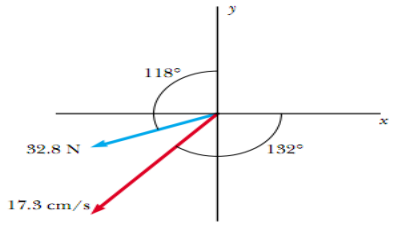
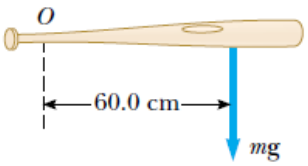
EXERCISES 3.B

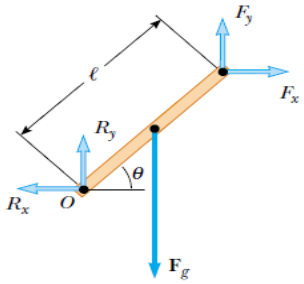
1. Vector A has a magnitude of 5.00 units, and B has a magnitude of 9.00 units. The two vectors make an angle of 50° with each other. Find A.B.
2. For any two vectors A and B, show that $A.B = A_xB_x+A_yB_y+ A_zB_z$.
3. A force $F = (6\vec{\imath} + 2\vec{\jmath})$ N acts on a particle that undergoes a displacement $\Delta r = (3\vec{\imath}+\vec{\jmath})$ m. Find
   a) The work done by the force on the particle
   b) The angle between F and Δr.
4. Find the scalar product of the vectors in Figure



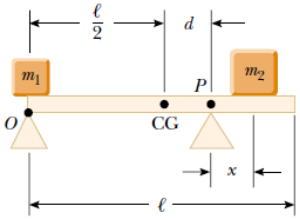
5. Using the definition of the scalar product, find the angles between
   a) $A = (3\vec{\imath} -2\vec{\jmath})$ and $B= (4\vec{\imath} - 4\vec{\jmath})$
   b) $A = (-2\vec{\imath} + 4\vec{\jmath})$ and $B = (3\vec{\imath} - 4\vec{\jmath}+2\vec{k})$
   c) $A = (\vec{\imath} - 2\vec{\jmath}+2\vec{k})$ and $B = (3\vec{\jmath}+4\vec{k})$
6. For $A= (3\vec{\imath} +\vec{\jmath}-\vec{k})$, $B = (-\vec{\imath} +2\vec{\jmath}+5\vec{k})$ and $C= (2\,\vec{\jmath}-3\vec{k})$.Find C. (A - B)
7. A baseball player holds a 36-oz bat (weight =10N) with one hand at the point *O*. The bat is in equilibrium. The weight of the bat acts along a line 60cm to the right of *O*. Determine the force and the torque exerted by the player on the bat around an axis through *O*.



8. Write the necessary conditions for equilibrium of the object shown in Figure. Take the origin of the torque equation at the point *O*.



9. A uniform beam of mass m_b and length *L* supports blocks with masses m_1 and m_2 at two positions, as in Figure. The beam rests on two knife edges. For what value of *x* will the beam be balanced at *P* such that the normal force at *O* is zero?



10. A carpenter's square has the shape of an L, as in Figure P12.5. Locate its center of gravity.

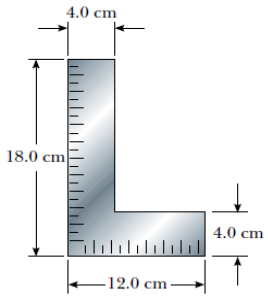
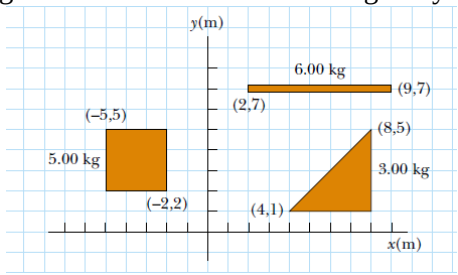


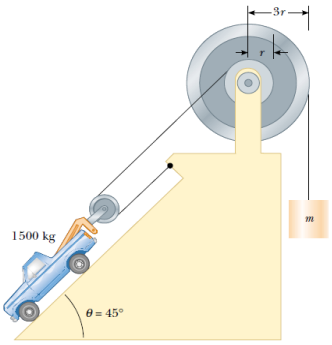
Figure P12.5

11.Consider the following mass distribution: 5.00 kg at (0, 0) m, 3.00 kg at (0, 4.00) m, and 4.00 kg at (3.00, 0) m. Where should a fourth object of mass 8.00 kg be placed so that the center of gravity of the four-object arrangement will be at (0, 0)?

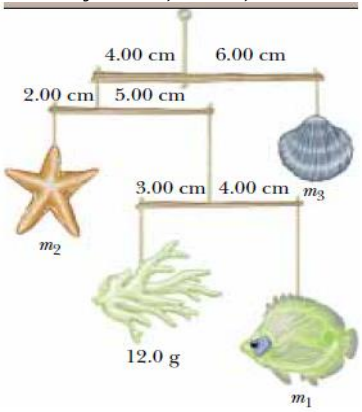
12. Figure shows three uniform objects: a rod, a right triangle, and a square. Their masses and their coordinates in meters are given. Determine the center of gravity for



13.Find the mass *m* of the counterweight needed to balance the 1500kg truck on the incline shown in Figure .Assume all pulleys are frictionless and massless.



14. A mobile is constructed of light rods, light strings, and beach souvenirs, as shown in Figure. Determine the masses of the objects :a) m_1, b) m_2, and c) m_3.

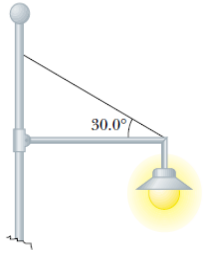


15. Two pans of a balance are 50cm apart. The fulcrum of the balance has been shifted 1cm away from the center by a dishonest shopkeeper. By what percentage is the true weight of the goods being marked up by the shopkeeper? (Assume the balance has negligible mass.)

16. A 20kg floodlight in a park is supported at the end of a horizontal beam of negligible mass that is hinged to a pole, as shown in Figure. A cable at an angle of 30° with the beam helps to support the light.

Find: a) the tension in the cable and

b) the horizontal and vertical forces exerted on the beam by the pole.



17. A 15m uniform ladder weighing 500 N rests against a frictionless wall. The ladder makes a 60° angle with the horizontal.

a) Find the horizontal and vertical forces the ground exerts on the base of the ladder when an 800N firefighter is 4m from the bottom.

b) If the ladder is just on the verge of slipping when the firefighter is 9m up, what is the coefficient of static friction between ladder and ground?

18. A uniform ladder of length L and mass m_1 rests against a frictionless wall. The ladder makes an angle θ) with the horizontal.

a) Find the horizontal and vertical forces the ground exerts on the base of the ladder when a firefighter of mass m_2 is a distance x from the bottom.

b) If the ladder is just on the verge of slipping when the firefighter is a distance d from the bottom, what is the coefficient of static friction between ladder and ground?

19. Figure shows a claw hammer as it is being used to pull a nail out of a horizontal board. If a force of 150 N is exerted horizontally as shown,

find :a) the force exerted by the hammer claws on the nail

b) the force exerted by the surface on the point of contact with the hammer head. Assume that the force the hammer exerts on the nail is parallel to the nail.

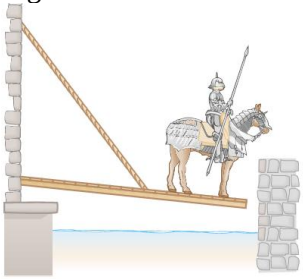
20. A uniform plank of length 6m and mass 30kg rests horizontally across two horizontal bars of a scaffold. The bars are 4.5m apart, and 1.5m of the plank hangs over one side of the scaffold. Draw a free-body diagram of the plank. How far can a painter of mass 70kg walk on the overhanging part of the plank before it tips?

21.A 1 500kg automobile has a wheel base (the distance between the axles) of 3m. The center of mass of the automobile is on the center line at a point 1.2m behind the front axle. Find the force exerted by the ground on each wheel.

22. A vertical post with a square cross section is 10m tall. Its bottom end is encased in a base 1.5m tall, which is precisely square but slightly loose. A force 5.5N to the right acts on the top of the post. The base maintains the post in equilibrium. Find the force that the top of the right side wall of the base exerts on the post. Find the force that the bottom of the left side wall of the base exerts on the post.

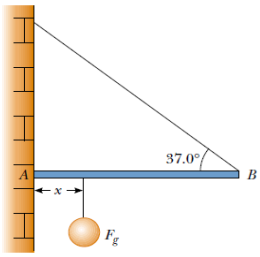
23. A flexible chain weighing 40N hangs between two hooks located at the same height . At each hook, the tangent to the chain makes an angle $\theta = 42°$ with the horizontal. Find (a) the magnitude of the force each hook exerts on the chain and (b) the tension in the chain at its midpoint. (*Suggestion:* for part (b), make a free-body diagram for half of the chain.)

24. Sir Lost-a-Lot dons his armor and sets out from the castle on his trusty steed in his quest to improve communication between damsels and dragons. Unfortunately, his squire lowered the drawbridge too far and finally stopped it 20° below the horizontal. Lost-a-Lot and his horse stop when their combined center of mass is 1m from the end of the bridge. The uniform bridge is 8m long and has mass 2000 kg. The lift cable is attached to the bridge 5m from the hinge at the castle end, and to a point on the castle wall 12m above the bridge. Lost-a- Lot's mass combined with his armor and steed is 1000kg. Determine (a) the tension in the cable and the (b) horizontal and (c) vertical force components acting on the bridge at the hinge.

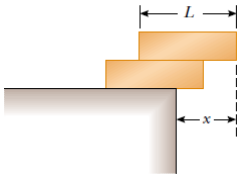


25. Stephen is pushing his sister Joyce in a wheelbarrow when it is stopped by a brick 8cm high. The handles make an angle of 15° below the horizontal. A downward force of 400 N is exerted on the wheel, which has a radius of 20cm. (a) What force must Stephen apply along the handles in order to just start the wheel over the brick? (b) What is the force (magnitude and direction) that the brick exerts on the wheel just as the wheel begins to lift over the brick? Assume in both parts that the brick remains fixed and does not slide along the ground.

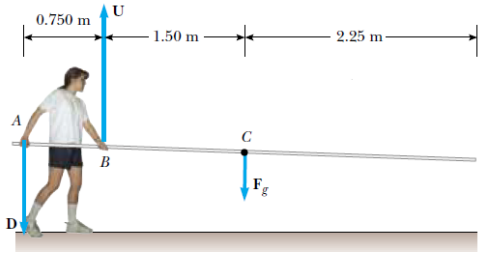
26. One end of a uniform 4m long rod of weight F_g is supported by a cable. The other end rests against the wall, where it is held by friction, as in Figure. The coefficient of static friction between the wall and the rod is μ_s=0.5. Determine the minimum distance x from point A at which an additional weight Fg (the same as the weight of the rod) can be hung without causing the rod to slip at point A.



27. Two identical uniform bricks of length L are placed in a stack over the edge of a horizontal surface with the maximum overhang possible without falling, as in Figure. Find the distance x.



28. A vaulter holds a 29.4N pole in equilibrium by exerting an upward force U with her leading hand and a downward force D with her trailing hand, as shown in Figure. Point C is the center of gravity of the pole. What are the magnitudes of U and D?



29. A lightweight, rigid beam 10m long is supported by a cable attached to a spring of force constant k=8.25 kN/m as shown in Figure. When no load is hung on the beam (F_g=0), the length L is equal to 5m.

a) Find the angle θ in this situation.

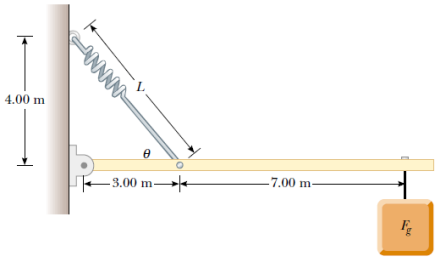
b) Now a load of F_g=250N is hung on the end of the beam. Temporarily ignore the extension of the spring and the change in the angle θ. Calculate the tension in the cable with this approximation.

c) Use the answer to part (b) to calculate the spring elongation and a new value for the angle θ.

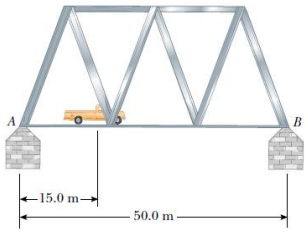
d) With the value of θ from part (c), find a second approximation for the tension in the cable.

e) Use the answer to part (d) to calculate more precise values for the spring elongation and the angle).

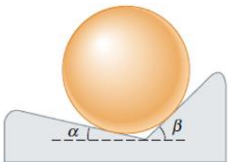
f) To three-digit precision, what is the actual value of θ under load?



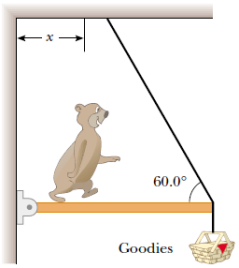
30. A bridge of length 50m and mass 8×10^4 kg is supported on a smooth pier at each end as in Figure. A truck of mass 3×10^4 kg is located 15m from one end. What are the forces on the bridge at the points of support?



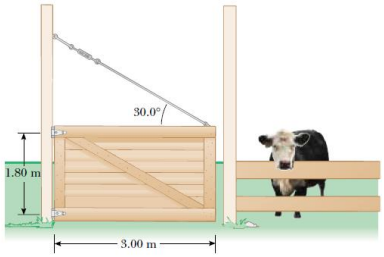
31. A solid sphere of radius *R* and mass *M* is placed in a trough as shown in Figure P12.42. The inner surfaces of the trough are frictionless. Determine the forces exerted by the trough on the sphere at the two contact points.



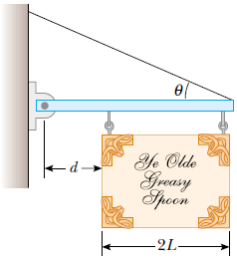
32. A hungry bear weighing 700 N walks out on a beam in an attempt to retrieve a basket of food hanging at the end of the beam in figure. The beam is uniform, weighs 200N, and is 6m long; the basket weighs 80N.
a) Draw a free-body diagram for the beam.
b) When the bear is at x=1m, find the tension in the wire and the components of the force exerted by the wall on the left end of the beam.
c) What If? If the wire can withstand a maximum tension of 900N, what is the maximum distance the bear can walk before the wire breaks?



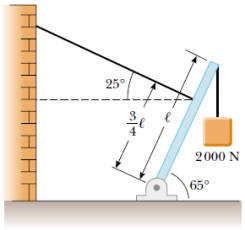
33.A farm gate (Fig) is 3m wide and 1.8m high, with hinges attached to the top and bottom. The guy wire makes an angle of 30° with the top of the gate and is tightened by a turnbuckle to a tension of 200N. The mass of the gate is 40kg.
a) Determine the horizontal force exerted by the bottom hinge on the gate.
b) Find the horizontal force exerted by the upper hinge.
c) Determine the combined vertical force exerted by both hinges.
d) What If? What must be the tension in the guy wire so that the horizontal force exerted by the upper hinge is zero?



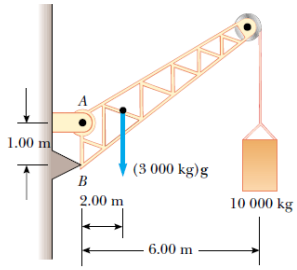
34. A uniform sign of weight F_g and width $2L$ hangs from a light, horizontal beam, hinged at the wall and supported by a cable (Fig). Determine (a) the tension in the cable and (b) the components of the reaction force exerted by the wall on the beam, in terms of F_g, d, L, and θ.



35. A 1200N uniform boom is supported by a cable as in Figure. The boom is pivoted at the bottom, and a 2000N object hangs from its top. Find the tension in the cable and the components of the reaction force exerted by the floor on the boom.

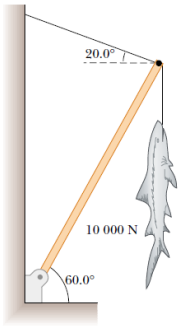


36. A crane of mass 3000 kg supports a load of 10000 kg as in Figure. The crane is pivoted with a frictionless pin at *A* and rests against a smooth support at *B*. Find the reaction forces at *A* and *B*.

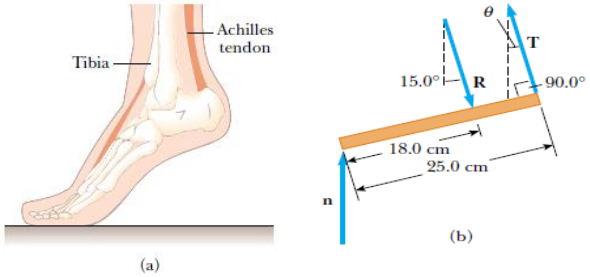


37. A ladder of uniform density and mass *m* rests against a frictionless vertical wall, making an angle of 60° with the horizontal. The lower end rests on a flat surface where the coefficient of static friction is μ_s=0.4. A window cleaner with mass *M* =2*m* attempts to climb the ladder. What fraction of the length *L* of the ladder will the worker have reached when the ladder begins to slip?

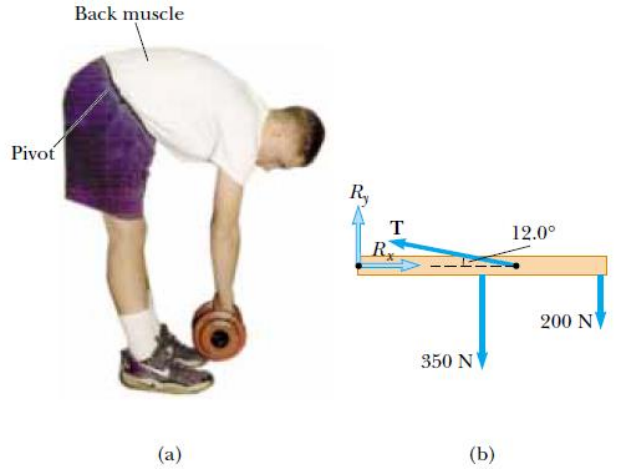
38.A 10000N shark is supported by a cable attached to a 4m rod that can pivot at the base. Calculate the tension in the tie-rope between the rod and the wall if it is holding the system in the position shown in Figure. Find the horizontal and vertical forces exerted on the base of the rod. (Neglect the weight of the rod.)



39. When a person stands on tiptoe (a strenuous position), the position of the foot is as shown in Figure (a). The gravitational force on the body F_g is supported by the force n exerted by the floor on the toe. A mechanical model for the situation is shown in Figure (b), where T is the force exerted by the Achilles tendon on the foot and R is the force exerted by the tibia on the foot. Find the values of *T*, *R*, and θ when F_g =700N.

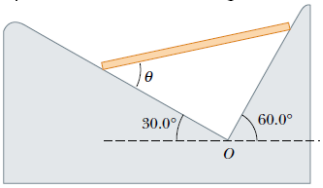


40. A person bending forward to lift a load “with his back” (Fig. a) rather than “with his knees” can be injured by large forces exerted on the muscles and vertebrae. The spine pivots mainly at the fifth lumbar vertebra, with the principal supporting force provided by the erector spinalis muscle in the back. To see the magnitude of the forces involved, and to understand why back problems are common among humans, consider the model shown in (Figure b) for a person bending forward to lift a 200N object. The spine and upper body are represented as a uniform horizontal rod of weight 350N, pivoted at the base of the spine. The erector spinalis muscle, attached at a point two thirds of the way up the spine, maintains the position of the back. The angle between the spine and this muscle is 12°. Find the tension in the back muscle and the compressional force in the spine.

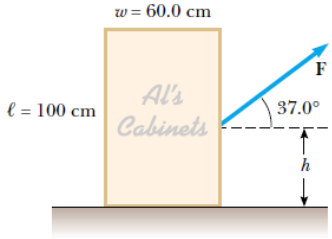


(a) (b)

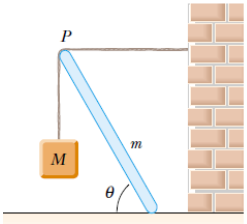
41. A uniform rod of weight F_g and length L is supported at its ends by a frictionless trough as shown in Figure.
a) Show that the center of gravity of the rod must be vertically over point O when the rod is in equilibrium.
b) Determine the equilibrium value of the angle θ.



42. A force acts on a rectangular cabinet weighing 400N, as in Figure. a) If the cabinet slides with constant speed when F=200N and h=0.4m, find the coefficient of kinetic friction and the position of the resultant normal force. b) If F=300 N, find the value of h for which the cabinet just begins to tip.

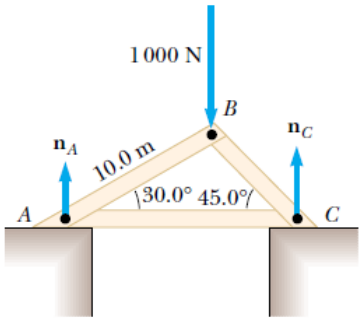


43.A uniform beam of mass m is inclined at an angle θ to the horizontal. Its upper end produces a ninety degree bend in a very rough rope tied to a wall, and its lower end rests on a rough floor.
a) If the coefficient of static friction between beam and floor is μ_s, determine an expression for the maximum mass M that can be suspended from the top before the beam slips.
b) Determine the magnitude of the reaction force at the floor and the magnitude of the force exerted by the beam on the rope at P in terms of m, M, and μ_s.

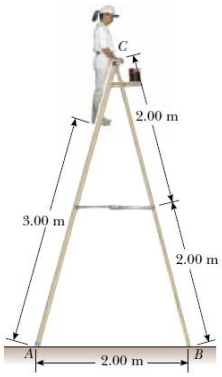


44. Figure shows a truss that supports a downward force of 1000N applied at the point B. The truss has negligible weight. The piers at A and C are smooth.
a) Apply the conditions of equilibrium to prove that n_A=366N and n_C = 634N.

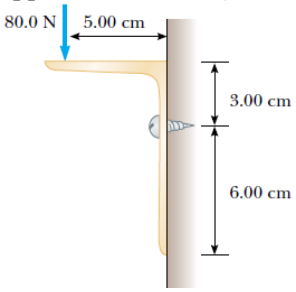
b) Show that, because forces act on the light truss only at the hinge joints, each bar of the truss must exert on each hinge pin only a force along the length of that bar a force of tension or compression.
c) Find the force of tension or of compression in each of the three bars.



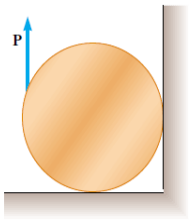
45. A stepladder of negligible weight is constructed as shown in Figure. A painter of mass 70kg stands on the ladder 3m from the bottom. Assuming the floor is frictionless, find: a) the tension in the horizontal bar connecting the two halves of the ladder, b) the normal forces at *A* and *B*, and (c) the components of the reaction force at the single hinge *C* that the left half of the ladder exerts on the right half. (*Suggestion:* Treat the ladder as a single object, but also each half of the ladder separately.)



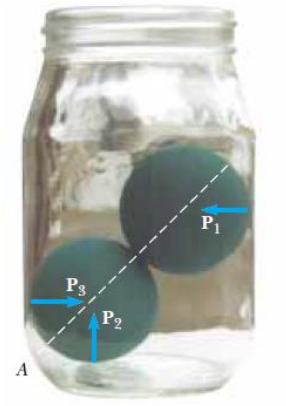
46. A flat dance floor of dimensions 20m by 20m has a mass of 1000kg. Three dance couples, each of mass 125kg, start in the top left, top right, and bottom left corners. (a) Where is the initial center of gravity? (b) The couple in the bottom left corner moves 10m to the right. Where is the new center of gravity? (c) What was the average velocity of the center of gravity if it took that couple 8s to change positions?
47. A shelf bracket is mounted on a vertical wall by a single screw, as shown in Figure. Neglecting the weight of the bracket, find the horizontal component of the force that the screw exerts on the bracket when an 80N vertical force is applied as shown. (*Hint:* Imagine that the bracket is slightly loose.)



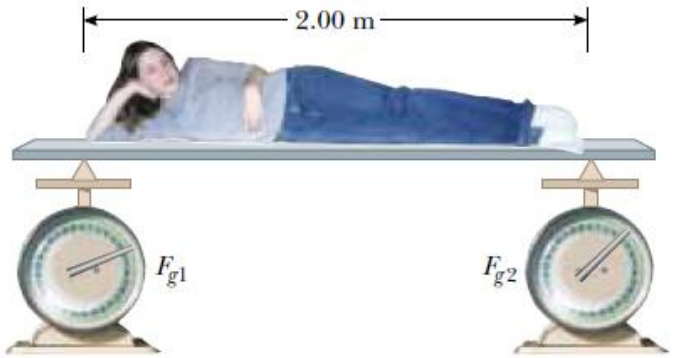
48. Figure shows a vertical force applied tangentially to a uniform cylinder of weight F_g. The coefficient of static friction between the cylinder and all surfaces is 0.5. In terms of F_g , find the maximum force P that can be applied that does not cause the cylinder to rotate. (*Hint:* When the cylinder is on the verge of slipping, both friction forces are at their maximum values. Why?)



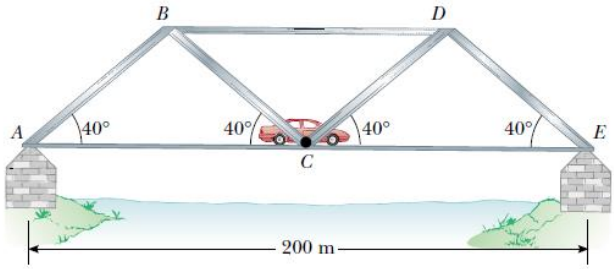
49.Two racquetballs are placed in a glass jar, as shown in Figure. Their centers and the point *A* lie on a straight line. (a) Assume that the walls are frictionless, and determine P_1, P_2, and P_3. (b) Determine the magnitude of the force exerted by the left ball on the right ball. Assume each ball has a mass of 170g.



50. In exercise physiology studies it is sometimes important to determine the location of a person's center of mass. This can be done with the arrangement shown in Figure. A light plank rests on two scales, which give readings of F_{g1}=380N and F_{g2}=320N. The scales are separated by a distance of 2m. How far from the woman's feet is her center of mass?



51. A bridge truss extends 200m across a river (Fig). The structure is free to slide horizontally to permit thermal expansion. The structural components are connected by pin joints, and the masses of the bars are small compared with the mass of a 1360kg car at the center. Calculate the force of tension or compression in each structural component.



52. A bridge truss extends 100m across a river (Fig). The structure is free to slide horizontally to permit thermal expansion. The structural components are connected by pin joints, and the masses of the bars are small compared with the mass of a 1500kg car halfway between points *A* and *C*. Show that the weight of the car is in effect equally distributed between points *A* and *C*. Specify whether each structural component is under tension or compression and find the force in each.