6.E: Newton's Laws of Motion (Exercises)

Conceptual Questions

5.1 Forces

1. What properties do forces have that allow us to classify them as vectors?

5.2 Newton's First Law

2. Taking a frame attached to Earth as inertial, which of the following objects cannot have inertial frames attached to them, and which are inertial reference frames?
   a. A car moving at constant velocity
   b. A car that is accelerating
   c. An elevator in free fall
   d. A space capsule orbiting Earth
   e. An elevator descending uniformly
3. A woman was transporting an open box of cupcakes to a school party. The car in front of her stopped suddenly; she applied her brakes immediately. She was wearing her seat belt and suffered no physical harm (just a great deal of embarrassment), but the cupcakes flew into the dashboard and became “smushcakes.” Explain what happened.

5.3 Newton's Second Law

4. Why can we neglect forces such as those holding a body together when we apply Newton’s second law?
5. A rock is thrown straight up. At the top of the trajectory, the velocity is momentarily zero. Does this imply that the force acting on the object is zero? Explain your answer.

5.4 Mass and Weight

6. What is the relationship between weight and mass? Which is an intrinsic, unchanging property of a body?
7. How much does a 70-kg astronaut weight in space, far from any celestial body? What is her mass at this location?
8. Which of the following statements is accurate?
   a. Mass and weight are the same thing expressed in different units.
   b. If an object has no weight, it must have no mass.
   c. If the weight of an object varies, so must the mass.
   d. Mass and inertia are different concepts.
   e. Weight is always proportional to mass.
9. When you stand on Earth, your feet push against it with a force equal to your weight. Why doesn’t Earth accelerate away from you?
10. How would you give the value of $\vec{g}$ in vector form?

5.5 Newton’s Third Law

11. Identify the action and reaction forces in the following situations:
   a. Earth attracts the Moon,
   b. a boy kicks a football,
   c. a rocket accelerates upward,
   d. a car accelerates forward,
   e. a high jumper leaps, and
   f. a bullet is shot from a gun.
12. Suppose that you are holding a cup of coffee in your hand. Identify all forces on the cup and the reaction to each force.
13. (a) Why does an ordinary rifle recoil (kick backward) when fired? (b) The barrel of a recoilless rifle is open at both ends. Describe how Newton’s third law applies when one is fired. (c) Can you safely stand close behind one when it is fired?

5.6 Common Forces

14. A table is placed on a rug. Then a book is placed on the table. What does the floor exert a normal force on?

15. A particle is moving to the right. (a) Can the force on it to be acting to the left? If yes, what would happen? (b) Can that force be acting downward? If yes, why?

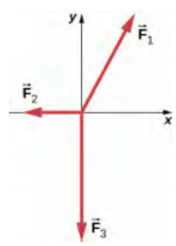
5.7 Drawing Free-Body Diagrams

16. In completing the solution for a problem involving forces, what do we do after constructing the free-body diagram? That is, what do we apply?
17. If a book is located on a table, how many forces should be shown in a free-body diagram of the book? Describe them.
18. If the book in the previous question is in free fall, how many forces should be shown in a free-body diagram of the book? Describe them.

Problems

5.1 Forces

19. Two ropes are attached to a tree, and forces of $\vec{F}_1 = 2.0\,\hat{i} + 4.0\,\hat{j}$ N and $\vec{F}_2 = 3.0\,\hat{i} + 6.0\,\hat{j}$ N are applied. The forces are coplanar (in the same plane). (a) What is the resultant (net force) of these two force vectors? (b) Find the magnitude and direction of this net force.
20. A telephone pole has three cables pulling as shown from above, with $\vec{F}_1 = (300.0\,\hat{i} + 500.0\,\hat{j})$, $\vec{F}_2 = -200.0\,\hat{i}$, and $\vec{F}_3 = -800.0\,\hat{j}$. (a) Find the net force on the telephone pole in component form. (b) Find the magnitude and direction of this net force.



21. Two teenagers are pulling on ropes attached to a tree. The angle between the ropes is 30.0°. David pulls with a force of 400.0 N and Stephanie pulls with a force of 300.0 N. (a) Find the component form of the net force. (b) Find the magnitude of the resultant (net) force on the tree and the angle it makes with David's rope.

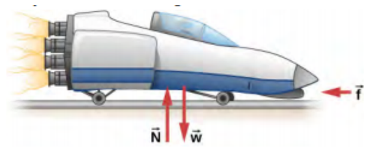
5.2 Newton's First Law

22. Two forces of $\vec{F}_1 = 75.0\ 2\,(\hat{i} - \hat{j})$ N and $\vec{F}_2 = \frac{150.0}{\sqrt{2}}(\hat{i} - \hat{j})$ N act on an object. Find the third force $\vec{F}_3$ that is needed to balance the first two forces.
23. While sliding a couch across a floor, Andrea and Jennifer exert forces $\vec{F}_A$ and $\vec{F}_J$ on the couch. Andrea's force is due north with a magnitude of 130.0 N and Jennifer's force is 32° east of north with a magnitude of 180.0 N. (a) Find the net force in component form. (b) Find the magnitude and direction of the net force. (c) If Andrea and Jennifer's housemates, David and Stephanie, disagree with the move and want to prevent its relocation, with what combined force $\vec{F}_{DS}$ should they push so that the couch does not move?

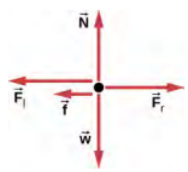
5.3 Newton's Second Law

24. Andrea, a 63.0-kg sprinter, starts a race with an acceleration of 4.200 m/s^2. What is the net external force on her?
25. If the sprinter from the previous problem accelerates at that rate for 20.00 m and then maintains that velocity for the remainder of a 100.00-m dash, what will her time be for the race?
26. A cleaner pushes a 4.50-kg laundry cart in such a way that the net external force on it is 60.0 N. Calculate the magnitude of his cart's acceleration.
27. Astronauts in orbit are apparently weightless. This means that a clever method of measuring the mass of astronauts is needed to monitor their mass gains or losses, and adjust their diet. One way to do this is to exert a known force on an astronaut and measure the acceleration produced. Suppose a net external force of 50.0 N is exerted, and an astronaut's acceleration is measured to be 0.893 m/s^2. (a) Calculate her mass. (b) By exerting a force on the astronaut, the vehicle in which she orbits experiences an equal and opposite force. Use this knowledge to find an equation for the acceleration of the system (astronaut and spaceship) that would be measured by a nearby observer. (c) Discuss how this would affect the measurement of the astronaut's acceleration. Propose a method by which recoil of the vehicle is avoided.

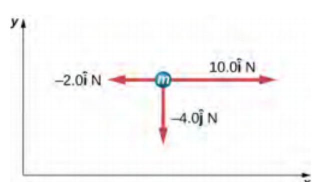
28. In Figure 5.4.3, the net external force on the 24-kg mower is given as 51 N. If the force of friction opposing the motion is 24 N, what force F (in newtons) is the person exerting on the mower? Suppose the mower is moving at 1.5 m/s when the force F is removed. How far will the mower go before stopping?
29. The rocket sled shown below decelerates at a rate of 196 m/s^2. What force is necessary to produce this deceleration? Assume that the rockets are off. The mass of the system is 2.10 x 10^3 kg.



30. If the rocket sled shown in the previous problem starts with only one rocket burning, what is the magnitude of this acceleration? Assume that the mass of the system is 2.10 x 10^3 kg, the thrust T is 2.40 x 10^4 N, and the force of friction opposing the motion is 650.0 N. (b) Why is the acceleration not one-fourth of what it is with all rockets burning?
31. What is the deceleration of the rocket sled if it comes to rest in 1.10 s from a speed of 1000.0 km/h? (Such deceleration caused one test subject to black out and have temporary blindness.)
32. Suppose two children push horizontally, but in exactly opposite directions, on a third child in a wagon. The first child exerts a force of 75.0 N, the second exerts a force of 90.0 N, friction is 12.0 N, and the mass of the third child plus wagon is 23.0 kg. (a) What is the system of interest if the acceleration of the child in the wagon is to be calculated? (See the free-body diagram.) (b) Calculate the acceleration. (c) What would the acceleration be if friction were 15.0 N?



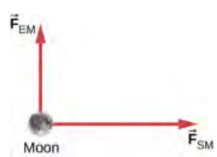
33. A powerful motorcycle can produce an acceleration of 3.50 m/s^2 while traveling at 90.0 km/h. At that speed, the forces resisting motion, including friction and air resistance, total 400.0 N. (Air resistance is analogous to air friction. It always opposes the motion of an object.) What is the magnitude of the force that motorcycle exerts backward on the ground to produce its acceleration if the mass of the motorcycle with rider is 245 kg?
34. A car with a mass of 1000.0 kg accelerates from 0 to 90.0 km/h in 10.0 s. (a) What is its acceleration? (b) What is the net force on the car?
35. The driver in the previous problem applies the brakes when the car is moving at 90.0 km/h, and the car comes to rest after traveling 40.0 m. What is the net force on the car during its deceleration?
36. An 80.0-kg passenger in an SUV traveling at 1.00 x 10^2 km/h is wearing a seat belt. The driver slams on the brakes and the SUV stops in 45.0 m. Find the force of the seat belt on the passenger.
37. A particle of mass 2.0 kg is acted on by a single force $\vec{F}_1 = 18\ \hat{i}$ N. (a) What is the particle's acceleration? (b) If the particle starts at rest, how far does it travel in the first 5.0 s?
38. Suppose that the particle of the previous problem also experiences forces $\vec{F}_2 = -15\ \hat{i}$ N and $\vec{F}_3 = 6.0\ \hat{j}$ N. What is its acceleration in this case?
39. Find the acceleration of the body of mass 5.0 kg shown below.



40. In the following figure, the horizontal surface on which this block slides is frictionless. If the two forces acting on it each have magnitude F = 30.0 N and M = 10.0 kg , what is the magnitude of the resulting acceleration of the block?

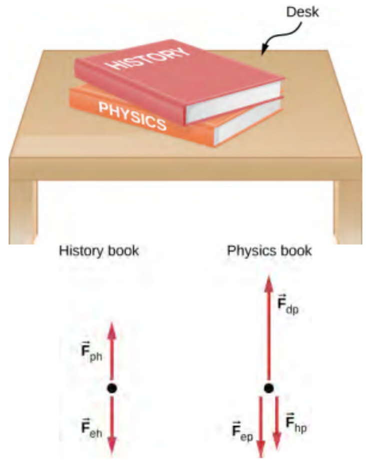
5.4 Mass and Weight

41. The weight of an astronaut plus his space suit on the Moon is only 250 N. (a) How much does the suited astronaut weigh on Earth? (b) What is the mass on the Moon? On Earth?
42. Suppose the mass of a fully loaded module in which astronauts take off from the Moon is 1.00 x 10^4 kg. The thrust of its engines is 3.00 x 10^4 N. (a) Calculate the module's magnitude of acceleration in a vertical takeoff from the Moon. (b) Could it lift off from Earth? If not, why not? If it could, calculate the magnitude of its acceleration.
43. A rocket sled accelerates at a rate of 49.0 m/s^2. Its passenger has a mass of 75.0 kg. (a) Calculate the horizontal component of the force the seat exerts against his body. Compare this with his weight using a ratio. (b) Calculate the direction and magnitude of the total force the seat exerts against his body.
44. Repeat the previous problem for a situation in which the rocket sled decelerates at a rate of 201 m/s^2. In this problem, the forces are exerted by the seat and the seat belt.
45. A body of mass 2.00 kg is pushed straight upward by a 25.0 N vertical force. What is its acceleration?
46. A car weighing 12,500 N starts from rest and accelerates to 83.0 km/h in 5.00 s. The friction force is 1350 N. Find the applied force produced by the engine.
47. A body with a mass of 10.0 kg is assumed to be in Earth's gravitational field with g = 9.80 m/s^2. What is the net force on the body if there are no other external forces acting on the object?
48. A fireman has mass m; he hears the fire alarm and slides down the pole with acceleration a (which is less than g in magnitude). (a) Write an equation giving the vertical force he must apply to the pole. (b) If his mass is 90.0 kg and he accelerates at 5.00 m/s^2, what is the magnitude of his applied force?
49. A baseball catcher is performing a stunt for a television commercial. He will catch a baseball (mass 145 g) dropped from a height of 60.0 m above his glove. His glove stops the ball in 0.0100 s. What is the force exerted by his glove on the ball?
50. When the Moon is directly overhead at sunset, the force by Earth on the Moon, F_{EM}, is essentially at 90° to the force by the Sun on the Moon, F_{SM}, as shown below. Given that F_{EM} = 1.98 x 10^{20} N and F_{SM} = 4.36 x 10^{20} N, all other forces on the Moon are negligible, and the mass of the Moon is 7.35 x 10^{22} kg, determine the magnitude of the Moon's acceleration.



5.5 Newton's Third Law

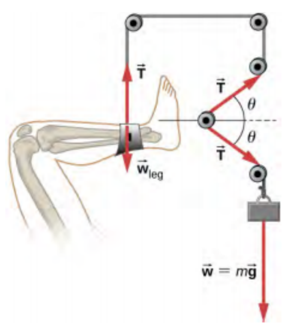
51. (a) What net external force is exerted on a 1100.0-kg artillery shell fired from a battleship if the shell is accelerated at 2.40 x 10^4 m/s^2? (b) What is the magnitude of the force exerted on the ship by the artillery shell, and why?
52. A brave but inadequate rugby player is being pushed backward by an opposing player who is exerting a force of 800.0 N on him. The mass of the losing player plus equipment is 90.0 kg, and he is accelerating backward at 1.20 m/s^2. (a) What is the force of friction between the losing player's feet and the grass? (b) What force does the winning player exert on the ground to move forward if his mass plus equipment is 110.0 kg?
53. A history book is lying on top of a physics book on a desk, as shown below; a free-body diagram is also shown. The history and physics books weigh 14 N and 18 N, respectively. Identify each force on each book with a double subscript notation (for instance, the contact force of the history book pressing against physics book can be described as $\vec{F}_{HP}$), and determine the value of each of these forces, explaining the process used.



54. A truck collides with a car, and during the collision, the net force on each vehicle is essentially the force exerted by the other. Suppose the mass of the car is 550 kg, the mass of the truck is 2200 kg, and the magnitude of the truck's acceleration is 10 m/s^2. Find the magnitude of the car's acceleration.

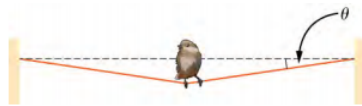
5.6 Common Forces

55. A leg is suspended in a traction system, as shown below. (a) Which part of the figure is used to calculate the force exerted on the foot? (b) What is the tension in the rope? Here $\vec{T}$ is the tension, $\vec{w}_{leg}$ is the weight of the leg, and $\vec{w}$ is the weight of the load that provides the tension.

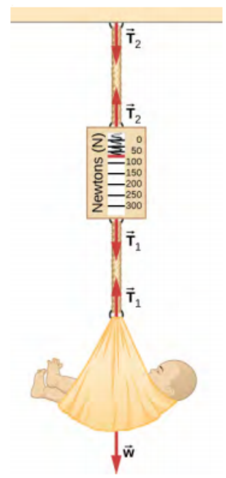


56. Suppose the shinbone in the preceding image was a femur in a traction setup for a broken bone, with pulleys and rope available. How might we be able to increase the force along the femur using the same weight?
57. A team of nine members on a tall building tug on a string attached to a large boulder on an icy surface. The boulder has a mass of 200 kg and is tugged with a force of 2350 N. (a) What is magnitude of the acceleration? (b) What force would be required to produce a constant velocity?
58. What force does a trampoline have to apply to Jennifer, a 45.0-kg gymnast, to accelerate her straight up at 7.50 m/s^2? The answer is independent of the velocity of the gymnast—she can be moving up or down or can be instantly stationary.
59. (a) Calculate the tension in a vertical strand of spider web if a spider of mass 2.00 x 10^{-5} kg hangs motionless on it. (b) Calculate the tension in a horizontal strand of spider web if the same spider sits motionless in the middle of it much like the tightrope walker in Figure 5.26. The strand sags at an angle of 12° below the horizontal. Compare this with the tension in the vertical strand (find their ratio).
60. Suppose Kevin, a 60.0-kg gymnast, climbs a rope. (a) What is the tension in the rope if he climbs at a constant speed? (b) What is the tension in the rope if he accelerates upward at a rate of 1.50 m/s^2?
61. Show that, as explained in the text, a force $F_\perp$ exerted on a flexible medium at its center and perpendicular to its length (such as on the tightrope wire in Figure 5.26) gives rise to a tension of magnitude $T = \frac{F_\perp}{2\sin\theta}$.
62. Consider Figure 5.28. The driver attempts to get the car out of the mud by exerting a perpendicular force of 610.0 N, and the distance she pushes in the middle of the rope is 1.00 m while she stands 6.00 m away from the car on the left and 6.00 m away from the tree on the right. What is the tension T in the rope, and how do you find the answer?
63. A bird has a mass of 26 g and perches in the middle of a stretched telephone line. (a) Show that the tension in the line can be calculated using the equation $T = \frac{mg}{2\sin\theta}$. Determine the tension when (b) θ = 5° and (c) θ = 0.5°. Assume that each

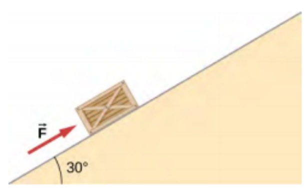
half of the line is straight.



64. One end of a 30-m rope is tied to a tree; the other end is tied to a car stuck in the mud. The motorist pulls sideways on the midpoint of the rope, displacing it a distance of 2 m. If he exerts a force of 80 N under these conditions, determine the force exerted on the car.
65. Consider the baby being weighed in the following figure. (a) What is the mass of the infant and basket if a scale reading of 55 N is observed? (b) What is tension T_1 in the cord attaching the baby to the scale? (c) What is tension T_2 in the cord attaching the scale to the ceiling, if the scale has a mass of 0.500 kg? (d) Sketch the situation, indicating the system of interest used to solve each part. The masses of the cords are negligible.



66. What force must be applied to a 100.0-kg crate on a frictionless plane inclined at 30° to cause an acceleration of 2.0 m/s^2 up the plane?

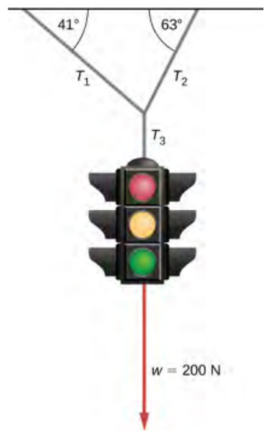


67. A 2.0-kg block is on a perfectly smooth ramp that makes an angle of 30° with the horizontal. (a) What is the block's acceleration down the ramp and the force of the ramp on the block? (b) What force applied upward along and parallel to the ramp would allow the block to move with constant velocity?

5.7 Drawing Free-Body Diagrams

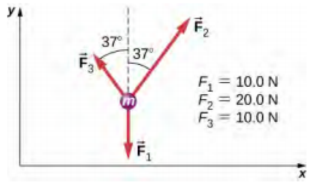
68. A ball of mass m hangs at rest, suspended by a string. (a) Sketch all forces. (b) Draw the free-body diagram for the ball.
69. A car moves along a horizontal road. Draw a free-body diagram; be sure to include the friction of the road that opposes the forward motion of the car.
70. A runner pushes against the track, as shown. (a) Provide a free-body diagram showing all the forces on the runner. (**Hint**: Place all forces at the center of his body, and include his weight.) (b) Give a revised diagram showing the xy-component form.

71. The traffic light hangs from the cables as shown. Draw a free-body diagram on a coordinate plane for this situation.

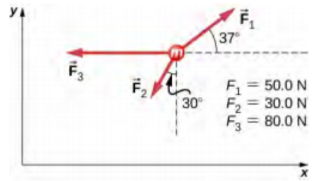


Additional Problems

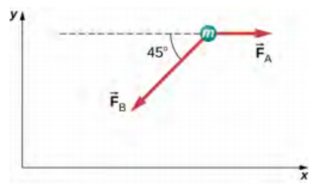
72. Two small forces, $\vec{F}_1 = -2.40\ \hat{i} - 6.10t\ \hat{j}$ N and $\vec{F}_2 = 8.50\ \hat{i} - 9.70\ \hat{j}$ N, are exerted on a rogue asteroid by a pair of space tractors. (a) Find the net force. (b) What are the magnitude and direction of the net force? (c) If the mass of the asteroid is 125 kg, what acceleration does it experience (in vector form)? (d) What are the magnitude and direction of the acceleration?
73. Two forces of 25 and 45 N act on an object. Their directions differ by 70°. The resulting acceleration has magnitude of 10.0 m/s^2. What is the mass of the body?
74. A force of 1600 N acts parallel to a ramp to push a 300-kg piano into a moving van. The ramp is inclined at 20°. (a) What is the acceleration of the piano up the ramp? (b) What is the velocity of the piano when it reaches the top if the ramp is 4.0 m long and the piano starts from rest?
75. Draw a free-body diagram of a diver who has entered the water, moved downward, and is acted on by an upward force due to the water which balances the weight (that is, the diver is suspended).
76. For a swimmer who has just jumped off a diving board, assume air resistance is negligible. The swimmer has a mass of 80.0 kg and jumps off a board 10.0 m above the water. Three seconds after entering the water, her downward motion is stopped. What average upward force did the water exert on her?
77. (a) Find an equation to determine the magnitude of the net force required to stop a car of mass m, given that the initial speed of the car is v_0 and the stopping distance is x. (b) Find the magnitude of the net force if the mass of the car is 1050 kg, the initial speed is 40.0 km/h, and the stopping distance is 25.0 m.
78. A sailboat has a mass of 1.50 x 10^3 kg and is acted on by a force of 2.00 x 10^3 N toward the east, while the wind acts behind the sails with a force of 3.00 x 10^3 N in a direction 45° north of east. Find the magnitude and direction of the resulting acceleration.
79. Find the acceleration of the body of mass 10.0 kg shown below.



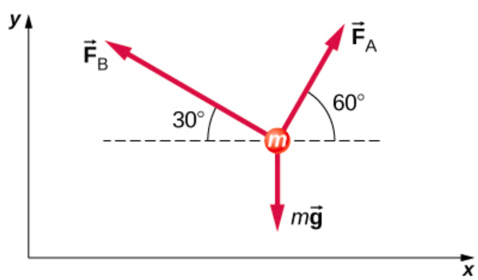
80. A body of mass 2.0 kg is moving along the x-axis with a speed of 3.0 m/s at the instant represented below. (a) What is the acceleration of the body? (b) What is the body's velocity 10.0 s later? (c) What is its displacement after 10.0 s?



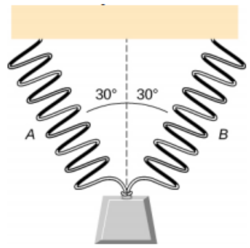
81. Force $\vec{F}_B$ has twice the magnitude of force $\vec{F}_A$. Find the direction in which the particle accelerates in this figure.



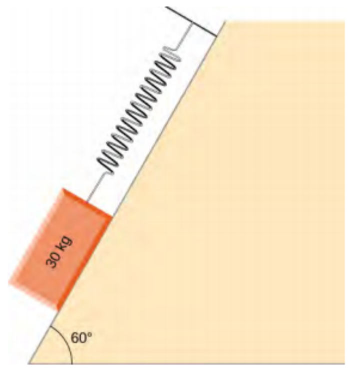
82. Shown below is a body of mass 1.0 kg under the influence of the forces $\vec{F}_A$, $\vec{F}_B$, and m$\vec{g}$. If the body accelerates to the left at 20 m/s^2, what are $\vec{F}_A$ and $\vec{F}_B$?



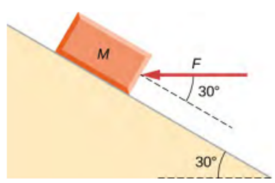
83. A force acts on a car of mass m so that the speed v of the car increases with position x as $v = kx^2$, where k is constant and all quantities are in SI units. Find the force acting on the car as a function of position.
84. A 7.0-N force parallel to an incline is applied to a 1.0-kg crate. The ramp is tilted at 20° and is frictionless. (a) What is the acceleration of the crate? (b) If all other conditions are the same but the ramp has a friction force of 1.9 N, what is the acceleration?
85. Two boxes, A and B, are at rest. Box A is on level ground, while box B rests on an inclined plane tilted at angle θ with the horizontal. (a) Write expressions for the normal force acting on each block. (b) Compare the two forces; that is, tell which one is larger or whether they are equal in magnitude. (c) If the angle of incline is 10°, which force is greater?
86. A mass of 250.0 g is suspended from a spring hanging vertically. The spring stretches 6.00 cm. How much will the spring stretch if the suspended mass is 530.0 g?
87. As shown below, two identical springs, each with the spring constant 20 N/m, support a 15.0-N weight. (a) What is the tension in spring A? (b) What is the amount of stretch of spring A from the rest position?



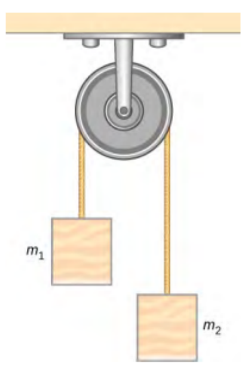
88. Shown below is a 30.0-kg block resting on a frictionless ramp inclined at 60° to the horizontal. The block is held by a spring that is stretched 5.0 cm. What is the force constant of the spring?



89. In building a house, carpenters use nails from a large box. The box is suspended from a spring twice during the day to measure the usage of nails. At the beginning of the day, the spring stretches 50 cm. At the end of the day, the spring stretches 30 cm. What fraction or percentage of the nails have been used?
90. A force is applied to a block to move it up a 30° incline. The incline is frictionless. If F = 65.0 N and M = 5.00 kg, what is the magnitude of the acceleration of the block?

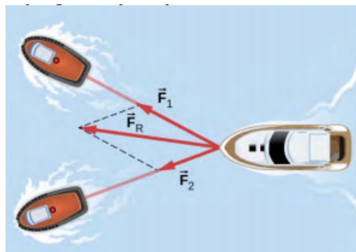


91. Two forces are applied to a 5.0-kg object, and it accelerates at a rate of 2.0 m/s^2 in the positive y-direction. If one of the forces acts in the positive x-direction with magnitude 12.0 N, find the magnitude of the other force.
92. The block on the right shown below has more mass than the block on the left ($m_2 > m_1$). Draw free-body diagrams for each block.



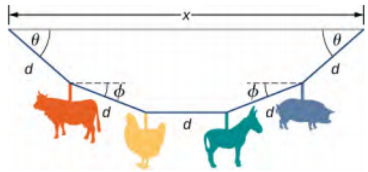
Challenge Problems

93. If two tugboats pull on a disabled vessel, as shown here in an overhead view, the disabled vessel will be pulled along the direction indicated by the result of the exerted forces. (a) Draw a free-body diagram for the vessel. Assume no friction or drag forces affect the vessel. (b) Did you include all forces in the overhead view in your free-body diagram? Why or why not?



94. A 10.0-kg object is initially moving east at 15.0 m/s. Then a force acts on it for 2.00 s, after which it moves northwest, also at 15.0 m/s. What are the magnitude and direction of the average force that acted on the object over the 2.00-s interval?
95. On June 25, 1983, shot-putter Udo Beyer of East Germany threw the 7.26-kg shot 22.22 m, which at that time was a world record. (a) If the shot was released at a height of 2.20 m with a projection angle of 45.0°, what was its initial velocity? (b) If while in Beyer's hand the shot was accelerated uniformly over a distance of 1.20 m, what was the net force on it?
96. A body of mass m moves in a horizontal direction such that at time t its position is given by $x(t) = at^4 + bt^3 + ct$, where a, b, and c are constants. (a) What is the acceleration of the body? (b) What is the time-dependent force acting on the body?
97. A body of mass m has initial velocity v_0 in the positive x-direction. It is acted on by a constant force F for time t until the velocity becomes zero; the force continues to act on the body until its velocity becomes $-v_0$ in the same amount of time. Write an expression for the total distance the body travels in terms of the variables indicated.
98. The velocities of a 3.0-kg object at t = 6.0 s and t = 8.0 s are $(3.0\,\hat{i} - 6.0\,\hat{j} + 4.0\,\hat{k})$ m/s and $(-2.0\,\hat{i} + 4.0\,\hat{k})$ m/s, respectively. If the object is moving at constant acceleration, what is the force acting on it?
99. A 120-kg astronaut is riding in a rocket sled that is sliding along an inclined plane. The sled has a horizontal component of acceleration of 5.0 m/s^2 and a downward component of 3.8 m/s^2. Calculate the magnitude of the force on the rider by the sled. (**Hint**: Remember that gravitational acceleration must be considered.)
100. Two forces are acting on a 5.0-kg object that moves with acceleration 2.0 m/s^2 in the positive y-direction. If one of the forces acts in the positive x-direction and has magnitude of 12 N, what is the magnitude of the other force?
101. Suppose that you are viewing a soccer game from a helicopter above the playing field. Two soccer players simultaneously kick a stationary soccer ball on the flat field; the soccer ball has mass 0.420 kg. The first player kicks with force 162 N at 9.0° north of west. At the same instant, the second player kicks with force 215 N at 15° east of south. Find the acceleration of the ball in $\hat{i}$ and $\hat{j}$ form.
102. A 10.0-kg mass hangs from a spring that has the spring constant 535 N/m. Find the position of the end of the spring away from its rest position. (Use g = 9.80 m/s^2.)
103. A 0.0502-kg pair of fuzzy dice is attached to the rearview mirror of a car by a short string. The car accelerates at constant rate, and the dice hang at an angle of 3.20° from the vertical because of the car's acceleration. What is the magnitude of the acceleration of the car?
104. At a circus, a donkey pulls on a sled carrying a small clown with a force given by $2.48\,\hat{i} + 4.33\,\hat{j}$ N . A horse pulls on the same sled, aiding the hapless donkey, with a force of $6.56\,\hat{i} + 5.33\,\hat{j}$ N. The mass of the sled is 575 kg. Using $\hat{i}$ and $\hat{j}$ form for the answer to each problem, find (a) the net force on the sled when the two animals act together, (b) the acceleration of the sled, and (c) the velocity after 6.50 s.
105. Hanging from the ceiling over a baby bed, well out of baby's reach, is a string with plastic shapes, as shown here. The string is taut (there is no slack), as shown by the straight segments. Each plastic shape has the same mass m, and they are equally spaced by a distance d, as shown. The angles labeled θ describe the angle formed by the end of the string and the ceiling at each end. The center length of sting is horizontal. The remaining two segments each form an angle with the horizontal, labeled ϕ. Let T_1 be the tension in the leftmost section of the string, T_2 be the tension in the section adjacent to it, and T_3 be the tension in the horizontal segment. (a) Find an equation for the tension in each section of the string in

terms of the variables m, g, and θ. (b) Find the angle ϕ in terms of the angle θ. (c) If θ = 5.10°, what is the value of ϕ? (d) Find the distance x between the endpoints in terms of d and θ.



106. A bullet shot from a rifle has mass of 10.0 g and travels to the right at 350 m/s. It strikes a target, a large bag of sand, penetrating it a distance of 34.0 cm. Find the magnitude and direction of the retarding force that slows and stops the bullet.
107. An object is acted on by three simultaneous forces: $\vec{F}_1$ =(−3.00 $\hat{i}$ + 2.00 $\hat{j}$) N, $\vec{F}_2$ = (6.00 $\hat{i}$ − 4.00 $\hat{i}$) N, and $\vec{F}_3$ = (2.00 $\hat{i}$ + 5.00 $\hat{i}$) N. The object experiences acceleration of 4.23 m/s^2. (a) Find the acceleration vector in terms of m. (b) Find the mass of the object. (c) If the object begins from rest, find its speed after 5.00 s. (d) Find the components of the velocity of the object after 5.00 s.
108. In a particle accelerator, a proton has mass 1.67 x 10^{-27} kg and an initial speed of 2.00 x 10^5 m/s. It moves in a straight line, and its speed increases to 9.00 x 10^5 m/s in a distance of 10.0 cm. Assume that the acceleration is constant. Find the magnitude of the force exerted on the proton.
109. A drone is being directed across a frictionless ice-covered lake. The mass of the drone is 1.50 kg, and its velocity is 3.00 $\hat{i}$ m/s. After 10.0 s, the velocity is 9.00 $\hat{i}$ + 4.00 $\hat{j}$ m/s. If a constant force in the horizontal direction is causing this change in motion, find (a) the components of the force and (b) the magnitude of the force.

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