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Chapter 5

1. I f a person does 50 J of work in moving a 30-kg box over a 10-m distance on a horizontal surface, what is the minimum force required?

2. A 5.0-kg box slides a 10-m distance on ice. If the coefficient of kinetic friction is 0.20, what is the fork done by the friction force?

3. A passenger at an airport pulls a rolling suitcase by its handle. If the force used is 10 N and the handle makes an angle of 25° to the horizontal, what is the work done by the pulling force while the passenger walks 200 m?

4. A 3.00-kg block slides down a frictionless plane inclined 20° to the horizontal. If the length of the plane's surface is 1.50 m, how much work is done, and by what force?

5. Suppose the coefficient of kinetic friction between the block and the plane in Exercise 4 is 0.275. What would be the net work done in this case?

6. A father pulls his daughter on a sled with constant velocity on a level surface a distance of 10 m, as illustrated in Fig. 5.27a. If total mass of the sled and girl is 35 kg, and the coefficient of kinetic friction between the sled runners and snow is 0.20, how much work does the father do?

7. A father pushes horizontally on his daughter's sled to move it up a snowy incline, as illustrated in Fig. 5.27b. If the sled moves up the hill with a constant velocity, how much work is done by the father in moving it from the bottom to the top of the hill?

8. A block on a level frictionless surface has two horizontal forces applied, as shown in Fig. 5.28. (a) What force F_2 would cause the block to move in a straight line to the right? (b) Ff the block moves 50 cm, how much work is done by each force? (c) What is the total work done by the two forces?

9. A 0.50-kg shuffleboard puck slides a distance of 3.0 m on the board. If the coefficient of kinetic friction between the puck and the board is 0.15, what work is done by the force of friction?

10. A crate is dragged 3.0 m along a rough floor with a constant velocity by a worker applying a force of 500 N to a rope at an angle of 30° to the horizontal. (a) How many forces are acting on the crate? (b) How much work does each of these forces do? (c) What is the total work done on the crate?

11. A hot air balloon ascends at a constant rate. (a) The weight of the balloon does (1) positive work, (2) negative work, (3) no work. Why? (b) A hot-air balloon with a mass of 500 kg ascends at a constant rate of 1.50 m/s for 20.0 s. How much work is done by the upward buoyant force?

12. A hockey puck with a mass of 200 g and an initial speed of 25.0 m/s slides freely to rest in the space of 100 m on a sheet of horizontal ice. How many force do nonzero work on it as it slows: (a) (1) none, (2) one, (3) two, or (4) three? Explain. (b) Determine the work done by all the individual forces on the puck as it slows.

13. An eraser with a mass of 100 g sits on a book at rest. The eraser is initially 10.0 cm from any edge of the book. The book is suddenly yanked very hard and slides out from under the eraser. In doing so, it partially drags the eraser with it, although not enough to stay on the book. The coefficient of kinetic friction between the book and eraser is 0.150. (a) The sign of the work done by the force of kinetic friction of the book on the eraser is (1) positive, (2) negative, (3) zero work is done by kinetic friction. Explain. (b) How much work is done by the book's frictional force on the eraser by the time it fall off the edge of book?

14. A 500-kg, light-weight helicopter ascends from the ground with an acceleration of 2.00 m/s^2. Over a 5.00-s interval, what is (a) the work done by the lifting force, (b) the work done by the gravitational force, and (c) the net work done on the helicopter?

15. A man pushes horizontally on a desk that rests on a rough wooden floor. The coefficient of static friction between the desk and floor is 0.750 and the coefficient of kinetic friction is 0.600. The desk's mass is 100 kg. He pushes just hard enough to get the desk moving and continues pushing with that force for 5.00 s. How much work does he do on the desk?

16. A student could either pull or push, at an angle of 30° from the horizontal, a 50-kg crate on a horizontal surface, where the coefficient of kinetic friction between the crate and the surface is 0.2. The crate is to be moved a horizontal distance of 15 m. (a) Compared with pushing, pulling requires the student to do (1) less, (2) the same, or (3) more work. (b) Calculate the minimum work required for both pulling and pushing.

17. To measure the spring constant of a certain spring, a student applies a 4.0-N force, and the spring stretches by 5.0 cm. What is the spring constant?

18. A spring has a spring constant of 30 N/m. How much work is required to stretch the spring 2.0 from its equilibrium position?

19. If it takes 400 J of work to stretch a spring 8.00 cm, what is the spring constant?

20. If a 10-N force is used to compress a spring with a spring constant of 4.0×10^2 N/m, what is the resulting spring compression?

21. A certain amount of work is required to stretch a spring from its equilibrium position. (a) If twice the work is performed on the spring, the spring will stretch more by a factor of (1) $\sqrt{2}$, (2) 2, (3) $1/\sqrt{2}$, (4) ½. Why? (b) if 100 J of work is done to pull a spring 1.0 cm, what work is required to stretch it 3.0 cm?

22. Compute the work done by the variable force in the graph of F versus x in Fig. 5.29?

23. A spring with a force constant of 50 N/m is to be stretched from 0 to 20 cm. (a) The work required to stretch the spring from 10 cm to 20 cm is (1) more than, (2) the same as, (3) less than that required to stretch it from 0 to 10 cm. (b) Compare the two work values to prove your answer to part (a).

24. In gravity-free interstellar space, a spaceship fires its rockets to speed up. The rockets are programmed to increase thrust from zero to 1.00×10^4 N with a linear increase over the course of 18.0 km. Then the thrust decreases linearly back to zero over the next 18.0 km. Assuming the rocket was stationary to start, (a) during which segment will more work (magnitude) be done: (1) the first 60 s, (2) the second 60 s, or (3) the work done is the same in both segments? Explain your reasoning (b) Determine quantitatively how much work is done in each segment.

25. A particular spring has a force constant of 2.5×10^3 N/m. (a) How much work is done in stretching the relaxed spring by 6.0 cm? (b) How much more work is done in stretching the spring an additional 2.0 cm?

26. For the spring in Exercise 25, how much mass would have to be suspended from the vertical spring to stretch it (a) the first 6.0 cm and (b) the additional 2.0 cm?

27. In stretching a spring in an experiment, a student inadvertently stretches it past its elastic limit; the force-versus-stretch graph is shown in Fig. 5.30. Basically, after it reaches its limit, the spring begins to behave as if it were considerably stiffer. How much work was done on the spring? Assume that on the force axis, the tick marks are every 10 N, and on the x-axis, they are every 10 cm or 0.1 m.

28. A spring (spring 1) with a spring constant of 500 N/m is attached to a wall and connected to another weaker spring (spring 2) with a spring constant of 250 N/m on a horizontal surface. Then an external force of 100 N is applied to the end of the weaker spring (#2). How much potential energy is stored in each spring?

29. A 0.20-kg object with a horizontal speed of 10 m/s hits a wall and bounces directly back with only half the original speed. (a) What percentage of the object's initial kinetic energy is lost: (1) 25%, (2) 50%, or (3) 75%? (b) How much kinetic energy is lost in the ball's collision with the wall?

30. A 1200-kg automobile travels at 90 km/h. (a) What is its kinetic energy? (b) What net work would be required to bring it to a stop?

31. A constant net force of 75 N acts on an object initially at rest as it moves through a parallel distance of 0.60 m? (a0) What is the final kinetic energy of the object? (b) If the object has a mass of 0.20 kg, what is it its final speed?

32. A 2.00-kg mass is attached to a vertical spring with a spring constant of 250 N/m. A student pushes on the mass vertically upward with her hand while slowly lowering to its equilibrium position. (a) How many forces do nonzero work on the object: (1) one, (2) two, (3) three? (b) Calculate work done on the object by each of the forces acting on it as it is lowered into position.

33. The stopping distance of a vehicle is an important safety factor. Assuming a constant braking force, use the work-energy theorem to show that a vehicle's stopping distance is proportional to the square of its initial speed. If an automobile traveling at 45 km/h is brought to a stop in 50 m, what would be the stopping distance for an initial speed of 90 km/h?

34. A large car of mass 2m travels at speed v. A small car of mass m travels with a speed 2v. Both skid to a stop with the same coefficient of friction. (a) The small car will have (1) longer, (2) the same, (3) a shorter stopping distance. (b) Calculate the ratio of the stopping distance of the small car to that of the large car.

35. An out-of-control truck with a mass of 5000 kg is traveling at 35.0 m/s when it starts descending a steep (15°) incline. The incline is icy, so the coefficient of friction is only 0.30. Use the work-energy theorem to determine how far the truck will skid (assuming it locks its brakes and skids the whole way) before coming to rest.

36. If the work required to speed up the car from 10 km/h to 20 km/h is 5.0×10^3 J, what would be the work required to increase the car’s speed from 20 km/h to 30 km/h?

37. How much more gravitational potential energy does a 1.0-kg hammer have when it is on the shelf 1.2 m high than when it is on the shelf 0.90 m high?

38. You are told that the gravitational potential energy of a 2.0 kg object has decreased by 10 J. (a) With this information, you can determine (1) the objects initial height, (2) the object's final height, (3) both the initial and the final height, or (4) only the difference between the two heights. Why? (b) What can you say has physically happened to the object?

39. Six identical books, 4.0 cm thick and each with a mass of 0.80 kg, lie individually on a flat table. How much work would be needed to stack the books one on top of the other?

40. The floor of the basement of a house is 3.0 m below ground level, and the floor of the attic is 4.5 m above ground level. (a) If an object in the attic were brought to the basement, the change in potential energy will be the greatest relative to which floor: (1) attic, (2) ground, (3) basement, or (4) all the same? Why? (b) What are the respective potential energies of 1.5-kg objects in the basement and attic, relative to the round level? (c) What is the change in potential energy if the object in the attic is brought to the basement?

41. A 0.50-kg mass is placed on the end of a vertical spring that has a spring constant of 75 N/m and eased down into its equilibrium position. (a) Determine the change in spring (elastic) potential energy of the system. (b) Determine the system’s change in gravitational potential energy.

42. A horizontal spring, resting on a frictionless tabletop, is stretched 15 cm from its unstretched configuration and a 1.00-kg mass is attached to it. The system is released from rest. A fraction of a second later, the spring

finds itself compressed 3.0 cm from its unstretched configuration. How does its final potential energy compare to its initial potential energy?

43. A student has six textbooks, each with a thickness of 4.0 cm and a weight of 30 N. What is the minimum work the student would have to do to place all the books in a single vertical stack, starting with all the books on the surface of the table?

44. A 1.50-kg mass is placed on the end of a spring that has a spring constant of 175 N/m. The mass-spring system rests on a frictionless incline that is at an angle of 30° from the horizontal. The system is eased into its equilibrium position, where it stays. a) Determine the change in elastic potential energy of the system. b) Determine the system's change in gravitational potential energy.

45. A 0.300-kg ball is thrown vertically upward with an initial speed of 10.0 m/s. If the initial potential energy is taken as zero, find the ball's kinetic, potential, and total mechanical energies (a) at its initial position, and (b) at 2.50 m above the initial position, (c) at its maximum height..

46. What is the maximum height reached by the ball in Exercise 45?

47. Referring to Fig. 3.13, find the speed with which the stone strikes the water using energy considerations.

48. A girl swings back and forth on a swing with ropes that are 4.00 m long. The maximum height she reaches is 2.00 m above the ground. At the lowest point of the swing, she is 0.500 m above the ground. (a) The girl attains the maximum speed (1) at the top, (2) in the middle, (3) at the bottom of the swing. Why? (b) What is the girl's maximum speed?

49. A 1.00-kg block (M) is on a flat frictionless surface. This block is attached to a spring initially at its relaxed length (spring constant is 50.0 N/m). A light string is attached to the block and runs over a frictionless pulley to a 450 g dangling mass (m). If the dangling mass is released from rest, how far does it fall before stopping?

50 A 500-g (small) mass on the end of a 1.50-m-long string is pulled aside 15° from the vertical and shoved downward (toward the bottom of its motion) with a speed of 2.00 m/s. (a) Is the angle on the side (1) greater than, (2) less than, or (3) the same as the angle on the initial side (15°) Explain in terms of energy? (b) Calculate the angle it goes to on the other side, neglecting air resistance.

51. A 0.20-kg rubber ball is dropped from a height of 1.0 m above the floor and it bounces back to a height of 0.70 m. (a) What is the ball's speed just before hitting the floor? (b) What is the speed of the ball just as it leaves the ground? (c) How much energy was lost and where did it go?

52. A skier coasts down a very smooth, 10-m-high slope similar to one shown in Fig. 5.21. If the speed of the skier on the top of the slope is 5.0 m/s, what is his speed at the bottom of the slope?

53. A roller coaster travels on a frictionless track as shown in Fig. 5.33. (a) If the speed of the roller coaster at point A is 5.0 m/s, what is its speed at point B? (b) Will it reach point C? (c) What minimum speed at point A is required for the roller coaster to reach point C?

54. A simple pendulum has a length of 0.75 m and a bob whose mass is 0.15 kg. The bob is released from an angle of 25º relative to a vertical reference line. (a) Show that the vertical height of the bob when it is released is $h = L(1- \cos 25°)$. (b) What is the kinetic energy of the bob when the string is at an angle of 9.0°? (c) What is the speed of the bob at the bottom of the swing?

55. Suppose the simple pendulum in Exercise 54 were released from an angle of 60°. (a) What would be the speed of the bob at the bottom of the swing? (b) To what height would the bob swing on the other side? (c) What angle of release would give half the speed of that for the 60° release angle at the bottom of the swing?

56. A 1.5-kg box that is sliding on a frictionless surface with a speed of 12 m/s approaches a horizontal spring. (See Fig. 5.19). The spring has a spring constant of 2000 N/m. If one end of the spring is fixed and the other end

changes its position, (a) how far will the spring be compressed in stopping the box? (b) How far will the spring be compressed when the box's speed is reduced to half of its initial speed?

57. A 0.50-kg mass is suspended on a spring that stretches 3.0 cm. (a) What is the spring constant? (b) What added mass would stretch the spring an additional 2.0 cm? (c) What is the change in potential energy when the mass is added?

58. A vertical spring with a force constant of 300 N/m is compressed 6.0 cm and a 0.25-kg ball placed on top. The spring is released and the ball flies vertically upward. How high does the ball go?

59. A block with a mass m_1 = 6.0 kg sitting on a frictionless table is connected to a suspended mass m_2 = 2.0 kg by a light string passing over a frictionless pulley. Using energy considerations, find the speed at which m_2 hits the floor after descending 0.75 m.

60. A hiker plans to swing on a rope across a ravine in the mountains, as illustrated in the Fig. 5.35, and to drop when she is just above the far edge. (a) At what horizontal speed should she be moving when she starts to swing? (b) Below what speed would she be in danger of falling into the ravine? Explain.

61. In Exercise 52, if the skier has a mass of 60 kg and the force of friction retards his motion by doing 2500 J of work, what is his speed at the bottom of the slope?

62. A 1.00-kg block (M) is on a frictionless, 20° inclined plane. The block is attached to a spring (k= 25 N/m) that is fixed to a wall at the bottom of the incline. A light string attached to the block runs over a frictionless pulley to a 40.0 g suspended mass. The suspended mass is given an initial downward speed of 1.50 m/s. How far does it drop before coming to rest?

63. A girl consumes 8.4×10^6 J (2000 food calories) of energy per day while maintaining a constant weight. What is the average power she produces in a day?

64. A 1500-kg race car can go from 0 to 90 km/h in 5.0 s. What average power is required to do this?

65. The two 0.50-kg weights of a cuckoo clock descend 1.5 m in a three-day period. At what rate is their total gravitational potential energy decreased?

66. A pump lifts 200 kg of water per hour a height of 5.0 m. What is the minimum necessary power output rating of the water pump in watts and horsepower?

67. A race car is driven at a constant velocity of 200 km/h on a straight, level track. The power delivered to the wheels is 150 kW. What is the total resistive force on the car?

68. An electric motor with a 2.0-hp output drives a machine with an efficiency of 40%. What is the energy output of the machine per second?

69. Water is lifted out of a well 30.0 m deep by a motor rated at 1.00 hp. Assuming 90% efficiency, how many kilograms of water can be lifted in 1 min?

70. How much power must you exert to horizontally drag a 25.0-kg table 10.m across a brick floor in 30.0 s at constant velocity, assuming the coefficient of kinetic friction between the table and floor is 0.550?

71. A 3250-kg aircraft takes 12.5 min to achieve its cruising altitude of 10.0 km and a cruising speed of 850 km/h. If the plane's engines deliver, on average, 1500 hp of power during this time, what is the efficiency of the engines?

72. A sleigh and driver with a total mass of 120 kg are pulled up a hill with a 15° incline by a horse, as illustrated in Fig. 5.36. (a) If the overall retarding frictional force is 950 N and the sled moves up the hill with a constant velocity of 5.0 km/h, what is the power output of the horse? (Express in horsepower, of course.) (b)

Suppose that in a spurt of energy, the horse accelerates the sled uniformly from 5.0 km/h to 20 km/h in 5.0 s. What is the horse's maximum instantaneous power output? Assume the same force of friction.

73. A construction hoist exerts an upward force of 500 N on an object with a mass of 50 kg. If the hoist started from rest, determine the power it expended to lift the object vertically for 10 s under these conditions.

74. Two identical springs (neglect their masses) are used to "play catch" with a small block of mass 100 g (Fig. 5.37). Spring A is attached to the floor and compressed 10.0 cm with the mass on the end of it (loosely). Spring A is released from rest and the mass is accelerated upward. It impacts the spring attached to the ceiling, compresses it 2.00 cm, and stops after traveling a distance of 30.0 cm from the relaxed position of spring A to the relaxed position of spring B as shown. Determine the spring constant of the two springs (same since they are identical).

75. A 200-g ball is launched from a height of 200 m height above a lake. Its launch angle is 40° and it has an initial kinetic energy is 90.0 J. (a) Use energy methods to determine its maximum height above the lake surface. (b) Use projectile motion kinematics to repeat part (a). (c) Use energy methods to determine its speed just before impact with the water. (d) Repeat part (c) using projectile motion kinematics.

76. A 1.20-kg ball is projected straight upward with an initial speed of 18.5 m/s and reaches a maximum height of 1.7 m. (a) Show numerically that total mechanical energy is not conserved during this part of the ball's motion. (b) Determine the work done on the ball by the force of air resistance. (c) Calculate the average air resistance force on the ball and the ball's average acceleration.

Chapter 6

1. If a 60-kg woman is riding in a car traveling at 90 km/h, what is her linear momentum relative to (a) the ground and (b) the car?

2. The linear momentum of a runner in a 100-m dash is 7.5×10^2 kg m/s. If the runner's speed is 10 m/s. what is his mass?

3. Find the magnitude of the linear momentum of (a) a 7.1-kg bowling ball traveling at 12 m/s and (b) a 1200-kg automobile traveling at 90 km/h.

4. In a football game, a lineman usually has more mass than a running back. (a) Will a lineman always have greater linear momentum that a running back? Why? (b) Who has greater linear momentum, a 75-kg running back at 8.8 m/s or a 120-kg lineman running at 5.0 m/s?

5. A 0.150-kg baseball traveling with a horizontal speed of 4.50 m/s is hit by a bat and then moves with a speed of 34.7 m/s in the opposite direction. What is the change in the ball's momentum?

6. A 15.0-g rubber bullet hits a wall with a speed of 150 m/s. If the bullet bounces straight back with a speed of 120 m/s, what is the change in momentum of the bullet?

7. Two protons approach each other with different speeds. (a) Will the magnitude of the total momentum of the two-proton system be (1) greater than the magnitude of the momentum of either proton, (2) Equal to the difference between the magnitudes of momenta of the two protons, or (3) equal to the sum of the magnitudes of momenta of the two protons? Why? (B) If the speeds of the two protons are 340 m/s and 450 m/s, respectively, what is the total momentum of the two-proton system?

8. How much momentum is acquired by a 75-kg skydiver in free fall in 2.0 minutes after jumping from the plane?

9. A 5.0-g bullet with a speed of 200 m/s is fired horizontally into a 0.75-kg wooden block at rest on a table. If the block containing the bullet slides a distance of 0.20 m before coming to rest, (a) what is the coefficient of kinetic friction between the block and the table? (b) What fraction of the bullet's energy is dissipated in the collision?

10. Two runners of mass 70 kg and 60 kg, respectively, have a total linear momentum of 350 kg m/s. The heavier runner is running at 2.0 m/s. Determine the possible velocities of the lighter runner.

11. A 0.20-kg billiard ball traveling at a speed of 15 m/s strikes the side rail of a pool table at an angle of 60°. If the ball rebounds at the same speed and angle, what is the change in its momentum?

12. Suppose the billiard ball in Fig. 6.31 approaches the rail at a speed of 15 m/s and an angle of 60°, as shown, but rebounds at a speed of 10 m/s and an angle of 50°. What is the change in momentum in this case?

13. A loaded tractor-trailer with a total mass of 5000 kg traveling at 3.0 km/h hits a loading dock and comes to a stop in 0.64 s. What is the magnitude of the average force exerted on the truck by the dock?

14. A 2.0-kg mud ball drops from rest at a height of 15 m. If the impact between the ball and the ground lasts 0.50 s, what is the average net force exerted by the ball on the ground?

16. A major league catcher catches a fastball moving at 95.0 mi/h and his hand and glove recoil 10.0 cm in bringing the ball to rest. If it took 0.00470 seconds to bring the ball (with a mass of 250 g) to rest in the glove, (a) what are the magnitude and direction of the change in momentum of the ball? (b) Find the average force the ball exerts on the hand and glove.

17. At a basketball game, a 120-lb cheerleader is tossed vertically upward with a speed of 4.50 m/s by a male cheerleader. (a) What is the cheerleader's change in momentum from the time she is released to just before being caught if she is caught at the height at which she was released? (b) Would there be any difference if she were caught 0.30 m below the point of release? If so, what is the change then?

18. A ball of mass 200 g is released from rest at a height of 2.00 m above the floor and it rebounds straight up to a height of 0.900 m. (a) Determine the ball's change in momentum due to its contact with the floor. (b) If the contact time with the floor was 0.0950 s, what was the average force the floor exerted on the ball, and in what direction?

19. When tossed upward and hit horizontally by a batter, a 0.20-kg softball receives an impulse of 3.0 N s. With what horizontal speed does the ball move away from the bat?

20. An automobile with linear momentum of 3.0×10^4 kg m/s is brought to a stop in 5.0 s. What is the magnitude of the average braking force?

21. A pool player imparts an impulse of 3.2 N s to a stationary 0.25-kg cue ball with a cue stick. What is the speed of the ball after just after impact?

22. For the karate chop in Fig. 6.27, assume that the hand has a mass of 0.35 kg and that the speeds of the hand just before and just after hitting the board are 10 m/s and 0, respectively. What is the average force exerted by the fist on the board if (a) the fist follows through, so the contact time is 3.0 ms, and (b) the fist stops abruptly, so the contact time is only 0.30 ms.

23. When bunting, a baseball player uses the bat to change both the speed and direction of the baseball. (a) Will the magnitude of the change in momentum of the baseball be before and after the bunt be (1) greater than the magnitude of the momentum of the baseball either before or after the bunt, (2) equal to the difference between the magnitudes of momenta of the baseball before and after the bunt, or (3) equal to the sum of the magnitudes of momenta of the baseball before and after the bunt? Why? (b) The base ball has a mass of 0.16 kg; its speed before and after the bunt are 15 m/s and 10 m/s, respectively; the bunt lasts 0.025 s. what is the change in momentum of the baseball? (c) What is the average force on the ball by the bat?

24. A car with a mass of 1500 kg is rolling on a level road at 30.0 m/s. It receives an impulse with a magnitude of 2000 N s and its speed is reduced as much as possible by an impulse of this size. (a) Was this impulse caused by (1) the driver hitting the accelerator, (2) the driver putting on the brakes, or (3) the driver turning the steering wheel? (b) What was the car's speed after the impulse was applied?

25. An astronaut (mass of 100 kg, with equipment) is headed back to her space station at a speed of 0.750 m/s but at the wrong angle. To correct her direction, she fires rockets from her backpack at right angles to her motion for a brief time. These directional rockets exert a constant force of 100.0 N for only 0.200 s. (a) What is the magnitude of the impulse delivered to the astronaut? (b) What is her new direction (relative to the initial direction)? (c) What is her new speed?

26. A volleyball is traveling toward you. (a) Which action will require a greater force on the volleyball, your catching the ball or your hitting the ball back? Why? (b) A 0.45-kg volleyball travels with a horizontal velocity of 4.0 m/s over the net. You jump up and hit the ball back with a horizontal velocity of 7.0 m/s. If the contact time is 0.040 s, what was the average force on the ball?

27. A boy catches – with bare hands and his arms rigidly extended - a 0.16-kg baseball coming directly toward him at a speed of 25 m/s. He emits an audible "ouch!", because the ball stings his hands. He learns quickly to move his hands with the ball as he catches it. If the contact time of the collision is increased from 3.5 ms to 8.5 ms in this way, how do the magnitudes of the average impulse forces compare?

28. A one-dimensional impulse force acts on a 3.0-kg object as diagrammed in Fig. 6.32. Find (a) the magnitude of the impulse given to the object, (b) the magnitude of the average force, and (c) the final speed if the object had an initial speed of 6.0 m/s.

29. A 0.45-kg piece of putty is dropped from a height of 2.5 m above a flat surface. When it hits the surface, the putty comes to rest in 0.30 s. What is the average force exerted on the putty by the surface?

30. A 50-kg driver sits in her car waiting for the traffic light to change. Another car hits her from behind in a head on, rear end collision and her car suddenly receives an acceleration of 16 m/s^2. If all of this takes place in 0.25 sec, (a) what is the impulse on the driver? (b) What is the average force exerted on the driver, and what exerts this force?

31. An incoming 0.14-kg baseball has a speed of 45 m/s. The batter hits the ball, giving it a speed of 60 m/s. If the contact time is 0.040 s, what is the average force of the bat on the ball.

32. At a shooting competition, a contestant fires and 12.0 g bullet leaves the rifle with a muzzle speed of 130 m/s. The bullet hits the thick target backing and stops after traveling 4.00 cm. Assuming a uniform acceleration, (a) what is the impulse on the target? (b) What is the average force on the target?

33. If the billiard ball in Fig. 6.31 is in contact with the rail for 0.010 s., what is the magnitude of the average force on the ball?

34. A 15000-N automobile travels at a speed of 45 km/h northwards along a street, and a 7500 N sports car travels at a speed of 60 km/h eastward along an intersecting street. (a) If neither driver brakes and the cars collide at the intersection and lock bumpers, what will the velocity of the cars be immediately after the collision? (b) What percentage of the initial kinetic energy will be lost in the collision?

35. In a simulated head-on crash test, a car impacts a wall at 25 mi/h (40 km/h) and comes abruptly to rest. A 120 lb passenger dummy (with a mass of 55 kg), without a seatbelt, is stopped by an air bag, which exerts a force on the dummy of 2400 lb. How long was the dummy in contact with the air bag while coming to a stop?

36. A baseball player pops a pitch straight up. The ball (mass 200 g) was traveling horizontally at 35.0 m/s just before contact with the bat, and 20.0 m/s just after contact. Determine the direction and magnitude of the impulse delivered to the ball by the bat.

37. A 60-kg astronaut floating at rest in space outside a space capsule throws his 0.50 kg hammer such that it moves with a speed of 10 m/s relative to the capsule. What happens to the astronaut?

38. In a pairs figure-skating competition, a 65 kg man and his 45 kg female partner stand facing each other on skates on the ice. If they push apart and the woman has a velocity of 1.5 m/s eastward, what is the velocity of her partner?

39. To get off a frozen, frictionless lake, a 65.0-kg person, takes off a 0.150-kg shoe and throws it horizontally, directly away from the shore with a speed of 2.00 m/s. If the person is 5.00 m from the shore, how long does he take to reach it?

40. An object initially at rest explodes and splits into three fragments. The first fragment flies off to the west, and the second fragment flies off south. The third fragment will fly off toward a general direction of (1) southwest (2) north of east, (3) either due north or due east. Why? (b) If the object has a mass of 3.0 kg, the first fragment has a mass of 0.50 kg and a speed of 2.8 m/s, and the second fragment has a mass of 1.3 kg and a speed of 1.5 m/s, what are the speed and direction of the third fragment?

41. Consider two string-suspended balls, both with a mass of 0.15 kg. One ball is pulled back in line with the other so it has a vertical height of 10cm, and is then released. (a) What is the speed of the ball just before hitting the stationary one? (b) If the collision is completely inelastic, to what height do the balls swing?

42. A cherry bomb-explodes into three pieces of equal mass. One piece has an initial velocity of 10 m/s x. Another piece has an initial velocity of 6.0 m/s x – 3.0 m/s y. What is the velocity of the third piece?

43. Two ice-skaters not paying attention collide in a completely inelastic collision. Prior to the collision, skater 1, with amass of 60 kg, has a velocity of 5.0 km/h eastward, and, moves at a right angle to skater 2, who has a mass of 75 kg and a velocity of 7.5 km/h southward. What is the velocity of the skaters after the collision?

44. Two balls of equal mass (0.50 kg) approach the origin along the positive x- and y-axes at the same speed (3.3 m/s). (a) What is the total momentum of the system? (b) Will the balls necessary collide at the origin? What is the total momentum of the system after both balls have passé through the origin?

45. A 1200-kg car moving to the right to the right with a speed of 25 m/s collides with a 1500 kg truck and locks bumpers with the truck. Calculate the velocity of the combination after the collision if the truck is initially (a) at rest (b) moving to the right with a speed of 20 m/s, and (c) moving to the left with a speed of 20 m/s.

46. A 10-g bullet moving horizontally at 400 m/s penetrates a 3.0 kg wood block resting on a horizontal surface. If the bullet slows down to 300 m/s after emerging from the block, what is the speed of the block immediately after the bullet emerges?

47. An explosion of a 10.0-kg bomb releases only two separate pieces. The bomb was initially at rest and a 4.00 kg piece travels westward at 100 m/s immediately after the explosion. (a) What is the speed and direction of the other piece immediately after the explosion? (b) How much kinetic energy was released in this explosion?

48. A 1600-kg (empty) truck rolls with a speed of 2.5 m/s under a loading bin, and a mass of 3500 kg is deposited in the truck. What is the truck's speed immediately after loading?

49. A new crowd control method utilizes “rubber” bullets instead f real ones. Suppose that, in a test, one of these "bullets" with a mass of 500 g is traveling at 250 m/s to the right. It hits a stationary target head-on. The target's mass is 25.0 kg and it rests on a smooth surface. The bullet bounces backward (to the left) off the target at 100 m/s. (a) Which way must the target move after the collision: (1) right, (2) left, (3) it could be stationary, or (4) you can’t tell from the data given? (b) Determine the recoil speed of the target after the collision.

50. For a movie scene, a 75-kg stuntman drops from a tree onto a 50 kg sled that is moving on a frozen lake with a velocity of 10 m/s toward the shore. (a) What is the speed of the sled after the stuntman is on board? (b) If the sled hits the bank and stops, but the stuntman keeps on going, with what speed does he leave the sled?

51. A 90-kg astronaut is stranded in space at a point 6.0 m from his spaceship, and he needs to get back in 4.0 min to control the spaceship. To get back, he throws a 0.50-kg piece of equipment so that it moves at a speed of 4.0 m/s directly away from the spaceship. (a) Does he get back in time? (b) How fast must he throw the piece of equipment so he gets back in time?

52. A projectile that is fired from a gun has an initial velocity of 90.0 km/h at an angle of 60.0^{o} above the horizontal. When the projectile is at the top of its trajectory, an internal explosion causes it to separate into two fragments of equal mass. One of the fragments falls straight downward as though it had been released from rest. How far from the gun does the other fragment land?

53. A moving shuffleboard puck has a glancing collision with a stationary puck of the same mass, as shown in Fig. 6.34. If friction is negligible, what are the speeds of the pucks after the collision?

54. A small asteroid (mass of 10 g) strikes a glancing blow at a satellite in empty space. The satellite was initially at rest and the asteroid traveling at 2000 m/s. The satellite's mass if 100 kg. The asteroid is deflected 10° from its original direction and its speed decreases to 1000 m/s, but neither object loses mass. Determine the (a) direction and (b) speed of the satellite after the collision.

55. A ballistic pendulum is a device used to measure the velocity of a projectile - for example, the muzzle velocity of a rifle bullet. The projectile is shot horizontally into, and becomes embedded in, the bob of a pendulum, as illustrated in Fig. 6.35. The pendulum swings upward to some height h, which is measured. The masses of the block and the bullet are known. Using the laws of momentum and energy, show that the initial velocity of the projectile is given by $v_0=[(m+M)/m]\sqrt{(2gh)}$

56. For the apparatus in Fig. 6.15, one ball swinging in at a speed of $2v_0$ will not cause two balls to swing out with speeds v_0. (a) Which law of physics precludes this situation from happening: the law of conservation of momentum or the law of conservation of mechanical energy? (b) Prove this law mathematically.

57. A proton of mass m mowing with a speed of 3.0×10^6 m/s undergoes a head-on elastic collision with an alpha particle of mass 4m, which is initially at rest. What are the velocities of the two particles after the collision?

58. A 4.0 kg ball with a velocity of 4.0 m/s in the +x-direction collides head-on elastically with a stationary 2.0 kg ball. What are the velocities of the balls after the collision?

59. A dropped rubber ball hits the floor with a speed of 8.0 m/s and rebounds to a height of 0.25 m. What fraction of the initial kinetic energy was lost in the collision?

60. At a county fair, two children ram each other head-on while riding on the bumper cars. Jill and her car, traveling left at 3.50 m/s, have a total mass of 325 kg. Jack and his car, traveling to the right at 2.00 m/s, have a total mass of 290 kg. Assuming the collision to be elastic, determine their velocities after the collision.

61. In a high-speed chase, a policeman's car bumps a criminal's car directly from behind to get his attention. The policeman's car is moving at 40.0 m/s to the right and has a total mass of 1800 kg. The criminal's car is initially moving in the same direction at 38.0 m/s. His car has a total mass of 1500 kg. Assuming an elastic collision, determine their two velocities immediately after the bump.

62. Fig. 6.36 shows a bird catching a fish. Assume that initially the fish jumps up and that the bird coasts horizontally and does not touch water with its feet or flap its wings. (a) Is this kind of collision (1) elastic, (2) inelastic, or (3) completely inelastic? Why? (b) If the mass of the bird is 5.0 kg, the mass of the fish is 0.80 kg, and the bird coasts with a speed of 6.5 m/s before grabbing, what is the speed of the bird after grabbing the fish?

63. A 1.0-kg object moving at 10 m/s collides with a stationary 2.0-kg object as shown in Fig. 6.37. If the collision is perfectly inelastic, how far along the inclined plain will the combined system travel?

64. In a pool game, a cue ball travelling at 0.75 m/s hits the stationary eight ball. The eight ball moves off with a velocity of 0.25 m/s at an angle of 37° relative to the cue ball's initial direction. Assuming that the collision is inelastic, at what angle will the cue ball be deflected, and what will be its speed?

65. Two balls approach each other as shown in Fig. 6.38, where m = 2.0 kg, v = 3.0 m/s, M = 4.0 kg, and V = 5.0 m/s. If the balls collide and stick together at the origin, (a) what are the components of the velocity v of the balls after the collision, and (b) what is the angle ϑ?

66. A car traveling east and a minivan traveling south collide in a completely inelastic collision at a perpendicular intersection. (a) Right after the collision, will the car and minivan move toward a general direction (south) of east, (2) north of west, (3) either due south or due east? Why? (b) If the initial speed of the 1500 kg car was 90.0 km/h and the initial speed of the 3000 kg minivan was 60.0 km/h, what is the velocity of the vehicles immediately after collision?

67. A 1.0-kg object moving at 2.0 m/s collides elastically with a stationary 1.0 kg object, similar to the situation shown in Fig. 6.37. How far will the initially stationary object travel along a 37° inclined plane?

68. A fellow student states that the total momentum of a three-particle (m_1 = 0.25 kg, m_2 = 0.20 kg, and m_3 = 0.33 kg) is initially zero, and he calculates that after an inelastic triple collision, the particles have velocities of 4.0 m/s at 0°, 6.0 m/s at 120°, and 2.5 m/s at 230°, respectively, measured from the +x-axis. Do you agree with his calculations? If not, assuming the first two answers to be correct, what should be the momentum of the third particle so the total momentum is zero?

69. A freight car with a mass of 25000 kg rolls down an inclined track through a vertical distance of 1.5. At the bottom of the incline, on a level track, the car collides and couples with an identical freight car that was at rest. What percentage of the initial kinetic energy is lost in the collision?

70. In nuclear reactors, subatomic particles called neutrons are slowed down by allowing them to collide with the atoms of a moderator material, such as carbon atoms, which are 12 times as massive as neutrons. (a) In a head-on elastic collision with a carbon atom, what percentage of a neutron's energy is lost? (b) If the neutron has an initial speed of 1.5×10^7, what will be its speed after collision?

71. In a noninjury chain-reaction accident on a foggy freeway, car 1 (mass of 2000 kg) moving at 15.0 m/s to right elastically collides with car 2, initially at rest. The mass of car 2 is 1500 kg. In turn, car 2 goes on to lock bumpers (that is, it is a completely inelastic collision) with car 3, which has a mass of 2500 kg and was also at rest. Determine the speed of all cars immediately after unfortunate accident.

72. Pendulum 1 is made of a 1.50-m string with a small Super Ball attached as a bob. It is pulled aside 30° and released. At the bottom of its arc, it collides with another pendulum bob of the same length, but the second pendulum has a bob made from a Super Ball whose mass is twice that of the bob of pendulum 1. Determine the angles to which both pendulums rebound (when they come to rest) after they collide and bounce back.

73. Show that the fraction of kinetic energy lost in a ballistic-pendulum collision (as in Fig. 6.35) is equal to M/(m+M).

74. (a) The center of mass of a system consisting of two 0.10–kg particles is located at the origin. If one of the particles is at (0, 0.45 m), where is the other? (b) If the masses are moved so their center of mass is located at (0.25 m, 0.15 m), can you tell where the particles are located?

75. (a) Find the center of mass of the Earth-Moon system. (b) Where is that center of mass relative to the surface of the Earth?

76. Find the center of mass of a system composed of three spherical objects with masses of 3.0 kg, 2.0 kg, and 4.0 kg and centers located at (-6.0m, 0), (1.0 m, 0), and (3.0 m, 0), respectively.

77. Rework Exercise 52, using the concept of the center of mass, and compute the distance the other fragment landed from the gun.

78. A 3.0-kg rod of length 5.0 m has an opposite ends point masses of 4.0 kg and 6.0 kg. (a) Will the center of mass of this system be (1) nearer to the 4.0 kg mass, (2) nearer to the 6.0 kg mass, or (3) at the center of the rod? Why? (b) Where is the center of mass of the system?

79. A piece of uniform sheet metal measures 25 cm by 25 cm. If a circular piece with a radius of 5.0 cm is cut from the center of the sheet, where is the sheet's center of mass now?

80. Locate the center of mass of the system shown in Fig. 6.39 (a) if all of the masses are equal; (b) if $m_2 = m_4 = 2m_1 = 2m_3$; (c) if m_1 = 1.0 kg, m_2 = 2.0 kg, m_3 = 3.0 kg, and m_4 = 4.0 kg.

81. Two cups are placed on a uniform board that is balanced on a cylinder (Fig. 6.40). The board has a mass of 2.00 kg and is 2.00 m long. The mass of cup 1 is 200 g and it is placed 1.05 m to the left of the balance point. The mass of cup 2 is 400 g. Where should cup 2 be placed for balance (relative to the right end of the board)?

82. Two skaters with masses of 65 kg and 45 kg, respectively, stand 8.0 m apart, each holding one end of a piece of rope. (a) If they pull themselves along the rope until they meet, how far does each skater travel? (Neglect friction.) (b) If only the 45-kg skater pulls along the rope until she meets her friend (who just holds onto the rope), how far does each skater travel?

83. Three particles, each with a mass of 0.25 kg, are located at (-4.0 m, 0), (2.0 m, 0) and (0, 3.0 m) and are acted on by forces F_1 = (-3.0 N)y, F_2 = (5.0 N)y, and F_3 = (4.0 N)x, respectively. Find the acceleration (magnitude and direction) of the center of mass of the system.

84. A 170-g hockey puck sliding on ice perpendicularly impacts a flat piece of sideboard. Its incoming momentum is 6.10 kg m/s. It rebounds along its incoming path after having suffered a momentum change (magnitude) of 8.80 kg m/s. (a) A. If the impact with the board took 35.0 ms, determine the average force (including direction) exerted by the puck on the board. (b) Determine the final momentum of the puck. (c) Was this collision elastic or in elastic? Prove your answer mathematically.

Chapter 7

1. The Cartesian coordinates of a point on a circle are (1.5 m, 2.0 m). What are the polar coordinates (r, ϑ) of this point?

2. The polar coordinates of a point are (5.3 m, 32°). What are the point's Cartesian coordinates?

3. Convert the following angles from degrees to radians, to two significant figures: (a) 15°, (b) 45°, (c) 95°, and (d) 120°.

4. Convert the following angles from radians to degrees: (a) π/6 rad, (b) 5π/12 rad, (c) 3π/4 rad, and (d) π rad.

5. Express the following angles in degrees, radians and/or revolutions (rev) as appropriate: (a) 105°, (b) 1.8 rad, and (c) 5/7 rev.

6. You measure the length of a distant car to be subtended by an angular distance of 1.5°. If the car is actually 5.0 m long, approximately how far away is the car?

7. How large an angle in radians and degrees does the diameter of the Moon subtend to a person on the Earth?

8. The hour, minute, and second hands on a clock are 0.25 m, 0.30 m, and 0.35 m long, respectively. What are the distances traveled by the tips of the hands in a 30-min interval?

9. A car with a 65-cm diameter wheel travels 3.0 km. How many revolutions does the wheel make in this distance?

10. Two gear wheels with radii of 25 cm and 60 cm have interlocking teeth. How many radians does the smaller wheel turn when the larger wheel turns 4.0 rev?

11. You ordered a 12-in pizza for a party of five. For the pizza to be distributed evenly, how should it be cut in triangular pieces?

12. To attend the 2000 Summer Olympics, a fan flew from Mosselbaai, South Africa (34° S, 22°E) to Sydney, Australia (34° S, 151° E). (a) What is the smallest angular distance the fan has to travel: (1) 34°, (2) 12°, (3) 117°, or (4) 129°? (b) Determine the appropriate shortest flight distance, in kilometers.

13. A bicycle wheel has a small pebble embedded in its tread. The rider sets the bike upside down, and accidentally bumps the wheel, causing the pebble to move through an arc length of 25.0 cm before coming to rest. In that time, the wheel spins 35°. (a) The radius of the wheel is therefore (1) more than 25.0 cm, (2) less than 25.0 cm, (3) equal to 25.0 cm. (b) Determine the radius of the wheel.

14. At the end of her routine, an ice skater spins through 7.50 revolutions with her arms always fully outstretched at right angles to her body. If her arms are 60.0 cm long, through what arc length distance do the tips of her fingers move during her finish?

15. (a) Could a circular pie be cut such that all of the wedge-shaped pieces have an arc length along the outer crust equal to the pie's radius? (b) If not, how many such pieces could you cut, and what would be the angular dimension of the final piece?

16. Electrical wire with a diameter of 0.50 cm is wound on a spool with a radius of 30 cm and a height of 24 cm. (a) Through how many radians must the spool be turned to wrap one even layer of wire? (b) What is the length of this wound wire?

17. A yo-yo with an axle diameter of 1.00 cm has a 90.0 cm length of string wrapped around it many times in such a way that the string completely covers the surface of its axle, but there are no double layers of string. The outermost portion of the yo-yo is 5.00 cm from the center of the axle. (a) If the yo-yo is dropped with the string fully wound, through what angle does it rotate by the time it reaches the bottom of its fall? (b) How much arc length has a piece of the yo-yo on its outer edge traveled by the time it bottoms out?

18. A computer DVD-ROM has a variable angular speed from 200 rpm to 450 rpm. Express this range of angular speed in radians per second.

19. A race car makes two and half laps around a circular track in 3.0 min. What is the car's average angular speed?

20. What are the angular speeds of the (a) second hand, (b) minute hand, and (c) hour hand of a clock? Are the speeds constant?

21. What is the period of revolution for (a) a 9500-rpm centrifuge and (b) a 9500-rpm computer hard disk drive?

22. Determine which has the greater angular speed: particle A, which travels 160° in 2.00 s, or particle B, which travels 4π rad in 8.00 s?

23. The tangential speed of a particle on a rotating wheel is 3.0 m/s. If the particle is 0.20 m from the axis of rotation, how long will the particle take to make one revolution?

24. A merry-go-round makes 24 revolutions in a 3.0-min ride. (a) What is its average angular speed in rad/s? (b) What are the tangential speeds of two people 4.0 m and 5.0 m from the center, or axis of rotation?

25. In Exercise 13, suppose the wheel took 1.20 s to stop after it was bumped. Assume as you face the plane of the wheel, it was rotating counterclockwise. During this time, determine (a) the average angular speed and tangential speed of the pebble, (b) the average angular speed and tangential speed of a piece of grease on the wheel's axle (radius 1.50 cm), and (c) the direction of their respective angular velocities.

26. The Earth rotates on its axis once a day and revolves around the Sun once a year. Which is greater the rotating angular speed or the revolving angular speed? Why? (b) Calculate both angular speeds in rad/s.

27. A little boy jumps onto a small merry-go-round (radius of 2.00 m) in a park and rotates for 2.30 s through an arc length of 2.55 m before coming to rest. If he landed (and stayed) at a distance of 1.75 m from the central axis of rotation of the merry-go-round, what was his average angular speed and average tangential speed?

28. The driver of a car sets the cruise control and ties the steering wheel so that the car travels at a uniform speed of 15 m/s in a circle with a diameter of 120 m. (a) Through what angular distance does the car move in 4.00 min? (b) What arc length does it travel in this time?

29. In a noninjury, noncontact skid on icy pavement on an empty road, a car spins 1.75 revolutions while it skids to a halt. It was initially moving at 15.0 m/s, and because of the ice it was able to decelerate at a rate of only 1.50 m/s^2. Viewed from above, the car spun clockwise. Determine its average angular velocity as it spun and slid to a halt.

30. An Indy car with a speed of 120 km/h goes around a level, circular track with a radius of 1.00 km. What is the centripetal acceleration of the car?

31. A wheel of radius 1.5 m rotates at a uniform speed. If a point on the rim of the wheel has a centripetal acceleration of 1.2 m/s^2, what is the point's tangential speed?

32. A rotating cylinder about 16 km long and 7.0 km in diameter is designed to be used as a space colony. With what angular speed must it rotate so that the residents on it will experience the same acceleration due to gravity on Earth?

33. An airplane pilot is going to demonstrate flying in a tight vertical circle. To ensure that she doesn't black out at the bottom of the circle, the acceleration must not exceed 4.0g. If the speed of the plane is 50 m/s at the bottom of the circle, what is the minimum radius of the circle so that the 4.0g limit is not exceeded?

34. Imagine that you swing about your head a ball attached to the end of a string. The ball moves at a constant speed in a horizontal circle. (a) Can the string be exactly horizontal? Why or why not? (b) If the mass of the ball is 0.250 kg, the radius is 1.5 m, and it takes 1.2 s for the ball to make one revolution, what is the ball's tangential speed? (c) What centripetal force are you imparting to the ball via the string?

35. In Exercise 34, if you supplied a tension force of 12.5 N to the string, what angle would the string make relative to the horizontal?

36. A car with a constant speed of 83.0 km/h enters a circular flat curve with a radius of curvature of 0.400 km. If the friction between the road and the car's tires can supply a centripetal acceleration of 1.25 m/s^2, does the car negotiate the curve safely? Justify the answer.

37. A student is to swing a bucket of water in a vertical circle without spilling any. (a) Explain how this task is possible. (b) If the distance from him shoulder to the centre of mass of the bucket of water is 1.0 m, what is the minimum speed required to keep the water from coming out of the bucket at the top of the swing?

38. In performing a “figure 8” maneuver, a figure skater wants to make the top part of the 8 approximately a circle of radius 2.20 m. He needs to glide through this part of the figure at approximately a constant speed, taking 4.50 s. His skates digging into the ice are capable of providing a maximum centripetal acceleration of

3.25 m/s^2. Will he be able to do this as planned? If not, what adjustment can he make if he wants this part of the figure to remain the same size?

39. A light string of length of 56.0 cm connects two small square blocks, each with a mass of 1.50 kg. The system is placed on a slippery (frictionless) sheet of horizontal ice and spun so that the two blocks rotate uniformly about their common center of mass, which itself does not move. They are supposed to rotate with a period of 0.750 s. If the string can exert a force of only 100 N before it breaks, determine whether this string will work.

40. A jet pilot puts an aircraft with a constant speed into a vertical circular loop. (a) Which is greater, the normal force exerted on the seat by the pilot at the bottom of the loop or that at the top of the loop? Why? (b) If the speed of the aircraft is 700 km/h and the radius of the circle is 2.0 km, calculate the normal forces exerted on the seat by the pilot at the bottom and top of the loop. Express your answer in terms of the pilot's weight.

41. A block of mass m slides down an inclined plane into a loop-the-loop of radius r. (a) Neglecting friction, what is the minimum speed the block must have at the highest point of the loop in order to stay in the loop? (b) At what vertical height on the inclined plane (in terms of the radius of the loop) must the block be released if it is to have the required minimum speed at the top of the hoop?

42. For a scene in a movie, a stunt driver drives a 1.50×10^3 kg SUV with a length of 4.25 m around a circular curve with a radius of curvature of 0.333 km. The vehicle is to be driven off the edge of a gully 10.0 m wide, and land on the other side 2.96 m below the initial side. What is the minimum centripetal acceleration the SUV must have in going around the circular curve to clear the gully and land on the other side?

43. Consider a simple pendulum of length L that has a small mass (the bob) of mass m attached to the end of its string. If the pendulum starts out horizontally and is released from rest, show that (a) the speed at the bottom of the swing is $v_{max} = \sqrt{(2gL)}$ and (b) the tension in the string at that point is three times the weight of the bob, or $T_{max} = 3mg$.

44. A CD originally at rest reaches an angular speed of 40 rad/s in 5.0 s.(a) What is the magnitude of its angular acceleration? (b) How many revolutions does the CD make in the 5.0 s?

45. A merry-go-round accelerating uniformly from rest achieves its operating speed of 2.5 rpm in 5 revolutions. What is the magnitude of its angular acceleration?

46. A flywheel rotates with an angular speed of 25 rev/s. As it is brought to rest with a constant acceleration, it turns 50 rev. (a) What is the magnitude of the angular acceleration? (b) How much time does it take to stop?

47. A car on a circular track accelerates from rest. (a) The car experiences (1) only angular acceleration, (2) only centripetal acceleration, (3) both angular and centripetal accelerations? Why? (b) If the radius of the track is 0.30 km and the magnitude of the constant angular acceleration is 4.5×10^{-3} rad/s^2, how long does the car take to make one lap around the track? © What is the total (vector) acceleration of the car when it has completed half of a lap?

48. Show that for a constant acceleration $\vartheta = \vartheta_0 + (\omega^2 - \omega_0^2)/2\alpha$

49. The blades of a fan running at low speed turn at 250 rpm. When the fan is switched to high speed, the rotation rate increases uniformly to 350 rpm in 5.75 s. (a) What is the magnitude of the angular acceleration of the blades? (b) How many revolutions do the blades go through while it is accelerating?

50. In the spin-dry cycle of a modern washing machine, a wet towel with mass of 1.50 kg is "stuck to" the inside surface of the perforated (to allow the water out) washing cylinder. To have decent removal of water, damp/ wet clothes need to experience a centripetal acceleration of at least 10g. Assuming this value, and that the cylinder has a radius of 35.0 cm, determine the constant angular acceleration of the towel required if the washing machine takes 2.50 s to achieve its final angular speed.

51. A pendulum swinging in a circular arc under the influence of gravity, as shown in Fig. 7.35, has both centripetal and tangential components of acceleration.. (a) If the pendulum bob has a speed of 2.7 m/s when the cord makes an angle of $\vartheta = 15°$ with the vertical, what are the magnitudes of the components at this time? (b) Where is the centripetal acceleration a maximum? What is the value of the tangential acceleration at that location?

52. A simple pendulum of length 2.00 m is released from a horizontal position. When it makes an angle of 30° from the vertical, determine (a) its angular acceleration, (b) its centripetal acceleration, and (c) the tension in the string. Assume the bob's mass is 1.50 kg.

53. From the known mass and radius of the Moon, compute the value of the acceleration due to gravity, g_M, at the surface of the Moon.

54. The gravitational forces of the Earth and the Moon are attractive, so there must be a point on a line joining their centers where the gravitational forces on an object cancel. How far is this distance from the Earth's center?

55. Four identical masses of 2.5 kg each are located at the corners of a square with 1.0-m sides. What is the net force on any one of the masses?

56. The average density of the Earth is 5.52 g/cm^3. Assuming this is a uniform density, compute the value of G.

57. A 100-kg object is taken to a height of 300 km above the Earth's surface. (a) What's the object's mass at this height? (b) What's the object's weight at this height?

58. A man has a mass of 75 kg on the Earth's surface. How far above the surface of the Earth would he have to go to "lose" 10% of his body weight?

59. It takes 27 days for the Moon to orbit the Earth in a nearly circular orbit of radius 3.80×10^5 km. (a) Show in symbol notation that the mass of the Earth can be found using these data. (b) Compute the Earth's mass and compare with the value given inside the back cover of the book

60. Two objects are attracting each other with a certain gravitational force. (a) If the distance between the objects is halved, the new gravitational force will (1) increase by a factor of 2, (2) increase by a factor of 4, (3) decrease by a factor of 2, (4) decrease by a factor of 4. Why? (b) If the original force between the two objects is 0.90 N, and the distance is tripled, what is the new gravitational force between the objects?

61. During the Apollo lunar explorations of the late 1960s and early 1970s, the main section of the spaceship remained in orbit about the Moon with one astronaut in it while the other two astronauts descended to the surface in the landing module. If the main section orbited about 50 mi above the lunar surface, determine that section's centripetal acceleration.

62. Referring to Exercise 61, determine (a) the gravitational potential energy, (b) the total energy, (c) the energy needed to "escape" the Moon for the main section of the lunar exploration mission in orbit. Assume the mass of this section is 5000 kg.

63. The diameter of the Moon's (nearly circular) orbit about the Earth is 3.6×10^5 km and it takes 27 days for one orbit. What is (a) the Moon's tangential speed, (b) its kinetic energy, (c) the system potential energy and system total energy?

64. (a) What is the mutual gravitational potential energy of the configuration shown in Fig. 7.36 if all the masses are 1.0 kg? (b) What is gravitational force per unit mass at the center of the configuration?

66. An instrument package is projected vertically upward to collect data near the top of the Earth's atmosphere (at an altitude of about 900 km). (a) What initial speed is required at the Earth's surface for the package to reach this height? (b) What percentage of the escape speed is this initial speed?

67. What is the orbital speed of a geosynchronous satellite?

68. In the year 2056, Martian Colony I wants to put a Mars-synchronous communication satellite in orbit about Mars to facilitate communications with the new bases being planned on the Red Planet. At what distance above the Martian equator would this satellite be placed?

69. The asteroid belt that lies between Mars and Jupiter may be the debris of a planet that broke apart or that was not able to form as a result of Jupiter’s strong gravitation. An average asteroid has a period of about 5.0 y. Approximately how far from the Sun would this "fifth" planet have been?

70. Using a development similar to Kepler’s law periods for planets orbiting the Sun, find the required altitude of geosynchronous satellites above the Earth.

71. Venus has a rotational period of 243 days. What would be the altitude of a synchronous satellite for this planet?

72. A small space probe is put into circular orbit about a newly discovered moon of Saturn. The moon's radius is known to be 550 km. If the probe orbits at a height of 1500 km above the moon's surface and takes 2.00 Earth days to make one orbit, determine the moon's mass.