End-of-Chapter Exercises

Exercises 1 – 12 are conceptual questions designed to see whether you understand the main concepts of the chapter.

1. Three identical objects are traveling north with identical speeds v. Each object experiences a collision, after which the states of motion are: Object A is at rest; object B is traveling south with a speed v; and object C is traveling east with a speed v. Rank these objects, from largest to smallest, based on the magnitude of the impulse they experienced during their collision.

2. Case 1: you run with speed v toward a wall and then stick to it because you and the wall are covered with Velcro. Case 2: you run with speed v toward a wall and bounce straight back at speed v because the wall is covering with an elastic material. If you assume that the time during which you experience an acceleration, because of the force applied by the wall, is the same in both cases, in which case do you experience a larger force?

3. You are driving down the road at high speed. All of a sudden, you see your evil twin, driving an identical car with an equal-and-opposite velocity to you. You both apply the brakes, but it is too late and a collision is imminent. At the last instant, you see a large immovable (completely rigid) object on the side of the road. Considering only the likelihood that you will survive the crash, is it better for you to hit your evil twin or to hit the immovable object? Briefly explain your answer.

4. As you are driving along the road, you hit a mosquito, squashing it on the windshield of your car. During the collision, which object (a) exerts a force of a larger magnitude on the other? (b) experiences a change in momentum of larger magnitude? (c) experiences a change in velocity of larger magnitude?

5. Must the center of mass of an object always be located at a point where the object has some mass? If it must, explain why. If not, give an example (or two) of objects where the center of mass is located at a point where none of the mass of the object is located.

6. (a) Give an example of an object (or system of objects) such that when you make a single straight cut through the center of mass the object (or system) is split into two parts with the same mass. (b) If possible, give an example of an object or system such that when you make a single straight cut through the center of mass the two parts have different masses.

7. Consider the following four cases, in which a net force is applied to an object initially moving in the $+x$ direction with a velocity of 5 m/s. Case 1: the object's mass is 1 kg, and a force of 10 N in the $+x$ direction is applied for 1 s. Case 2: the same as case 1 except the object's mass is 2 kg. Case 3: the same as case 1 except the force is in the $-x$ direction. Case 4: the same as case 1 except the magnitude of the force is 5 N. Rank the four cases from largest to smallest based on (a) the magnitude of the change in momentum the object experiences; (b) the magnitude of the object's final momentum; (c) the object's final speed; (d) the final kinetic energy of the object.

8. Cars have crumple zones that are designed to crumple and compress when your car is in a collision. In many cases after a collision, this crumpling means that the car is ruined and you have to buy a new one (preferably with the aid of a payment from your insurance company). Is the crumple zone a huge conspiracy on the part of the auto industry, or is it

an important safety feature? Briefly explain your answer, using concepts of impulse and momentum, or work and kinetic energy.

9. Two objects, A and B, are initially at rest. The mass of object B is two times larger than that of object A. Identical net forces are then applied to the two objects, making them accelerate. Each net force is removed once the object that it is applied to has moved through a distance d. After both net forces are removed, how do: (a) the kinetic energies compare? (b) the speeds compare? (c) the momenta compare?

10. Repeat Exercise 9, assuming that both net forces are removed after the same amount of time instead.

11. (a) Is it possible to apply a force to an object so that the object's momentum changes but its kinetic energy remains the same? If so, give an example. (b) Is it possible to apply a force to an object so that the object's kinetic energy changes but its momentum remains the same? If so, give an example.

12. Consider Exploration 6.6B, in which Andrea and Bob chose different points as the zero point of the ball's gravitational potential energy. Do Andrea and Bob agree or disagree about the following? The value of (a) the ball's initial gravitational potential energy? (b) the ball's final gravitational potential energy? (c) the ball's change in gravitational potential energy? (d) the work done by gravity on the ball?

Exercises 13 – 18 deal with momentum and impulse.

13. Three identical objects are traveling north with identical speeds v. Each object experiences a collision, after which the states of motion are: Object A is at rest; object B is traveling south with a speed v; and object C is traveling east with a speed v. If the mass of each object is 40 kg and $v = 12$ m/s, find the magnitude and direction of the impulse experienced by (a) object A, (b) object B, and (c) object C.

14. Just before hitting the boards of a hockey rink, a puck is sliding along the ice at a constant velocity. As shown in Figure 6.17, the components of this velocity are 3 m/s in the direction perpendicular to the boards and 4 m/s parallel to the boards. Immediately after bouncing off the boards, the puck's velocity component parallel to the boards is unchanged at 4 m/s, and its velocity component perpendicular to the boards is 1 m/s in case A, 2 m/s in case B, and 3 m/s in case C. Without doing any calculations, rank the three cases based on the impulse the puck experienced because of its collision with the boards.

15. Return to the situation described in Exercise 14, and shown in Figure 6.17. If the puck's mass is 160 g, find the impulse applied by the boards in (a) case C; (b) case A.

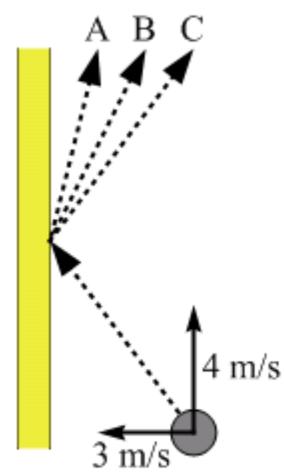


Figure 6.17: Three situations involving a hockey puck colliding with the boards, for Exercises 14 and 15.

16. An object with a mass of 5.00 kg is traveling east at 4.00 m/s. It is then subjected to a constant net force for a period of 2.00 s. In which direction should the force be applied if you want the object (a) to be moving fastest once the force is removed? (b) to experience the largest-magnitude change in momentum over the time period during which the force is applied?

17. Return to the situation described in Exercise 16. What are the magnitude and direction of the applied force if the object's velocity after the force is removed is (a) 12.0 m/s east? (b) zero? (c) 12.0 m/s west?

18. Return to the situation described in Exercise 16. What are the magnitude and direction of the applied force if the object's velocity after the force is removed is (a) 4.00 m/s north? (b) $4\sqrt{2}$ m/s northeast? (c) 8.00 m/s south?

Exercises 19 – 23 are designed to give you some practice in applying the general method for solving a problem involving impulse and momentum For each exercise, begin with the following parts: (a) Sketch a diagram of the situation. (b) Choose a coordinate system, and show it on the diagram. (c) Organize what you know, such as by drawing a free-body diagram or a graph of the net force as a function of time.

19. You throw a 200-gram ball straight up into the air, releasing it with a speed of 20 m/s. The goal here is to use impulse and momentum concepts to determine the time it takes the ball to reach its maximum height, assuming $g = 10$ m/s^2 down. Parts (a) – (c) as described above, where you should draw a free-body diagram of the ball after it leaves your hand for part (c). (d) What is the ball's momentum at the instant you let go of it? (e) What is the ball's momentum at the maximum-height point? (f) What is the change in the ball's momentum between the time you release it and the time it reaches its maximum height? (g) What is the force acting on the ball over this time interval? (h) Using equation 6.3, determine the time the ball takes to reach its maximum height.

20. You launch a 200-gram ball horizontally, with a speed of 30 m/s, from the top of a tall building, 80 m above the ground. The goal in this exercise is to use impulse and momentum concepts to determine the ball's momentum just before it hits the ground, assuming $g = 10$ m/s^2 down and air resistance is negligible. Parts (a) – (c) as described above, where you should draw a free-body diagram of the ball after it leaves your hand for part (c). (d) Using one or more constant-acceleration equations, determine the time it takes the ball to reach the ground. (e) What is the ball's momentum at the instant you let go of it? (f) Using equation 6.3, what is the change in the ball's momentum during the time it is in flight? (g) Use your answers to parts (e) and (f), noting that they are vectors, to find the ball's momentum just before it reaches the ground.

21. The Williams sisters are playing one another in the semi-finals at Wimbledon. At the instant Venus' racket makes contact with one of Serena's serves, the ball is traveling horizontally at 20 m/s, and it has no vertical velocity. The racket is in contact with the ball (which has a mass of 100 g) for 0.030 s, and the ball leaves the racket traveling at 40 m/s horizontally, in a direction exactly opposite to the path it was traveling just as her racket made contact with it. Parts (a) – (c) as described above, where you should sketch the x and y components of the average force exerted on the ball by the racket for the free-body diagram of the ball in part (c). (d) What is the x-component of the average force exerted by the racket on the ball in this case? (e) Does the average force exerted by the racket on the ball also have a non-zero y-component? Briefly explain your answer.

22. A box, with a weight of 40 N, is initially at rest on a horizontal surface. The coefficients of friction between the box and the surface are $\mu_S = 0.40$ and $\mu_K = 0.20$. You then exert a horizontal force on the box that increases linearly from 0 to 40 N over a 1.0-second period. Assume g = 10 m/s^2. Parts (a) – (c) as described above, where you should sketch a graph of the net force acting on the box, as a function of time, in part (c). (d) When does the box start to move? (e) What is the area under the net force versus time graph over the 1.0-second period? (f) Determine the speed of the box at the end of the 1.0-second period.

23. While you are out for a run, you see a patch of smooth ice ahead of you. You decide to slide (on your running shoes) across the ice. Your initial speed is 6.0 m/s. When you reach the end of the horizontal ice patch, after sliding for 2.0 s, your speed is 4.0 m/s. Your goal here is to determine the coefficient of kinetic friction between your running shoes and the ice, assuming that g = 10 m/s^2. Parts (a) – (c) as described above, where you should sketch a free-body diagram for the period you are sliding, in part (c). (d) Write an expression for the net force acting on you while you are sliding. This should involve the coefficient of kinetic friction and g. (e) Write an expression representing your change in momentum while you are sliding. (f) Use equation 6.3 to relate the expressions you wrote down in parts (d) and (e). (g) Solve for the coefficient of kinetic friction.

Exercises 24 – 30 deal with working with graphs.

24. At a time t = 0, a wheeled cart with a mass of 2.00 kg has an initial velocity of 5.00 m/s in the +x-direction. For the next 8.00 seconds, the cart then experiences a net force. As shown in the graph in Figure 6.18, the x-component of the applied force is +1.00 N for 2.00 seconds, then –4.00 N for 5.00 seconds, then +2.00 N for 1.00 seconds. (a) Sketch a graph of the x-component of the cart's momentum as a function of time. (b) What is the cart's maximum speed during the 8.00-second interval when the varying force is being applied? At what time does the cart reach this maximum speed? (c) What is the cart's minimum speed during the 8.00-second interval when the varying force is being applied? At what time does the cart reach this minimum speed?

25. Return to the situation described in Exercise 24. (a) How much work is done on the cart during the 8.00-second interval over which the force acts? (b) If the cart starts at the origin at t = 0, where is it at t = 8 s?

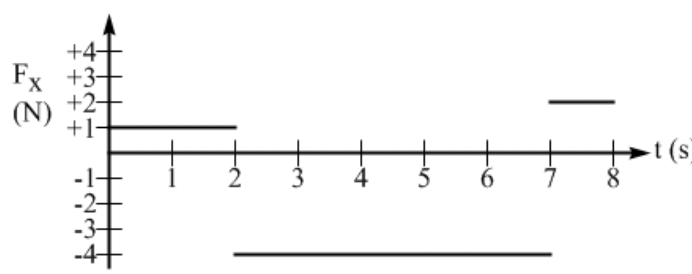


Figure 6.18: A plot of the force applied to a cart as a function of time, for Exercises 24 and 25.

26. A spaceship of mass 4000 kg is drifting at constant velocity through outer space, unaffected by any gravitational interactions. Figure 6.19 shows the trajectory followed by the spaceship in a particular *x-y* coordinate system during a 2.00 second interval. At t = 2.00 seconds, the spaceship fires its engine, producing a net force on the spaceship of 8000 N in the +y direction. The engine is turned off again after 2.00 seconds, at t = 4.00 seconds. Assume the mass of the spaceship does not change. The square boxes in the Figure 6.19 measure 1.00 m by 1.00 m. (a) Carefully plot the trajectory followed by the spaceship after t = 2.00 seconds. Note in particular where the spaceship is at t = 3.00 s, t = 4.00 s, and t = 5.00 s. (b) What is the speed of the spaceship at t = 5.00 seconds?

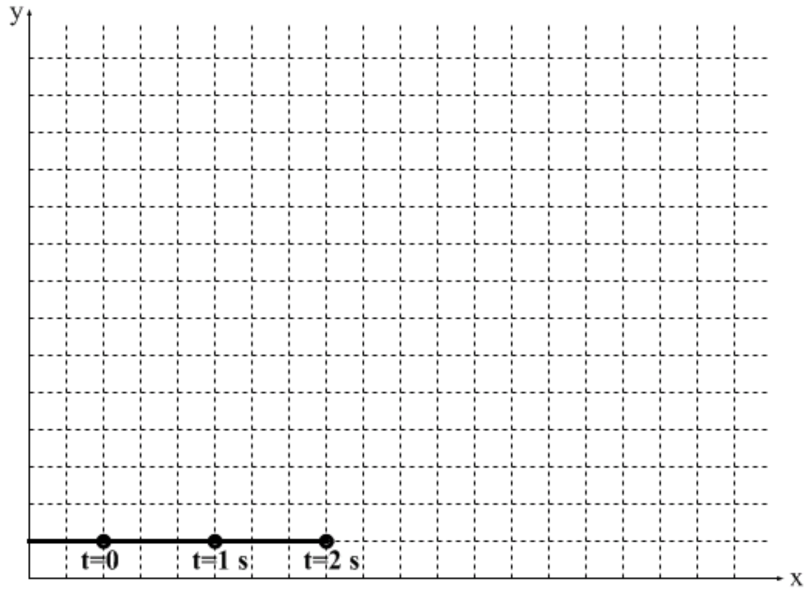


Figure 6.19: A plot of a spaceship's position as a function of time between t = 0 and t = 2 seconds, for Exercise 26.

27. An object of mass 2.0 kg is at rest at the origin, at t = 0, when it is subjected to a net force in the *x*-direction that varies in magnitude and direction as shown by the graph in Figure 6.20. (a) When does the object reach its maximum speed? (b) What is the maximum speed reached by the object? (c) What is the object's velocity at t = 8 s?

28. Repeat Exercise 27, with the only change being that the object has an initial velocity of 2.0 m/s in the negative *x* direction at t = 0.

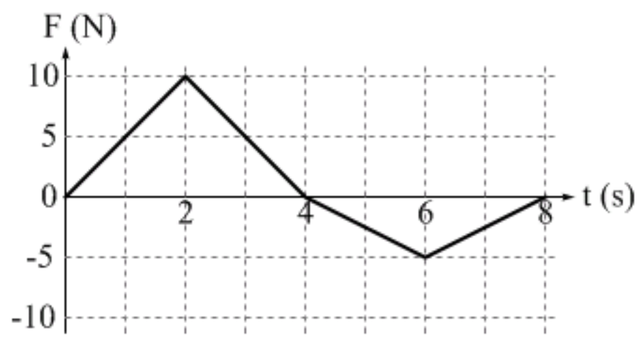


Figure 6.20: A graph of the net force in the *x*-direction that an object experiences, for Exercises 27 and 28.

29. After the time t = 0, an object of mass m = 1.0 kg is moving in the positive x direction at a constant speed of 8.0 m/s. The object is on a frictionless horizontal surface. Before t = 0, however, the object experienced a net force in the positive *x*-direction as shown in Figure 6.21. Determine the object's velocity at a time of (a) t = –1.0 s (b) t = –2.0 s (c) t = –4.0 s.

30. Repeat Exercise 29, but this time use a mass of m = 0.25 kg.

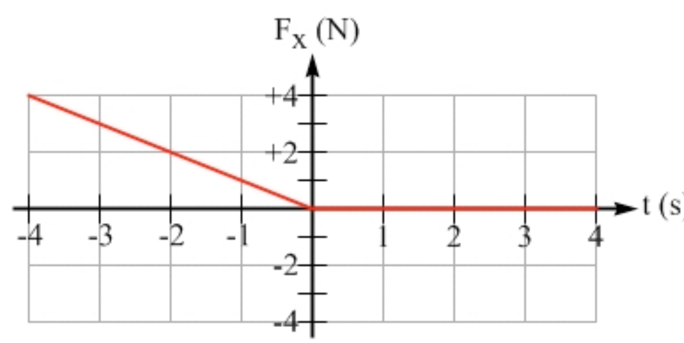


Figure 6.21: A graph of the net force applied to an object as a function of time, for Exercises 29 and 30.

Exercises 31 – 34 deal with the concept of center of mass.

31. A system consists of three balls. (a) Find the center of mass of the system, given that: Ball 1 has a mass of 2.0 kg and is located at x = +3 m, y = 0; ball 2 has a mass of 3.0 kg and is located at x = –1 m, y = –1 m; and ball 3 has a mass of 5.0 kg and is located at x = 0, y = +2 m. (b) If the mass of ball 3 is increased, the position of the center of mass shifts. In which direction does it shift?

32. A system consists of three balls at different locations on the x-axis. Ball 1 has a mass of 6.0 kg and is located at x = +3 m; ball 2 has a mass of 2.0 kg and is located at x = –1 m; ball 3 has an unknown mass and is located at x = –4 m. (a) If the center of mass of this system is located at x = –2 m, what is the mass of ball 3? (b) Let's say that you can make ball 3 as light or as heavy as you like. By adjusting the mass of ball 3, what range of positions on the x-axis can the center of mass of this system occupy?

33. A man with a mass of 120 kg is out fishing with his daughter, who has a mass of 40 kg. They are initially sitting at opposite ends of their 3.0-m boat, which has a mass of 80 kg and is at rest in the middle of a calm lake. If the man and the daughter then carefully trade places, how far does the boat move?

34. A uniform sheet of plywood measuring 4L by 4L is centered on the origin, as shown in Figure 6.22. One quarter of the sheet (the part in the first quadrant) is removed. Where is the center of mass of the remaining piece?

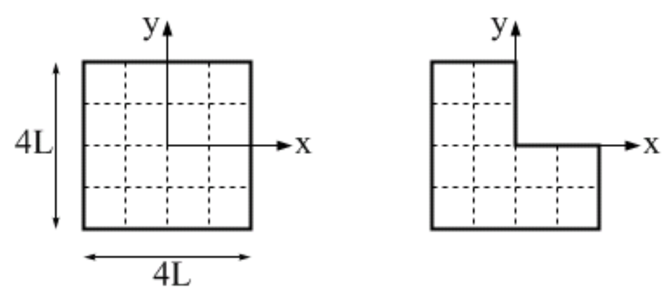


Figure 6.22: One quarter of a sheet of plywood is removed, for Exercise 34.

Exercises 35 – 39 are designed to give you some practice in applying the general method for solving a problem involving work and kinetic energy. For each exercise, begin with the following parts: (a) Sketch a diagram of the situation. (b) Choose a coordinate system, and show it on the diagram. (c) Organize what you know, such as by drawing a free-body diagram or a graph of the net force as a function of position.

35. You throw a 200-gram ball straight up into the air, releasing it with a speed of 20 m/s. The goal here is to use work and energy concepts to determine the ball's maximum height, assuming g = 10 m/s^2 down. Parts (a) – (c) as described above, where you should draw a free-body diagram of the ball after it leaves your hand for part (c). (d) What is the ball's kinetic energy at the instant you let go of it? (e) What is the ball's kinetic energy at the maximum-height point? (f) What is the change in the ball's kinetic energy between the point at which you release it and the point of maximum height? (g) What is the force acting on the ball over this distance? (h) Using equation 6.8, determine the distance between the point from which you released the ball and the point of maximum height.

36. You launch a 200-gram ball horizontally, with a speed of 30 m/s, from the top of a tall building, 80 m above the ground. The goal in this exercise is to use work and kinetic energy concepts to determine the ball's speed just before it hits the ground, assuming g = 10 m/s^2 down and air resistance is negligible. Parts (a) – (c) as described above, where you should draw a free-body diagram of the ball after it leaves your hand for part (c). (d) What is the ball's kinetic energy when you release it? (e) What is the net work done on the ball over its path from your hand to just above the ground? Hint: you can find

the net work by multiplying the net force acting on the ball by the ball's displacement in the direction of the net force. (f) Using equation 6.8, what is the ball's kinetic energy just before the ball reaches the ground? (g) What is the ball's speed just before it reaches the ground?

37. An object with a mass of 2.0 kg is following a straight path, along a line we can call the x axis. When it passes $x = 4.0$ m, it is traveling with a velocity of 8.0 m/s in the positive x direction. The object experiences a net force of 4.0 N in the positive x-direction at all locations where $x < 2.0$ m and a net force of 10 N in the positive x-direction at all locations where $x > 2.0$ m. Parts (a) – (c) as described above, where you should draw a graph of the net force acting on the ball as a function of position in part (c). The goal of this exercise is to determine, with the help of the graph, at what location the object has a velocity of 10 m/s in the positive x-direction, and at what location the object has a velocity of 2.0 m/s in the positive x-direction. (d) What is the object's kinetic energy at $x = 4.0$ m? (e) What is the object's kinetic energy when its speed is 10 m/s? (f) How much work is required to change the object's kinetic energy from what the object has at $x = 4.0$ m to what it has at the point at which the velocity is 10 m/s in the positive x-direction? Shade in the corresponding area on the force-vs.-position graph. (g) At what location will the object have a velocity of +10 m/s? (h) Follow a similar procedure to determine at what location the object will have a velocity of +2.0 m/s.

38. You are traveling in a car at 54 km/h when the car is involved in an accident. Assume that your mass is 60 kg. (a) What is your kinetic energy? (b) You are wearing your seat belt, and you come to rest after you and the car move through a distance of 2.0 m. What is the average force exerted on you by the seat belt? (c) What is your average acceleration? Express this in units of g, assuming $g = 10$ m/s^2. (d) If you are not wearing your seat belt, you may come to rest after striking the windshield and moving through a distance of 10 cm. What is your average acceleration in this case? Again, express this in units of g.

39. While you are out for a run you see a long patch of smooth ice ahead of you. You decide to slide (on your running shoes) across the ice. When you begin sliding, your speed is 6.0 m/s. When you reach the end of the horizontal ice patch, after sliding for a distance of 5.0 m, your speed is 4.0 m/s. Your goal here is to determine the coefficient of kinetic friction between your running shoes and the ice, assuming that $g = 10$ m/s^2. Parts (a) – (c) as described above, where you should sketch a free-body diagram for the period in which you are sliding, in part (c). (d) Write an expression for the net force acting on you while you are sliding. This expression should involve the coefficient of kinetic friction and g. (e) Write an expression representing your change in kinetic energy while you are sliding. (f) Use equation 6.8 to relate the expressions you wrote down in parts (d) and (e). (g) Solve for the coefficient of kinetic friction.

General Exercises and Conceptual Questions

40. A hose is used to spray water horizontally at a wall. The water has a speed of 4 m/s, and the flow rate is 5 liters per second. (a) Assuming that the water stops completely when it hits the wall, how much force does the water exert on the wall? (b) Rather than stopping completely, the water rebounds when it hits the wall. Does this change the force exerted by the water on the wall? If so, how?

41. An object has a momentum with a magnitude of 20 kg m/s and a speed of 4 m/s. It is then subjected to an impulse of 15 kg m/s in the $+x$ direction. What is the object's final velocity if the initial momentum is in the (a) $+x$ direction? (b) $-x$ direction? (c) $+y$ direction?

42. A hockey puck is sliding east at a constant velocity v over some ice. A net force F is then applied to the puck for 5 seconds. In case 1, the net force is directed west. In case 2, the net force is directed south. In case 3, the net force is directed east. The magnitude of the applied force is the same in each case. Rank the cases from largest to smallest, based on: (a) the magnitude of the change in momentum experienced by the puck, (b) the magnitude of the puck's final momentum, and (c) the work done on the puck.

43. You are shooting a free throw in basketball. If the center of the basket is 1.0 m higher, and 4.0 m horizontally, from the point at which the ball loses contact with your hands, what momentum (magnitude and direction) must the ball have when you release it, if the ball takes exactly 1.0 s to reach the center of the basket? The basketball has a mass of 0.50 kg. Use $g = 9.8$ m/s^2 for this exercise.

44. A firework of mass 10M is launched from the ground and follows a parabolic trajectory (assume air resistance is negligible) as shown in Figure 6.23. Its initial velocity has components v_{ix} = 30 m/s to the right and v_{iy} = 20 m/s up. It follows the parabolic trajectory shown at right. When the firework reaches its maximum height, it explodes into four pieces, A, B, C, and D (not shown on the diagram). The masses and velocities of the four pieces immediately after the explosion are:
$m_A = 1M$, v_{Af} = 24 m/s vertically up;
$m_B = 2M$, v_{Bf} = 50 m/s horizontally to the right;
$m_C = 3M$, v_{Cf} = an unknown speed vertically down;
$m_D = 4M$, v_{Df} = an unknown speed horizontally right or left.
(a)What is the speed of piece C after the collision? (b) What is the velocity (magnitude and direction) of piece D after the collision? (c) Before the explosion, the firework follows the typical parabolic path of an object moving under the influence of gravity alone. What path will the center of mass follow after the collision? Qualitatively, when will the center of mass divert from this path?

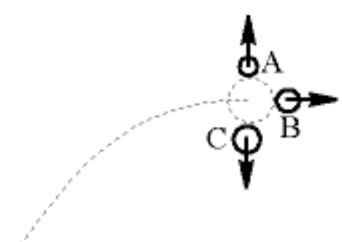


Figure 6.23: An exploding firework, for Exercises 44 and 45.

45. Repeat Exercise 44, parts (a) and (b), with the firework exploding not at the top of its trajectory, but 2.3 s after launch instead. Use $g = 10$ m/s^2, so you can do the calculations without a calculator.

46. How much work do you do on a box with a weight of 10 N in the following situations? (a) You hold the box motionless over your head for 2.0 s (b) You move the box 2.0 m horizontally at constant velocity (c) Starting and ending with the box at rest, you move the box 2.0 m straight up.

47. A box with a weight of 20.0 N is initially at rest on a horizontal surface, when a force is applied to it for 6.00 seconds. As shown in Figure 6.24, in case 1, the force is 5.00 N to the right, while in case 2, the force is 10.0 N at an angle of 60˚ above the horizontal. (a) If there is no friction between the box and the surface, in which case is more work done on the object? (b) What is the net work done in the two cases? (c) If, instead, the coefficients of friction are $\mu_s = 0.400$ and $\mu_k = 0.300$, in which case is more work done on the object? What is the net work done in the two cases now? Use $g = 10.0$ m/s^2 to simplify the calculations.

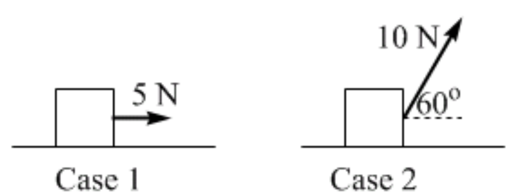


Figure 6.24: Two situations of a box subjected to a force, for Exercise 47.

48. A wheeled cart, which is free to move along the x-axis, is initially at rest at the origin. As the graph in Figure 6.25 shows, if the cart is between $x = -1$ m and $x = +2$ m, the net force is 1.00 N in the positive x-direction. If the cart is between $x = +2$ m and $x = +7$ m, the net force is 4.00 N in the negative x-direction. If the cart is between $x = +7$ m and $x = +8$ m, the net force is 2.00 N in the positive x-direction. The net force is zero at all other locations. (a) Describe, qualitatively, the resulting motion of the cart. (b) What is the maximum distance the cart gets from the origin? (c) Graph the cart's kinetic energy as a function of position as it moves. (d) If you wanted the cart to travel at least as far as $x = +8$ m, what is the minimum kinetic energy the cart needs to have at the origin?

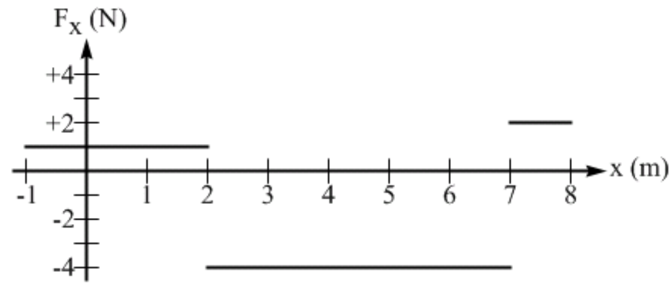
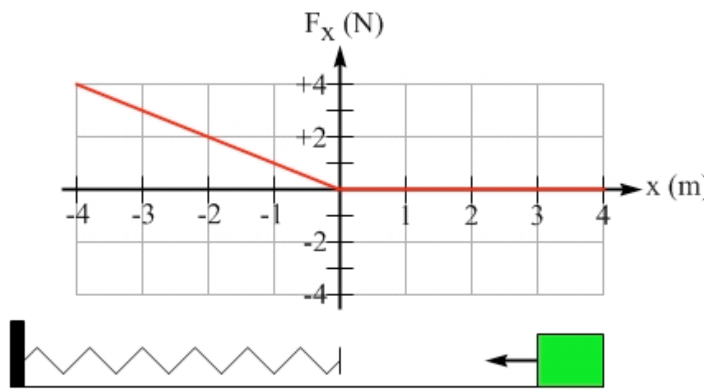


Figure 6.25: A graph showing the force applied to an object as a function of position, for Exercises 48 and 49.

49. Consider again the situation in Exercise 48. Assume the cart has a mass of 0.250 kg and is released from rest at the origin. (a) How long after the cart is released does it first pass $x = +2$ m? (b) What is the cart's maximum speed during its motion? (c) How long after it is released does the cart first return to the origin? (d) Graph the cart's velocity, as a function of time, for the first 10 seconds after its release.

50. We'll deal with springs in detail in chapter 12, but consider the situation shown in Figure 6.26. A block of mass $m = 0.25$ kg is traveling with a velocity $v = 4.0$ m/s to the left on a frictionless horizontal surface. When it reaches $x = 0$, the block encounters a spring, which exerts a force directed right on the block that depends on how much the spring is compressed. The graph shows the force the spring exerts on the block as a function of position, x. (a) How far will the block compress the spring in this case? (b) How far is the spring compressed when the block has a speed of $v = 2.0$ m/s?



51. Consider the situation described in Exercise 50. How far will the block compress the spring (a) if the mass of the block is doubled? (b) if, instead, the initial velocity of the block is doubled?

Figure 6.26: The graph shows the force a spring exerts on a block as a function of position. The diagram below the graph shows the block moving left on a frictionless surface before encountering the spring. For Exercises 50 and 51.

52. Two identical boxes of mass *m* are sliding along a horizontal floor, but both eventually come to rest because of friction. Box A has an initial speed of v, while box B has an initial speed of $2v$. The coefficient of kinetic friction between each box and the floor is μ_K, and the acceleration due to gravity is *g*. (a) If it takes box A a time *T* to come to a stop, how much time does it take for box B to come to a stop? (b) Find an expression for *T* in terms of the variables specified in the exercise. (c) If box A travels a distance *D* before coming to rest, how far does box B travel before coming to rest? (d) Find an expression for *D* in terms of the variables specified in the exercise.

53. Return to the situation described in Exercise 52. How does *T*, the stopping time for box A, change if (a) *m* is doubled? (b) *v* is doubled? (c) μ_K is doubled?

54. Return to the situation described in Exercise 52. How does *D*, the stopping distance for box A, change if (a) *m* is doubled? (b) *v* is doubled? (c) μ_K is doubled? (d) *g* is doubled?

55. A car traveling 50 km/h can be brought to a stop in a distance of 40 m under controlled braking conditions. (a) Assuming the force used to bring the car to rest is the same, how much distance is required to bring the car to a stop if the car is traveling 100 km/h, twice as fast as it was originally? (b) How do the stopping times compare? (Ignore the reaction time of the driver and find the distance and time after the brakes are applied.)

56. A box, with a weight of *mg* = 25 N, is placed at the top of a ramp and released from rest. The ramp is in the shape of a 3-4-5 triangle, measuring 4 meters horizontally and 3 meters vertically. The box accelerates down the incline, attaining a kinetic energy at the bottom of the ramp of 55 J. There is a force of kinetic friction acting on the box as it slides down the incline. (a) Sketch a free-body diagram of the box, showing all the forces acting on it. (b) How much work does the normal force do on the box as the box slides down the incline? (c) Calculate the change in gravitational potential energy that the box experiences in this process. (d) How much work does the force of friction do on the box as the box slides down the incline? (e) What is the coefficient of kinetic friction between the box and ramp?

57. A car is accelerating from rest and takes a time *T* to reach speed *v*. (a) Assuming the force accelerating the car is constant, what is the total time (measured from the starting point) needed to reach a speed of 2*v*? (b) Assuming instead that the power associated with accelerating the car is constant, what is the total time needed to reach a speed of 2*v*?

58. You are cycling at a constant speed of 10 m/s. (a) If the net resistive force acting against you from things like air resistance is 35 N, what is your power output as you pedal? (a) (b) How much additional power is required to maintain this speed up a hill inclined at 8.0° with the horizontal? Assume the combined mass of you and your bicycle is 50 kg.

59. On a monthly electricity bill, the power companies charge you for the number of kilowatt-hours you consume. (a) What kind of unit is the kilowatt-hour? Is it power? Momentum? Something else? (b) Convert 1 kW-h to MKS units. (c) 1 kilowatt-hour typically costs about 20 cents. If you were somehow able to obtain your daily intake of 2500 Cal by plugging yourself into a wall socket (don't try this, of course!), how much would it cost you?

60. An energy bar contains about 200 Cal. If your brain consumes about 20 W under typical conditions, for how long does one energy bar keep the brain functioning? 1 Cal = 1000 calories, and 1 calorie is approximately 4 J.

61. Consider the Earth, with a mass of 6.0 x 10^{24} kg, in its orbit around the Sun, with a mass of 2.0 x 10^{30} kg. Assume the orbit is circular, with a radius of 1.5 x 10^{11} m. The Earth, traveling at 30 km/s, takes six months to travel halfway around the orbit. (a) What is the magnitude of the Earth's change in momentum over this six-month period? (b) How much work does the Sun do on the Earth over this six-month period?

62. Comment on the statements made by three students who are working together to solve the following problem, and state the answer to the problem. A cart with a mass of 2.0 kg has an initial velocity of 4.0 m/s in the positive *x*-direction. A constant net force of 8.0 N, in the positive *x*-direction, is then applied to the cart for 0.50 s. What is the cart's kinetic energy at the end of this 0.50 second interval?

Christina: I think we should use impulse here. Using impulse, we can figure out the change in velocity, and then the final velocity. Once we get that, we can use the mass and velocity to get the kinetic energy.

Sandy: Don't we need to find the acceleration? That's just 4.0 meters per second squared. Then we can use one of the constant-acceleration equations to find the final speed, and get the kinetic energy that way.

Phil: I like getting the acceleration first, but then we can find the displacement using one of the constant-acceleration equations. After that, we can get the work, which is the change in kinetic energy, and then get the final kinetic energy. They basically give us the initial kinetic energy.