Unit 3 Problem Set

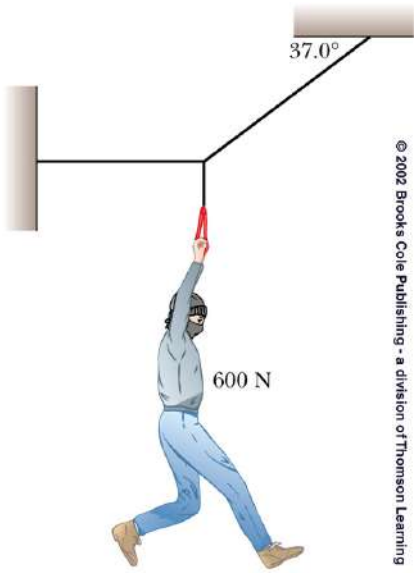
3.1 A 6.0-kg object undergoes an acceleration of 2.0 m/s^2. (a) What is the magnitude of the resultant force acting on it? (b) If this same force is applied to a 4.0-kg object, what acceleration is produced?

3.2 A football punter accelerates a football from rest to a speed of 10 m/s during the time in which his toe is in contact with the ball (about 0.20 s). If the football has a mass of 0.50 kg, what average force does the punter exert on the ball?

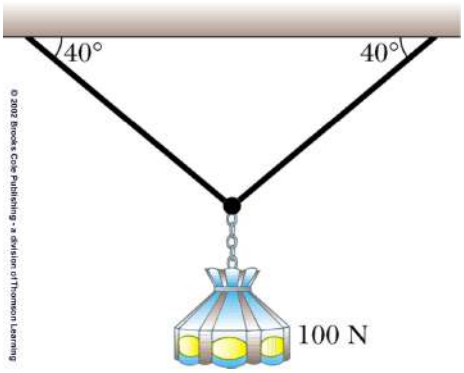
3.3 A 5.0-g bullet leaves the muzzle of a rifle with a speed of 320 m/s. What total force (assumed constant) is exerted on the bullet while it is traveling down the 0.82-m-long barrel of the rifle?

3.4 A performer in a circus is fired from a cannon as a “human cannonball” and leaves the cannon with a speed of 18.0 m/s. The performer’s mass is 80.0 kg. The cannon barrel is 9.20 m long. Find the average net force exerted on the performer while he is being accelerated inside the cannon.

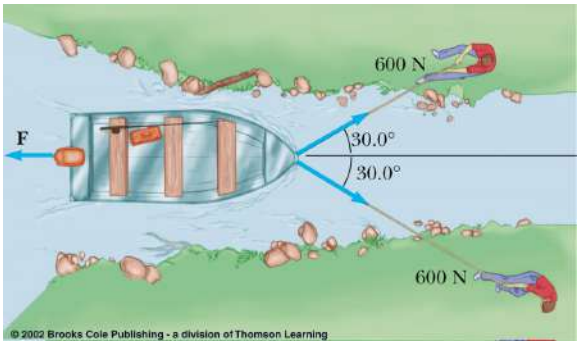
3.5 Find the tension in each cable supporting the 600-N cat burglar in Figure P4.15.



3.6 Find the tension in the two wires that support the 100-N light fixture in Figure P4.16.

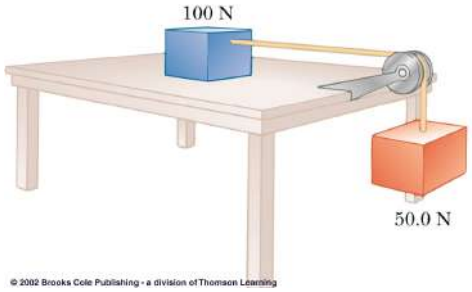


3.7 Two people are pulling a boat through the water as in Figure P4.20. Each exerts a force of 600 N directed at a 30.0° angle relative to the forward motion of the boat. If the boat moves with constant velocity, find the resistive force **F** exerted by the water on the boat.



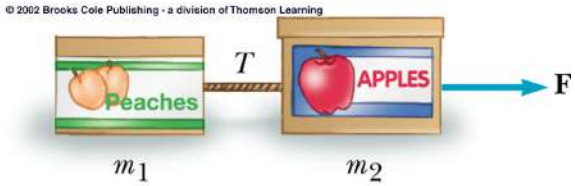
3.8 The distance between two telephone poles is 50.0 m. When a 1.00-kg bird lands on the telephone wire midway between the poles, the wire sags 0.200 m. Draw a free-body diagram of the bird. How much tension does the bird produce in the wire? Ignore the weight of the wire.
3.9 A 1000-N crate is being pushed across a level floor at a constant speed by a force **F** of 300 N at an angle of 20.0° below the horizontal as shown in Figure P4.37a. (a) What is the coefficient of kinetic friction between the crate and the floor? (b) If the 300-N force is instead pulling the block at an angle of 20.0° above the horizontal as shown in Figure P4.37b, what will be the acceleration of the crate? Assume that the coefficient of friction is the same as found in (a).

3.10 A hockey puck is hit on a frozen lake and starts moving with a speed of 12.0 m/s. Five seconds later, its speed is 6.00 m/s. (a) What is its average acceleration? (b) What is the average value of the coefficient of kinetic friction between puck and ice? (c) How far does the puck travel during this 5.00-s interval?
3.11 A box of books weighing 300 N is shoved across the floor of an apartment by a force of 400 N exerted downward at an angle of 35.2° below the horizontal. If the coefficient of kinetic friction between box and floor is 0.570, how long does it take to move the box 4.00 m, starting from rest?
3.12 An object falling under the pull of gravity experiences a frictional force of air resistance. The magnitude of this force is approximately proportional to the speed of the object, $f = bv$. Assume that b = 15 kg/s and m = 50 kg. (a) What is the terminal speed that the object reaches while falling? (b) Does your answer to part (a) depend on the initial speed of the object? Explain.
3.13 A girl coasts down a hill on a sled, reaching a level surface at the bottom with a speed of 7.0 m/s. If the coefficient of friction between runners and snow is 0.050 and the girl and sled together weigh 600 N, how far does the sled travel on the level surface before coming to rest?
3.14 (a) What is the minimum force of friction required to hold the system of Figure P4.58 in equilibrium? (b) What coefficient of static friction between the 100-N block and the table ensures equilibrium? (c) If the coefficient of kinetic friction between the 100-N block and the table is 0.250, what hanging weight should replace the 50.0-N weight to allow the system to move at a constant speed once it is set in motion?



3.15 A frictionless plane is 10.0 m long and inclined at 35.0°. A sled starts at the bottom with an initial speed of 5.00 m/s up the incline. When it reaches the point at which it momentarily stops, a second sled is released from the top of this incline with an initial speed v_i. Both sleds reach the bottom of the incline at the same moment. (a) Determine the distance that the first sled traveled up the incline. (b) Determine the initial speed of the second sled.
3.16 Three objects are connected by light strings as shown in Figure P4.62. The string connecting the 4.00-kg object and the 5.00-kg object passes over a light frictionless pulley. Determine (a) the acceleration of each object and (b) the tension in the two strings.

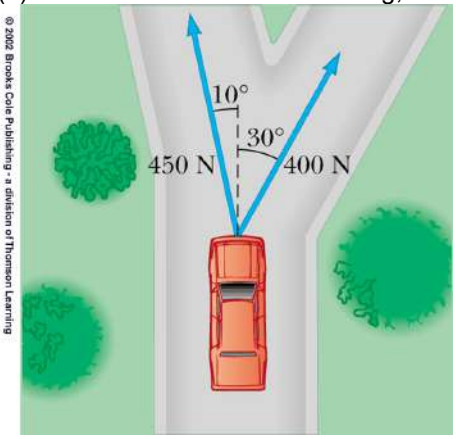
3.17 Two boxes of fruit on a frictionless horizontal surface are connected by a light string as in Figure P4.65, where m_1 = 10 kg and m_2 = 20 kg. A force of 50 N is applied to the 20-kg box. (a) Determine the acceleration of each box and the tension in the string. (b) Repeat the problem for the case where a coefficient of kinetic friction between each box and the surface is 0.10.



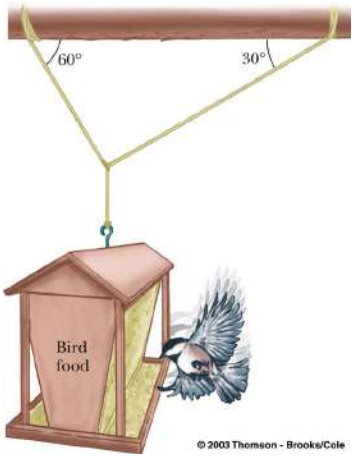
3.18 A high diver of mass 70.0 kg jumps off a board 10.0 m above the water. If his downward motion is stopped 2.00 s after he enters the water, what average upward force did the water exert on him?
3.19 An 80-kg stuntman jumps from the top of a building 30 m above a catching net. Assuming that air resistance exerts a 100-N force on the stuntman as he falls, determine his velocity just before he hits the net.
3.20 The parachute on a race car of weight 8800 N opens at the end of a quarter-mile run when the car is traveling at 35 m/s. What total retarding force must be supplied by the parachute to stop the car in a distance of 1000 m?

Practice Problems

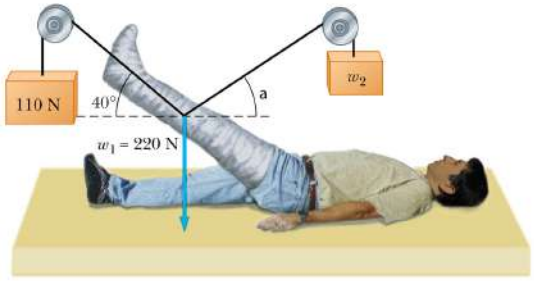
1. A bag of sugar weighs 5.00 lb on Earth. What should it weigh in newtons on the Moon, where the free-fall acceleration is 1/6 that on Earth? Repeat for Jupiter, where *g* is 2.64 times that on Earth. Find the mass of the bag of sugar in kilograms at each of the three locations.
2. A freight train has a mass of 1.5 x 10^7 kg. If the locomotive can exert a constant pull of 7.5 x 10^5 N, how long does it take to increase the speed of the train from rest to 80 km/h?
3. A boat moves through the water with two forces acting on it. One is a 2000-N forward push by the water on the propeller, and the other is an 1800-N resistive force due to the water around the bow. (a) What is the acceleration of the 1000-kg boat? (b) If it starts from rest, how far will it move in 10.0 s? (c) What will its velocity be at the end of this time?
4. Two forces are applied to a car in an effort to move it, as shown in Figure P4.12. (a) What is the resultant of these two forces? (b) If the car has a mass of 3000 kg, what acceleration does it have? Ignore friction.



5. A 150-N bird feeder is supported by three cables as shown in Figure P4.17. Find the tension in each cable.



6. The leg and cast in Figure P4.18 weigh 220 N (w_1). Determine the weight w_2 and the angle α needed so that no force is exerted on the hip joint by the leg plus cast.

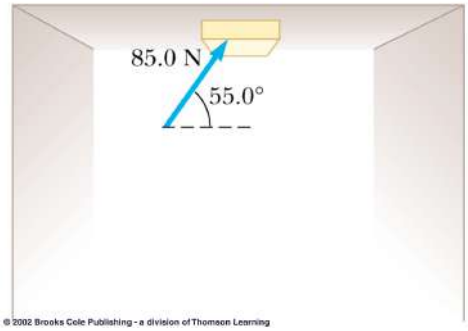


7. You are a judge in a children's kite-flying contest, and two children will win prizes for the kites that pull most strongly and least strongly on their strings. To measure string tensions, you borrow a weight hanger, some slotted weights, and a protractor from your physics teacher, and use the following protocol, illustrated in Figure P4.22: Wait for a child to get her kite well controlled, hook the hanger onto the kite string about 30 cm from her hand, pile on weight until that section of string is horizontal, record the mass required, and record the angle between the horizontal and the string running up to the kite. (a) Explain how this method works. As you construct your explanation, imagine that the children's parents ask you about your method, that they might make false assumptions about your ability without concrete evidence, and that your explanation is an opportunity to give them confidence in your evaluation technique. (b) Find the string tension if the mass is 132 g and the angle is 46.3°.

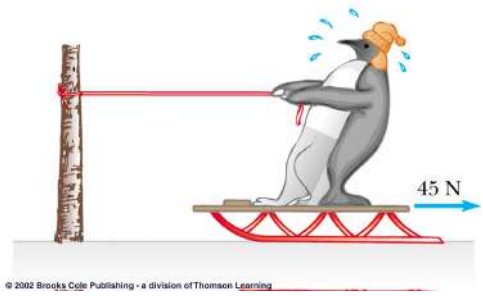
8. A 5.0-kg bucket of water is raised from a well by a rope. If the upward acceleration of the bucket is 3.0 m/s^2, find the force exerted by the rope on the bucket.

9. A woman at an airport is towing her 20.0-kg suitcase at constant speed by pulling on a strap at an angle of θ above the horizontal (Fig. P4.40). She pulls on the strap with a 35.0-N force, and the friction force on the suitcase is 20.0 N. Draw a free-body diagram of the suitcase. (a) What angle does the strap make with the horizontal? (b) What normal force does the ground exert on the suitcase?

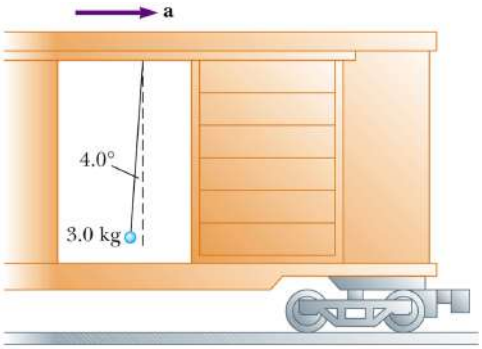
10. The coefficient of static friction between the 3.00-kg crate and the 35.0° incline of Figure P4.41 is 0.300. What mini-mum force **F** must be applied to the crate perpendicular to the incline to prevent the crate from sliding down the incline?
11. A student decides to move a box of books into her dormitory room by pulling on a rope attached to the box. She pulls with a force of 80.0 N at an angle of 25.0° above the horizontal. The box has a mass of 25.0 kg, and the coefficient of kinetic friction between box and floor is 0.300. (a) Find the acceleration of the box. (b) The student now starts moving the box up a 10.0° incline, keeping her 80.0-N force directed at 25.0° above the line of the incline. If the coefficient of friction is unchanged, what is the new acceleration of the box?
12. A car is traveling at 50.0 km/h on a flat highway. (a) If the coefficient of friction between road and tires on a rainy day is 0.100, what is the minimum distance in which the car will stop? (b) What is the stopping distance when the surface is dry and the coefficient of friction is 0.600?
13. A box rests on the back of a truck. The coefficient of static friction between box and truck bed is 0.300. (a) When the truck accelerates forward, what force accelerates the box? (b) Find the maximum acceleration the truck can have before the box slides.
14. A 4.00-kg block is pushed along the ceiling with a constant applied force of 85.0 N that acts at an angle of 55.0° with the horizontal, as in Figure P4.60. The block accelerates to the right at 6.00 m/s^2. Determine the coefficient of kinetic friction between block and ceiling.



15. A 3.00-kg block starts from rest at the top of a 30.0° incline and slides 2.00 m down the incline in 1.50 s. Find (a) the acceleration of the block, (b) the coefficient of kinetic friction between it and the incline, (c) the frictional force acting on the block, and (d) the speed of the block after it has slid 2.00 m.
16. A 5.0-kg penguin sits on a 10-kg sled, as in Figure P4.64. A horizontal force of 45 N is applied to the sled, but the penguin attempts to impede the motion by holding onto a cord attached to a wall. The coefficient of kinetic friction between the sled and snow as well as that between the sled and the penguin is 0.20. (a) Draw a free-body diagram for the penguin and one for the sled, and identify the reaction force for each force you include. Determine (b) the tension in the cord and, (c) the acceleration of the sled.



17. Two people pull as hard as they can on ropes attached to a 200-kg boat. If they pull in the same direction, the boat has an acceleration of 1.52 m/s^2 to the right. If they pull in opposite directions, the boat has an acceleration of 0.518 m/s^2 to the left. What is the force exerted by each person on the boat? (Disregard any other forces on the boat.)
18. A 3.0-kg object hangs at one end of a rope that is attached to a support on a railroad car. When the car accelerates to the right, the rope makes an angle of 4.0° with the vertical, as shown in Figure P4.68. Find the acceleration of the car.



19. On takeoff, the combined action of the air around the engines and wings of an airplane exerts an 8000-N force on the plane, directed upward at an angle of 65.0° above the horizontal. The plane rises with constant velocity in the vertical direction while continuing to accelerate in the horizontal direction. (a) What is the weight of the plane? (b) What is its horizontal acceleration?
20. A 72-kg man stands on a spring scale in an elevator. Starting from rest, the elevator ascends, attaining its maximum speed of 1.2 m/s in 0.80 s. It travels with this constant