacts (i.e., conservation of energy).

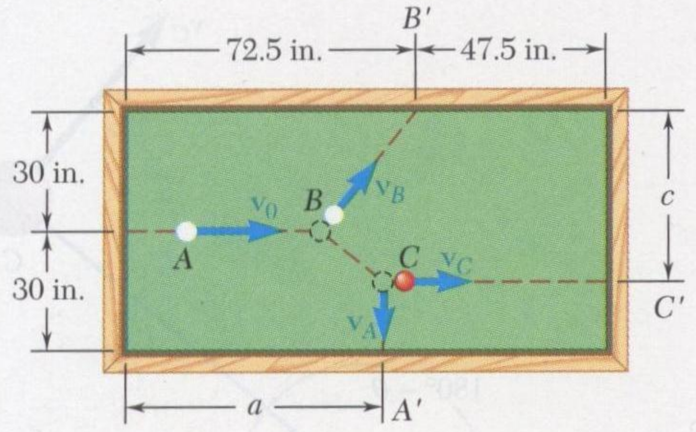

Fig. P14.53

14.54 For the game of billiards of Prob. 14.53, it is now assumed that $v_0 = 15$ ft/s, $v_C = 9.6$ ft/s, and $c = 48$ in. Determine (*a*) the velocities $\mathbf{v}_A$ and $\mathbf{v}_B$ of balls *A* and *B*, (*b*) the point *A'* where ball *A* hits the side of the table.