PRACTICE PROBLEMS Hooke's Law, MHR Pg. 258

35. A spring scale is marked from 0 to 50 N. The scale is 9.5 cm long. What is the spring constant of the spring in the scale?

36. A slingshot has an elastic cord tied to a Y-shaped frame. The cord has a spring constant of 1.10×10^3 N/m. A force of 455 N is applied to the cord.
    (a) How far does the cord stretch?
    (b) What is the restoring force from the spring?

37. The spring in a typical Hooke's law apparatus has a force constant of 1.50 N/m and a maximum extension of 10.0 cm. What is the largest mass that can be placed on the spring without damaging it?

PRACTICE PROBLEMS Elastic Potential Energy, MHR Pg. 261

38. An object is hung from a vertical spring, extending it by 24 cm. If the spring constant is 35 N/m, what is the potential energy of the stretched spring?

39. An unruly student pulls an elastic band that has a spring constant of 48 N/m, producing a 2.2 J increase in its potential energy. How far did the student stretch the elastic band?

40. A force of 18 N compresses a spring by 15 cm. By how much does the spring's potential energy change?

PRACTICE PROBLEMS Kinetic Energy, MHR Pg. 238

19. A 0.100 kg tennis ball is travelling at 145 km/h. What is its kinetic energy?

20. A bowling ball, travelling at 0.95 m/s, has 4.5 J of kinetic energy. What is its mass?

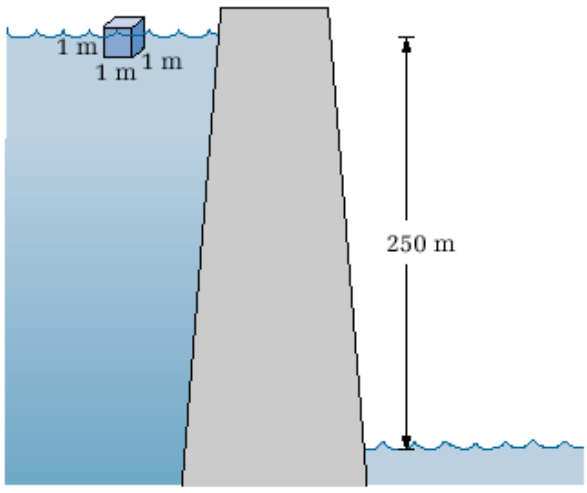
21. A 69.0 kg skier reaches the bottom of a ski hill with a velocity of 7.25 m/s. Find the kinetic energy of the skier at the bottom of the hill.

PRACTICE PROBLEMS Potential Energy, MHR Pg. 250

27. A framed picture that is to be hung on the wall is lifted vertically through a distance of 2.0 m. If the picture has a mass of 4.45 kg, calculate its gravitational potential energy with respect to the ground.

28. The water level in a reservoir is 250 m above the water in front of the dam. What is the potential energy of each cubic metre of surface water behind the dam? (Take the density of water to be 1.00 kg/L.)

29. How high would you have to raise a 0.300 kg baseball in order to give it 12.0 J of gravitational potential energy?



PRACTICE PROBLEMS — Work, MHR Pg. 221

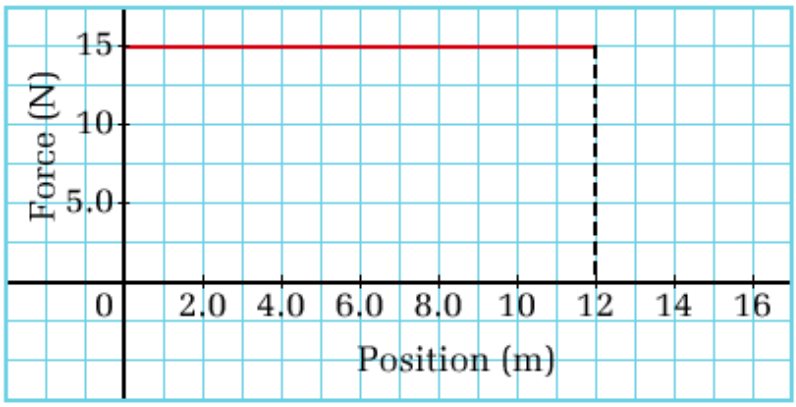
1. A weight lifter, Paul Anderson, used a circular platform attached to a harness to lift a class of 30 children and their teacher. While the children and teacher sat on the platform, Paul lifted them. The total weight of the platform plus people was 1.1×10^4 N. When he lifted them a distance of 52 cm, at a constant velocity, how much work did he do? How high would you have to lift one child, weighing 135 N, in order to do the same amount of work that Paul did?
2. A 75 kg boulder rolled off a cliff and fell to the ground below. If the force of gravity did 6.0×10^4 J of work on the boulder, how far did it fall?
3. A student in physics lab pushed a 0.100 kg cart on an air track over a distance of 10.0 cm, doing 0.0230 J of work. Calculate the acceleration of the cart. (Hint: Since the cart was on an air track, you can assume that there was no friction.)

PRACTICE PROBLEMS — Work, MHR Pg. 225

4. With a 3.00×10^2 N force, a mover pushes a heavy box down a hall. If the work done on the box by the mover is 1.90×10^3 J, find the length of the hallway.
5. A large piano is moved 12.0 m across a room. Find the average horizontal force that must be exerted on the piano if the amount of work done by this force is 2.70×10^3 J.
6. A crane lifts a 487 kg beam vertically at a constant velocity. If the crane does 5.20×10^4 J of work on the beam, find the vertical distance that it lifted the beam.
7. A teacher carries his briefcase 20.0 m down the hall to the staff room. The teacher's hand exerts a 30.0 N force upward as he moves down the hall at constant velocity.
   (a) Calculate the work done by the teacher's hand on the briefcase.
   (b) Explain the results obtained in part (a).
8. A 2.00×10^2 N force acts horizontally on a bowling ball over a displacement of 1.50 m. Calculate the work done on the bowling ball by this force.
9. The *Voyager* space probe has left our solar system and is travelling through deep space, which can be considered to be void of all matter. Assume that gravitational effects may be considered negligible when *Voyager* is far from our solar system.
   (a) How much work is done on the probe if it covers 1.00×10^6 km travelling at 3.00×10^4 m/s?
   (b) Explain the results obtained in part (a).
10. An energetic group of students attempts to remove an old tree stump for use as firewood during a party. The students apply an average upward force of 650 N. The 865 kg tree stump does not move after 15.0 min of continuous effort, and the group gives up.
    (a) How much work did the students do on the tree stump?
    (b) Explain the results obtained in part (a).

11. Determine the amount of work done by the forces represented in the four force-versus-position plots that follow.

A



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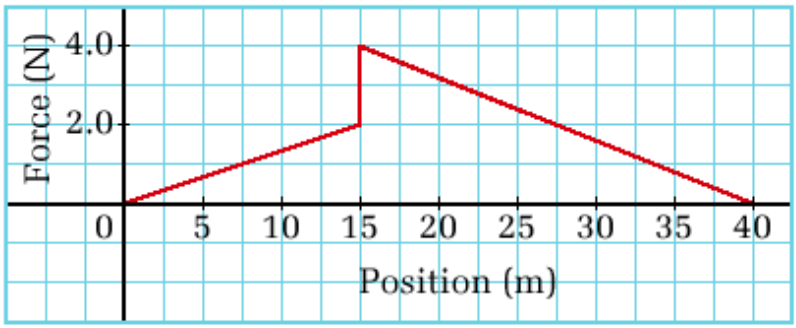

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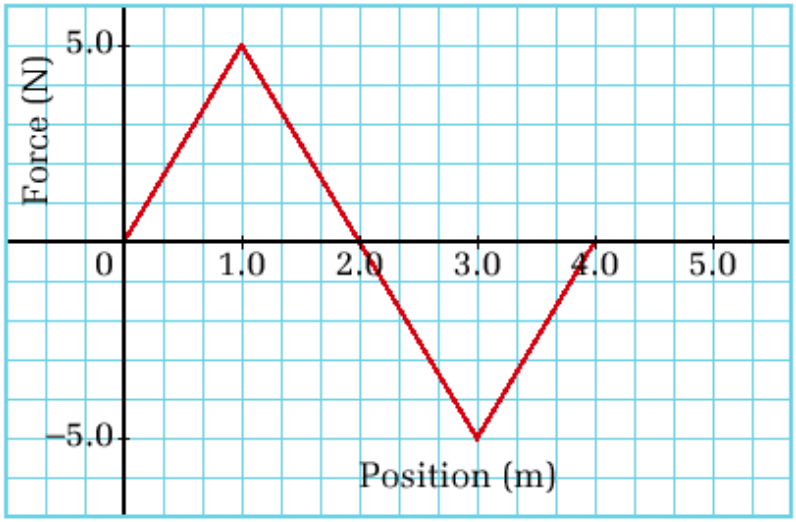


PRACTICE PROBLEMS — Work E_k Theorem, MHR Pg. 245

22. A 6.30 kg rock is pushed horizontally across a 20.0 m frozen pond with a force of 30.0 N. Find the velocity of the rock once it has travelled 13.9 m. (Assume there is no friction.)

23. The mass of an electron is 9.1×10^{-31} kg. At what speed does the electron travel if it possesses 7.6×10^{-18} J of kinetic energy?

24. A small cart with a mass of 500 g is accelerated, uniformly, from rest to a velocity of 1.2 m/s along a level, frictionless track. Find the kinetic energy of the cart once it has reached a velocity of 1.2 m/s. Calculate the force that was exerted on the cart over a distance of 0.1 m in order to cause this change in kinetic energy.

25. A child's toy race car travels across the floor with a constant velocity of 2.10 m/s. If the car possesses 14.0 J of kinetic energy, find the mass of the car.

Work E_g Theorem, MHR Pg. 254

PRACTICE PROBLEMS

30. A student lifts her 2.20 kg pile of textbooks into her locker from where they rest on the ground. She must do 25.0 J of work in order to lift the books. Calculate the height that the student must lift the books.

31. A 46.0 kg child cycles up a large hill to a point that is a vertical distance of 5.25 m above the starting position. Find

(a) the change in the child's gravitational potential energy

(b) the amount of work done by the child against gravity

32. A 2.50 kg pendulum is raised vertically 65.2 cm from its rest position. Find the gravitational potential energy of the pendulum.

33. A roller-coaster train lifts its passengers up vertically through a height of 39.4 m from its starting position. Find the change in gravitational potential energy if the mass of the train and its passengers is 3.90×10^3 kg.

Work - Energy - Power, MHR Pg. 266

PRACTICE PROBLEMS

41. A mover pushes a 25.5 kg box with a force of 85 N down a 15 m corridor. If it takes him 8.30 s to reach the other end of the hallway, find the power generated by the mover, in watts. (1.5×10^2 W)

42. A chair lift carries skiers uphill to the top of the ski run. If the lift is able to do 1.85×10^5 J of work in 12.0 s, what is the power of the chair lift in both watts and horsepower? (1.54×10^4 W, 20.6 hp)

43. A 75.0 kg student runs up two flights of stairs in order to reach her next class. The total height of the stairs is 5.75 m from the ground level. If the student can generate 200 W of power and has 20.0 s to reach her classroom at the top of the stairs, will the student be on time for class?

PRACTICE PROBLEMS — Work & Springs Pg. 306

9. A 1.2 kg dynamics cart is rolling to the right along a horizontal lab desk at 3.6 m/s, when it collides head on with a spring bumper that has a spring constant of 2.00×10^2 N/m.
   (a) Determine the maximum compression of the spring.
   (b) Determine the speed of the cart at the moment that the spring was compressed by 0.10 m.
   (c) Determine the acceleration of the cart at the moment that the spring was compressed 0.10 m.

10. A circus car with a clown has a total mass of 150 kg. It is coasting at 6.0 m/s, when it hits a large spring head on. If it is brought to a stop by the time the spring is compressed 2.0 m, what is the spring constant of the spring?

11. An archery bow has an effective spring constant of 485 N/m. The archer draws the bow a distance of 45.0 cm. If the arrow has a mass of 0.030 kg, what will be its speed at the moment it leaves the bow?

12. A 0.0250 kg mass on a frictionless surface is attached to a horizontal spring having a spring constant of 124 N/m. The spring is stretched to an amplitude of 9.00 cm and released. Find:
   (a) the maximum speed of the mass
   (b) the speed of the mass at 3.00 cm on either side of its equilibrium position.

13. A 0.150 kg mass on a frictionless surface is attached to a spring having a spring constant of 215 N/m. A motion detector determines that the mass is travelling at 15.0 m/s when it passes the equilibrium position.
   (a) What is the amplitude of the motion of the mass?
   (b) How much work was done to stretch the spring to its maximum amplitude?

14. An object on a frictionless surface is attached to a spring having a spring constant of 235 N/m. 50.0 J of work were done on the spring to stretch it to its maximum amplitude. As the mass passed through its equilibrium position, a motion detector determined that its speed was 14.6 m/s.
   (a) What was the mass of the object?
   (b) What was its amplitude?
   (c) What was the object's position when its speed was 5.00 m/s?

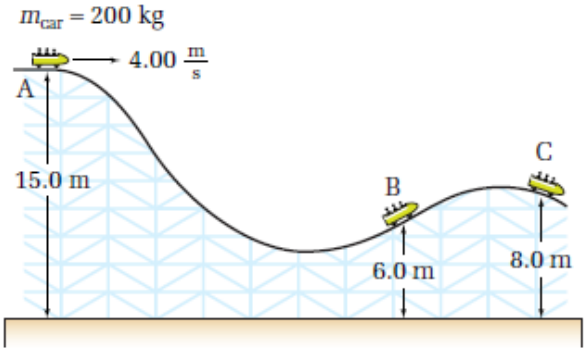
PRACTICE PROBLEMS — Work & Falling on a Spring Pg. 308

15. A 70.0 kg person steps through the window of a burning building and drops to a rescue net held 8.00 m below. If the surface of the net is 1.40 m above the ground, what must be the value of the spring constant for the net so that the person just touches the ground when the net stretches downward?

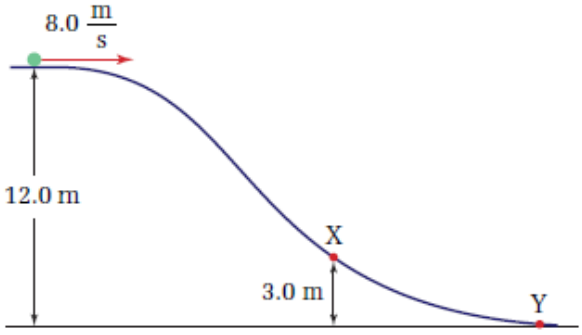
16. A 6.0 kg block is falling toward a spring located 1.80 m below. If it has a speed of 4.0 m/s at that instant, what will be the maximum compression of the spring? The spring constant is 2.000×10^3 N/m.

17. In a "head dip" bungee jump from a bridge over a river, the bungee cord is fastened to the jumper's ankles. The jumper then steps off and falls toward the river until the cord becomes taut. At that point, the cord begins to slow the jumper's descent, until his head just touches the water. The bridge is 22.0 m above the river. The unstretched length of the cord is 12.2 m. The jumper is 1.80 m tall and has a mass of 60.0 kg. Determine the
   (a) required value of the spring constant for this jump to be successful
   (b) acceleration of the jumper at the bottom of the descent

18. Determine the speed of the roller-coaster car in the sample problem at point C if point C is 8.0 m above the ground and another 4.00×10^2 J of heat energy are dissipated by friction between points B and C.



19. A sled at the top of a snowy hill is moving forward at 8.0 m/s, as shown in the diagram. The height of the hill is 12.0 m. The total mass of the sled and rider is 70.0 kg. Determine the speed of the sled at point X, which is 3.0 m above the base of the hill, if the sled does 1.22×10^3 J of work on the snow on the way to point X.



20. If the sled in the previous question reaches the base of the hill with a speed of 15.6 m/s, how much work was done by the snow on the sled between points X and Y?

21. A 0.50 kg basketball falls from a 2.3 m shelf onto the floor, then bounces up to a height of 1.4 m before you catch it.

(a) Calculate the gravitational potential energy of the ball before it falls.

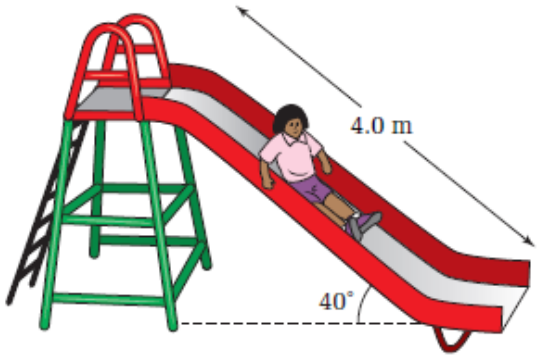
(b) Ignoring frictional effects, determine the speed of the ball as it strikes the floor, assuming that it fell from rest.

(c) How fast is the ball moving just before you catch it?

22. A 2.0 g bullet initially moving with a velocity of 87 m/s passes through a block of wood. On exiting the block of wood, the bullet's velocity is 12 m/s. How much work did the force of friction do on the bullet as it passed through the wood? If the wood block was 4.0 cm thick, what was the average force that the wood exerted on the block?

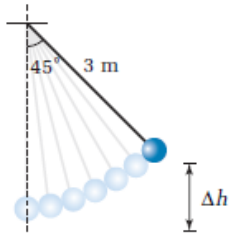
23. The Millennium Force, the tallest roller coaster in North America, is 94.5 m high at its highest point. What is the maximum possible speed of the roller coaster? The roller coaster's actual maximum speed is 41.1 m/s. What percentage of its total mechanical energy is lost to thermal energy due to friction?

24. A 15 kg child slides, from rest, down a playground slide that is 4.0 m long, as shown in the figure. The slide makes a 40° angle with the horizontal. The child's speed at the bottom is 3.2 m/s. What was the force of friction that the slide was exerting on the child?

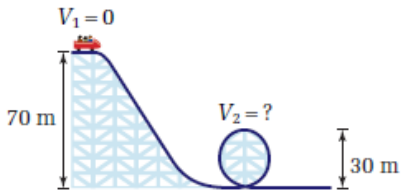


PRACTICE PROBLEMS Work Pg. 329

21. A 2.00 kg mass is attached to a 3.00 m string and is raised at an angle of 45° relative to the rest position, as shown. Calculate the gravitational potential energy of the pendulum relative to its rest position. If the mass is released, determine its velocity when it reaches its rest position.



22. A roller coaster at a popular amusement park has a portion of the track that is similar to the diagram provided. Assuming that the roller coaster is frictionless, find its velocity at the top of the loop.



23. A simple pendulum swings freely and rises at the end of its swing to a position 8.5 cm above its lowest point. What is its speed at its lowest point?

24. A 50.0 g pen has a retractable tip controlled by a button on the other end and an internal spring that has a constant of 1200 N/m. Suppose you hold the pen vertically on a table with the tip pointing up. Clicking the button into the table compresses the spring 0.50 cm. When the pen is released, how fast will it rise from the table? To what vertical height will it rise? (Assume for simplicity that the mass of the pen is concentrated in the button.)

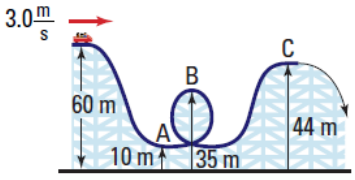
25. A spring with a spring constant of 950 N/m is compressed 0.20 m. What speed can it give to a 1.5 kg ball when it is released?

26. A 48.0 kg in-line skater begins with a speed of 2.2 m/s. Friction also does –150 J of work on her. Assume that she did not push on the ground any more. If her final speed is 5.9 m/s,
(a) determine the change (final – initial) in her gravitational potential energy.
(b) By how much, and in which direction (up or down), has her height changed?

PRACTICE PROBLEMS Work Review Pg. 332

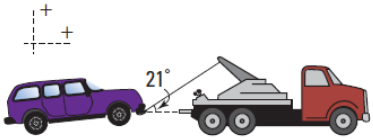
38. How fast will a 2.55 kg bowling ball be travelling if the 358 J of work done to the ball are transformed into kinetic energy?

39. A 250 kg roller coaster cart loaded with people has an initial velocity of 3.0 m/s. Find the velocity of the cart at A, B, and C. Assume that friction is negligible.



40. A 45 kg cyclist travelling 15 m/s on a 7.0 kg bike brakes suddenly and slides to a stop in 3.2 m.
(a) Calculate the work done by friction to stop the cyclist.
(b) Calculate the coefficient of friction between the skidding tires and the ground.
(c) Are you able to determine if the tires were digging into the ground from your answer in part (b)? Explain.

41. A tow truck pulls a car by a cable that makes an angle of 21° to the horizontal. The tension in the cable is 6.5×10^3 N.



(a) How large is the force that causes the car to move horizontally?
(b) How much work has the tow truck done on the car after pulling it 3.0 km?

44. An 8.0 kg stone falls off a 10.0 m cliff.
(a) How much work is done on it by the gravitational force?
(b) How much gravitational potential energy does it lose?

45. You are in a 1400 kg car, coasting down a 25° slope. When the car's speed is 15 m/s, you apply the brakes. If the car is to stop after travelling 75 m, what constant force (parallel to the road) must be applied?

46. An archery bow has a spring constant of 1.9×10^2 N/m. By how much does its elastic potential energy increase if it is stretched (a) 5.0 cm and (b) 71.0 cm?

PRACTICE PROBLEMS

Work Review Pg. 332

47. You exert 72 N to compress a spring with a spring constant of 225 N/m a certain distance.
- **(a)** What distance is the spring displaced?
- **(b)** What is the elastic potential energy of the displaced spring?

48. A 2.50 kg mass is attached to one end of a spring on a horizontal, frictionless surface. The other end of the spring is attached to one end of a spring is attached to a solid wall. The spring has a spring constant of 75.0 N/m. The spring is stretched to 25.0 cm from its equilibrium point and released.
- **(a)** What is the total energy of the mass-spring system?
- **(b)** What is the velocity of the mass when it passes the equilibrium position?
- **(c)** What is the elastic potential energy stored in the spring when the mass passes a point that is 15.0 cm from its equilibrium position?
- **(d)** What is the velocity of the spring when it passes a point that is 15.0 cm from its equilibrium position?

49. A 275 g ball is resting on top of a spring that is mounted to the floor. You exert a force of 325 N on the ball and it compresses the spring 44.5 cm. If you release the ball from that position, how high, above the equilibrium position of the spring-ball system will the ball rise?

50. A 186 kg cart is released at the top of a hill.
- **(a)** How much gravitational potential energy is lost after it descends through a vertical height of 8.0 m?
- **(b)** If the amount of friction acting on the cart is negligible, determine the kinetic energy and the speed of the cart after it has descended through a vertical height of 8.0 m.

51. A small 95 g toy consists of a piece of plastic attached to a spring with a spring constant of 365 N/m. You compress the spring against the floor through a displacement of 5.5 cm, then release the toy. How fast is it travelling when it rises to a height of 10.0 cm?

52. Suppose a 1.5 kg block of wood is slid along a floor and it compresses a spring that is attached horizontally to a wall. The spring constant is 555 N/m and the block of wood is travelling 9.0 m/s when it hits the spring. Assume that the floor is frictionless and the spring is ideal.
- **(a)** By how much does the block of wood compress the spring?

53. A spring with a spring constant of 120 N/m is stretched 5.0 cm from its rest position.
- **(a)** Calculate the average force applied.
- **(b)** Calculate the work done.
- **(c)** If the spring is then stretched from its 5.0 cm position to 8.0 cm, calculate the work done.
- **(d)** Sketch a graph of the applied force versus the spring displacement to show the extension of the spring. Explain how you can determine the amount of work done by analyzing the graph.

54. A 32.0 kg child descends a slide 4.00 m high. She reaches the bottom with a speed of 2.40 m/s. Was the mechanical energy conserved? Explain your reasoning and identify the energy transformations involved.

55. A 2.5 kg wooden block slides from rest down an inclined plane that makes an angle of 30° with the horizontal.
- **(a)** If the plane is frictionless, what is the speed of the block after slipping a distance of 2.0 m?
- **(b)** If the plane has a coefficient of kinetic friction of 0.20, what is the speed of the block after slipping a distance of 2.0 m?

Conservation of Energy Problems

1. A 200 g stone is whirled in a circle on a string 1.50 m long. It takes 1.20 s to make one revolution. Calculate:

   a) the kinetic energy of the stone.

   b) the centripetal force acting on the stone.

   c) the work done by the centripetal force in one revolution.

2. A car with a mass of 1200 kg goes around a 90° corner with a radius of 10.0 m in a time of 4.50 s. The total frictional forces acting on the care are 10.0 kN. Calculate:

   a) the kinetic energy of the car.

   b) the centripetal force acting on the car.

   c) the work done by the car's motor keeping the car going at a constant speed around the corner.

3. A model airplane with a mass of 5.60 kg is flying in a circle with a radius of 22.0 m. The airplane is flying once around the circle every 7.25 s. Calculate:

   a) the kinetic energy of the airplane.

   b) the centripetal force acting on the airplane.

   c) the work done by the centripetal force as it flies halfway around the circle.

4. A 2000 kg car goes through a 90° corner with a radius of 10.0 m in a time of 1.53 s. Calculate:

   a) the centripetal force acting on the car.

   b) the kinetic energy of the car.

   c) the work done on the car by the centripetal force.

5. A 950 g model train goes around a 90° corner with a radius of 1.50 m at a constant speed of 2.16 m/s. The force of friction acting on the train is 5.90 N. Calculate the work done on the train:

   a) by the motor.

   b) by the tracks.

6. A 3.50 kg mass with a kinetic energy of 43.75 J goes through a 90° corner with a radius of 1.25 m. If the centripetal force acting on the mass in the corner is 70.0 N, calculate the velocity of the mass as it leaves the corner.

7. An object starts at rest and is subjected to a force over a distance of 7.00 m. After the object is free of the above force, a 224 N force can turn the object through a 90° corner with a radius of 0.25 m. How great was the initial force?

8. A model train car is coasting (no driving force) on a circular track. Initially the centripetal force necessary to keep the car going around the track is 5.00 N. If after the car has gone halfway around the circle the necessary force has been reduced to 1.86 N, what force of friction must be acting on the car?

9. A model train is on a circular track. The force of friction is 5.60 N. The train started at rest and was driven by a force of 10.0 N for a distance of 0.454 m. The driving force was then reduced and held constant at 5.60N. The centripetal force that must be provided by the track is 2.00 N. Calculate the circumference of the track.

10. A toy pop gun is going to fire plastic 10.0 g bullets. When it is loaded the spring is compressed 7.00cm. The equation for this spring is F = 30.0x.

a) At what speed will the gun fire the bullets?

b) How much force will be required to load the gun?

11. A toy cannon is to be designed to shoot 100 g projectiles at 5.00 m/s. The projectiles are to be powered by a spring. There is only 15.0 cm of barrel length for the spring to propel the projectile.

a) What must the k-value of the spring be?

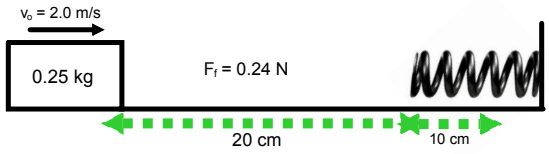
b) How much force will it take to load the cannon?

12. A spring, F = 100x, is used to fire 100 g darts from a gun. If when the fun is loaded the spring is compressed 10.0 cm, calculate the velocity the darts will have as they leave the gun.

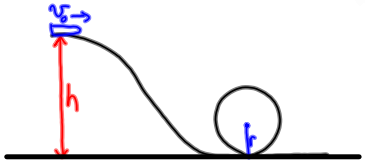
13. In the given diagram, the 0.250 kg mass is 20.0 cm away from the spring bumper moving towards it at 2.00 m/s/ The force of friction between the mass and the surface on which it is sliding is 0.240 N. If the mass compresses the spring 10.0 cm determine:

a) the k-value of the spring.

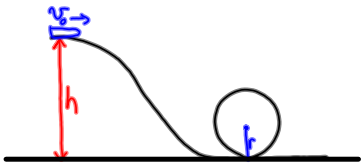
b) how fast the mass will be moving as it leaves the spring.



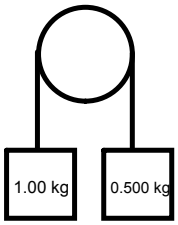
14. A roller coaster is to be constructed such that, starting from rest, a car will survive a 15 m radius loop. Assuming negligible friction, calculate the starting height of the roller coaster.



15. A car atop a roller coaster sits at rest 42 m above ground level. What is the largest circular loop it can survive. There is no friction and the base of the loop is at ground level.



16. Both masses start at rest and the pulley is frictionless. Calculate the velocity of each mass when the 0.500 kg mass is 1.00 m above the 1.00 kg mass.



17. A 2.00 kg ball is dropped from a height of 10.0 m.

a) what is the initial potential energy of the ball?

b) What is the potential energy of the ball 4.00 m into its fall?

c) Neglecting air resistance, with what speed would the ball hit the ground?

d) If the ball actually hit the ground at a speed of 12.0 m/s, what was the average air drag force?

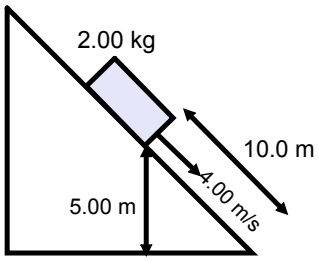
18. A 200 g golf ball is dropped from a window 12.0 m above the ground. Calculate:

a) how far the ball has fallen when the speed is 7.50 m/s.

b) the speed when it hits the ground.

c) the air resistance force acting on the ball if when it is at a height of 2.00 m it is moving 12.0 m/s.

19. Calculate the velocity at the bottom of the ramp if the force of friction acting on the mass is 3.30 N. See the image to the right for the initial values.



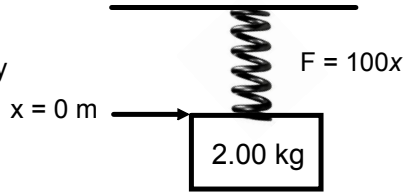
20. A 2.00 kg object is dropped 1.80 m on to a platform which is supported by a strong spring.

a) How fast is the object falling just as it hits the platform?

b) If the object sticks to the platform, and compresses the spring 70.0 cm, calculate the k-value of the spring.

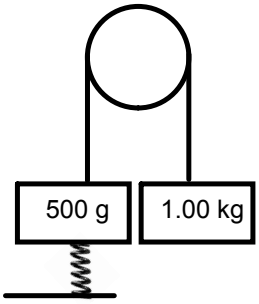
21. If when a 200 g mass is dropped 2.00 m, it sticks to a platform and compresses it 20.0 cm, calculate the k-value.

22. The mass in the image to the right starts at rest and the spring attached to the mass starts at its normal length. Calculate the velocity the mass will have after if falls 10.0 cm.

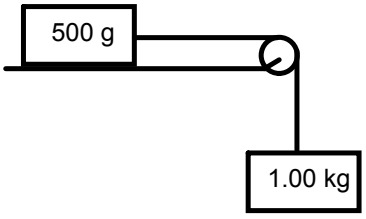


23. A spring that has a constant of 24.5 N/m is hung vertically on a stand. A 500 g mass is attached to the bottom of the spring (similar to the setup in the previous problem). The spring is stretched a bit and then the mass is allowed to drop. If the mass falls 10.0 cm, calculate how much the spring was stretched at the beginning of the fall.

24. In the given diagram to the right the pulley is frictionless and the force equation for the given spring is $F = 98x$. If the system starts at rest with the spring at its normal length, x = 0 m, calculate the velocity of the 1.00 kg mass after it has fallen 10.0 cm.



25. If the force of friction on the table is 2.80 N, and the pulley is frictionless; calculate how far the 1.00 kg mass must fall to five the 500 g mass a velocity of 2.50 m/s if both masses start at rest.



26. In the given diagram, the pulley is frictionless and the force of friction between the 500 g mass and the table is 4.80 N. The force equation for the spring is $F = 50x$. If the system starts at rest with the spring at its normal length, calculate the maximum speed the 1.0 kg mass will reach.