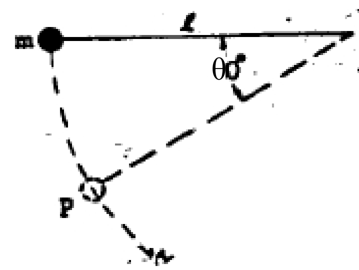
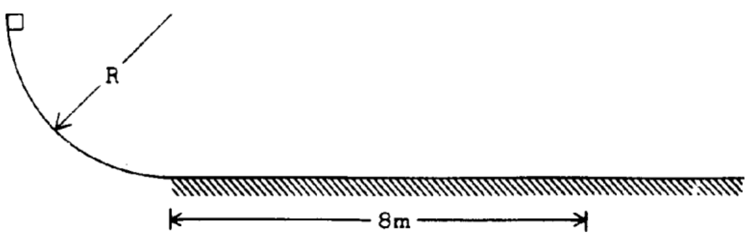
AP Physics Free Response Practice – Work Power Energy

1) A pendulum consisting of a small heavy ball of mass m at the end of a string of length L is released from a horizontal position. When the ball is at point P, the string forms an angle of θ with the horizontal as shown.

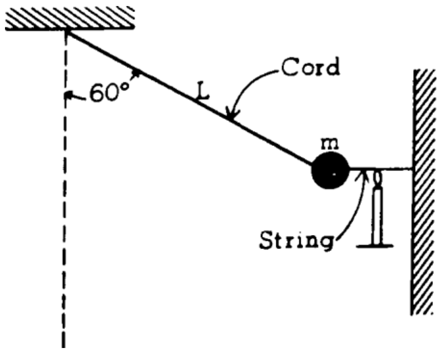


a) Draw a force diagram showing all of the forces acting on the ball at P. Identify each force clearly.
b) Determine the speed of the ball at P.
c) Determine the tension in the string when the ball is at P.



2) A 2-kilogram block is released from rest at the top of a curved incline in the shape of a quarter of a circle of radius R. The block then slides onto a horizontal plane where it finally comes to rest 8 meters from the beginning of the plane. The curved incline is frictionless, but there is an 8-newton force of friction on the block while it slides horizontally. Assume g = 10 meters per second^2.

a) Determine the magnitude of the acceleration of the block while it slides along the horizontal plane.
b) How much time elapses while the block is sliding horizontally?
c) Calculate the radius of the incline in meters.



3) A pendulum consists of a small object of mass m fastened to the end of an inextensible cord of length L. Initially, the pendulum is drawn aside through an angle of 60° with the vertical and held by a horizontal string as shown in the diagram above. This string is burned so that the pendulum is released to swing to and fro.

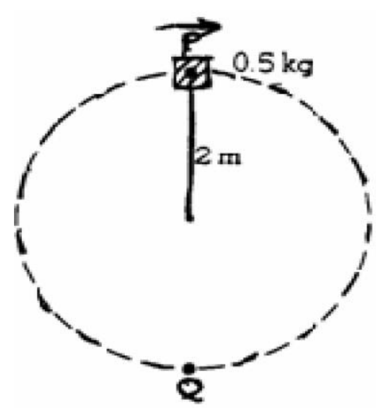
a) Draw a force diagram identifying all of the forces acting on the object while it is held by the string.
b) Determine the tension in the cord before the string is burned.

4) A block of mass 4 kilograms, which has an initial speed of 6 meters per second at time t = 0, slides on a horizontal surface.

a. Calculate the work W that must be done on the block to bring it to rest.

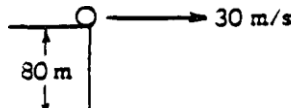
If a constant friction force of magnitude 8 newtons is exerted on the block by the surface, determine the following:

b. The speed v of the block as a function of the time t.
c. The distance x that the block slides as it comes to rest



5) A 0.50 kilogram object rotates freely in a vertical circle at the end of a string of length 2.0 meters as shown above. As the object passes through point P at the top of the circular path, the tension in the string is 20. newtons. Assume g = 10 meters per second squared.

(a) Draw the free body diagram on the object when it is at the point P.
(b) Calculate the speed of the object at point P.
(c) Calculate the increase in kinetic energy of the object as it moves from point P to point Q.
(d) Calculate the tension in the string as the object passes through point Q.

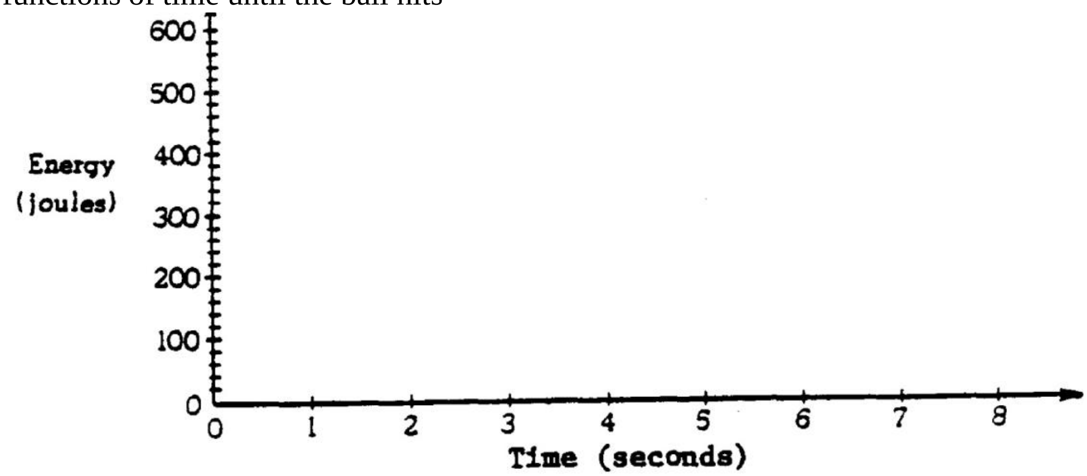


6) From the top of a cliff 80. meters high, a ball of mass 0.40 kilogram is launched horizontally with a velocity of 30. meters per second at time t = 0 as shown above. The potential energy of the ball is zero at the bottom of the cliff. Use g = 10 meters per second squared.

a. Calculate the potential, kinetic, and total energies of the ball at time t = 0.

b. On the axes below, sketch and label graphs of the potential, kinetic, and total energies of the ball as functions of the distance fallen from the top of the cliff

c. On the axes below sketch and label the kinetic and potential energies of the ball as functions of time until the ball hits



7) Two 10. kilogram boxes are connected by a massless string that passes over a massless frictionless pulley as shown above. The boxes remain at rest, with the one on the right hanging vertically and the one on the left 2.0 meters from the bottom of an inclined plane that makes an angle of 60.° with the horizontal. The coefficients of kinetic friction and static friction between the left-hand box and the plane are 0.15 and 0.30, respectively. You may use $g = 10 \text{ m/s}^2$

a. What is the tension T in the string?

b. Draw the FBD for the box that is on the plane.

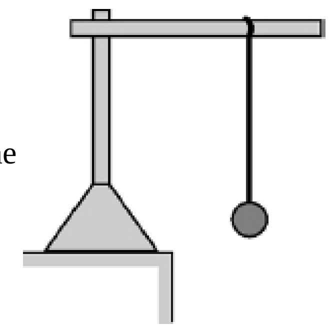
c. Determine the magnitude of the frictional force acting on the box on the plane.

The string is then cut and the left-hand box slides down the inclined plane.

d. Determine the amount of mechanical energy that is converted into thermal energy during the slide to the bottom.

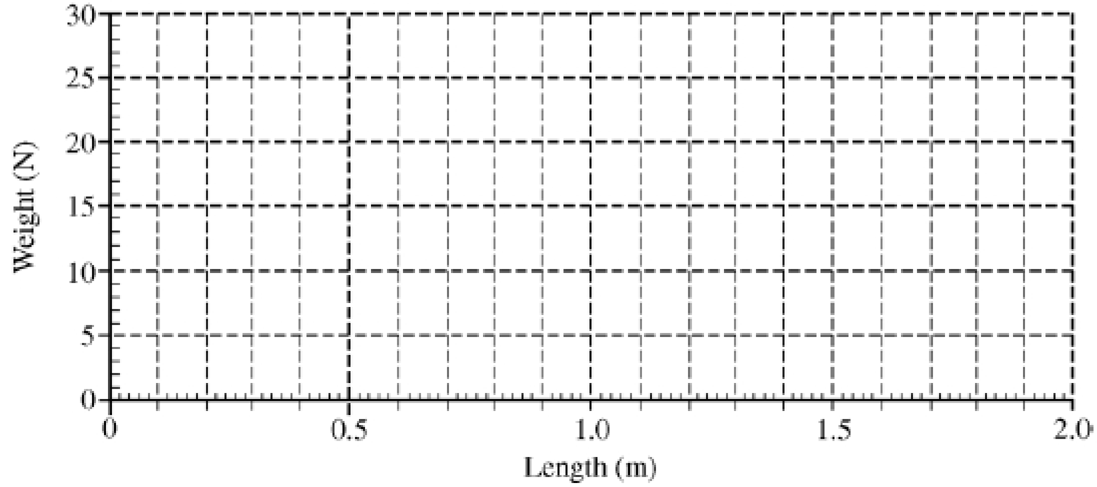
e. Determine the kinetic energy of the left-hand box when it reaches the bottom of the plane.

8) In an experiment to determine the spring constant of an elastic cord of length 0.60 m, a student hangs the cord from a rod as represented above and then attaches a variety of weights to the cord. For each weight, the student allows the weight to hang in equilibrium and then measures the entire length of the cord. The data are recorded in the table below:



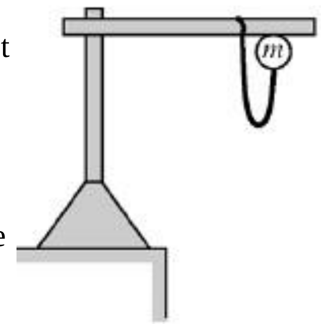
Weight (N)	0	10	15	20	25
Length (m)	0.60	0.97	1.24	1.37	1.64

a) Use the data to plot a graph of weight versus length on the axes below. Sketch a best-fit straight line through the data.



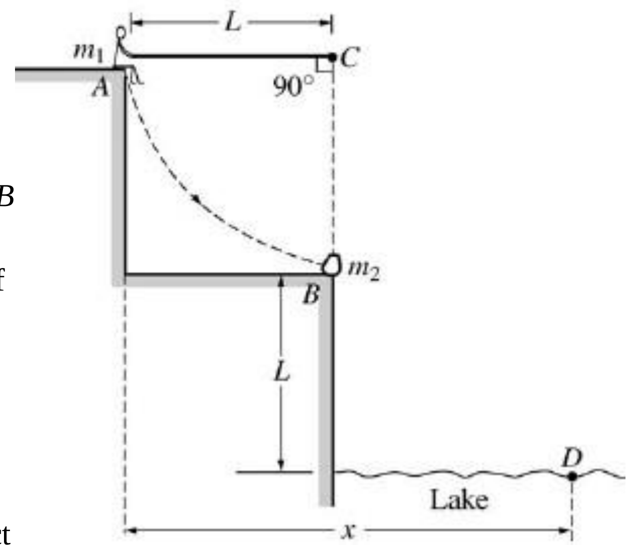
b) Use the best-fit line you sketched in part (a) to determine an experimental value for the spring constant *k* of the cord.

The student now attaches an object of unknown mass *m* to the cord and holds the object adjacent to the point at which the top of the cord is tied to the rod, as shown. When the object is released from rest, it falls 1.5 m before stopping and turning around. Assume that air resistance is negligible.

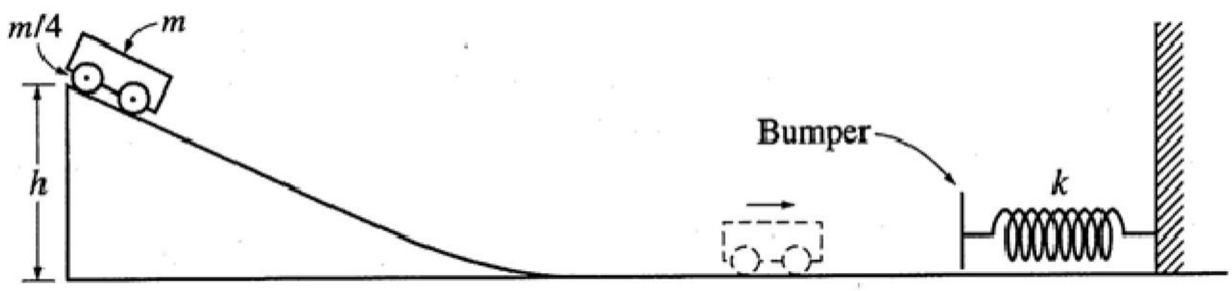


c) Calculate the value of the unknown mass *m* of the object.
d) Determine the magnitude of the force in the cord when the when the mass reaches the equilibrium position.
e) Determine the amount the cord has stretched when the mass reaches the equilibrium position.

9) A rope of length *L* is attached to a support at point *C*. A person of mass m_1 sits on a ledge at position *A* holding the other end of the rope so that it is horizontal and taut, as shown. The person then drops off the ledge and swings down on the rope toward position *B* on a lower ledge where an object of mass m_2 is at rest. At position *B* the person grabs hold of the object and simultaneously lets go of the rope. The person and object then land together in the lake at point *D*, which is a vertical distance *L* below position *B*. Air resistance and the mass of the rope are negligible. Derive expressions for each of the following in terms of m_1, m_2, *L*, and *g*

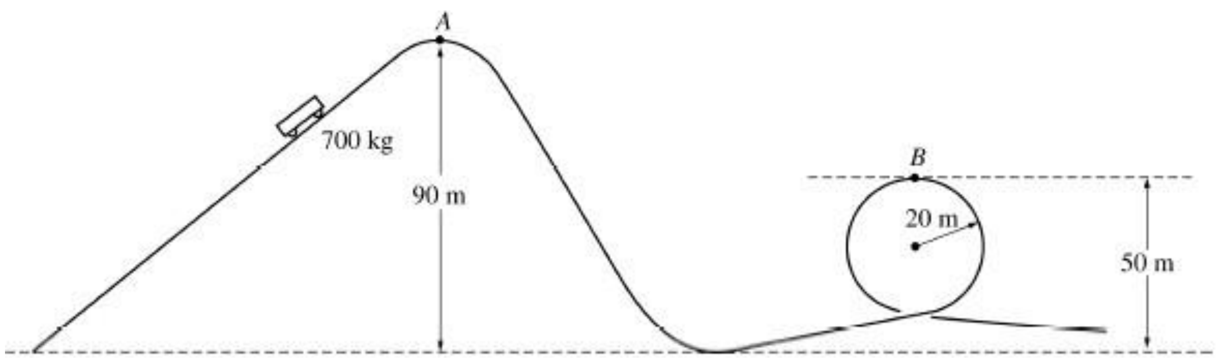


a) The speed of the person just before the collision with the object
b) The tension in the rope just before the collision with the object
c) After the person hits and grabs the rock, the speed of the combined masses is determined to be v'. In terms of v' and the given quantities, determine the total horizontal displacement *x* of the person from position *A* until the person and object land in the water at point *D*.



10) The cart shown above has a mass 2m. The cart is released from rest and slides from the top of an inclined frictionless plane of height h. Express all algebraic answers in terms of the given quantities and fundamental constants.

a) Determine the speed of the cart when it reaches the bottom of the incline.
b) After sliding down the incline and across the frictionless horizontal surface, the cart collides with a bumper of negligible mass attached to an ideal spring, which has a spring constant k. Determine the distance x_m the spring is compressed before the cart and bumper come to rest.



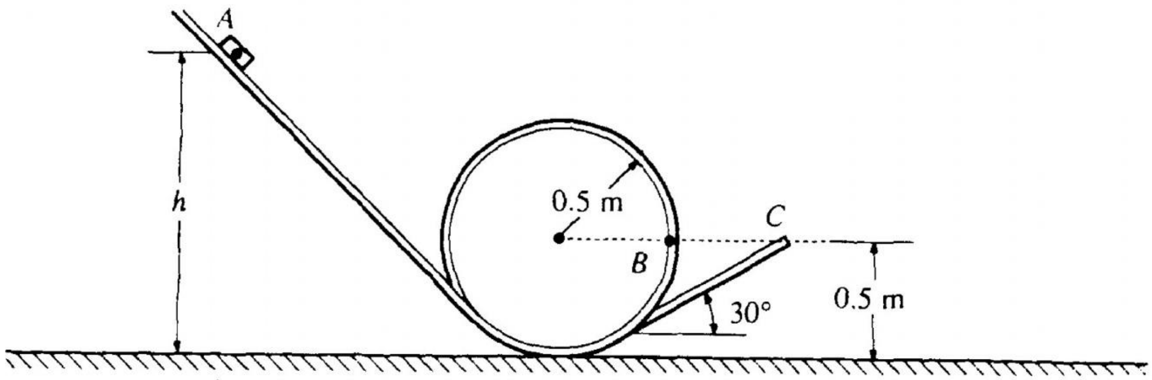
11) A roller coaster ride at an amusement park lifts a car of mass 700 kg to point *A* at a height of 90 m above the lowest point on the track, as shown above. The car starts from rest at point *A*, rolls with negligible friction down the incline and follows the track around a loop of radius 20 m. Point *B*, the highest point on the loop, is at a height of 50 m above the lowest point on the track.

a)
   i) Indicate on the figure the point *P* at which the maximum speed of the car is attained.
   ii) Calculate the value v_{msx} of this maximum speed.

b) Calculate the speed v_B of the car at point *B*.

c)
   i) Draw the forces acting on the car when it is upside down at point *B*.
   ii) Calculate the magnitude of all the forces identified in (c) i

d) Now suppose that friction is not negligible. How could the loop be modified to maintain the same speed at the top of the loop as found in (b)? Justify your answer.



12. A 0.10 kilogram block is released from rest at point A as shown above, a vertical distance h above the ground. It slides down an inclined track, around a circular loop of radius 0.5 meter, then up another incline that forms an angle of 30.° with the horizontal. The block slides off the track with a speed of 4.0 m/s at point C, which is a height of 0.50 meter above the ground. Assume the entire track to be frictionless and air resistance to be negligible. (use 2 sig figs!)

    a. Determine the height h

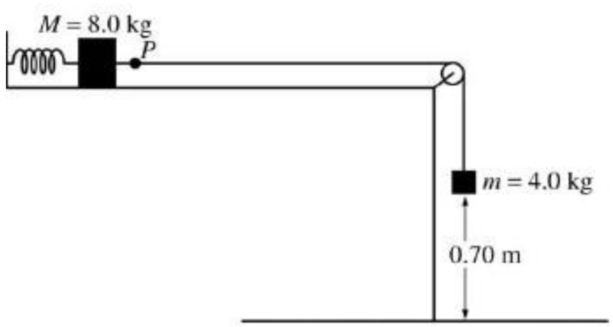
    b. Draw and label all the forces acting on the block when it is at point B. which is 0.50 meter above the ground.

    c. Determine the magnitude of the velocity of the block when it is at point B

    d. Determine the magnitude of the force exerted by the track on the block when it is at point B.

    e. Determine the maximum height above the ground attained by the block after it leaves the track.

    f. Another track that has the same configuration, but is **NOT** frictionless, is used. With this track it is found that if the block is to reach point C with a speed of 4.0 m/s, the height h must be 2.0 meters. Determine the work done by the frictional force



13. An ideal spring of unstretched length 0.20 m is placed horizontally on a frictionless table as shown above. One end of the spring is fixed and the other end is attached to a block of mass M = 8.0 kg. The 8.0 kg block is also attached to a massless string that passes over a small frictionless pulley. A block of mass m = 4.0 kg hangs from the other end of the string. When this spring-and-blocks system is in equilibrium, the length of the spring is 0.25 m and the 4.0 kg block is 0.70 m above the floor.

a. Draw free-body diagrams showing and labeling the forces on each block when the system is in equilibrium.

b. Calculate the tension in the string.

c. Calculate the force constant of the spring.

The string is now cut at point *P*.

d. Calculate the time taken by the 4.0 kg block to hit the floor.