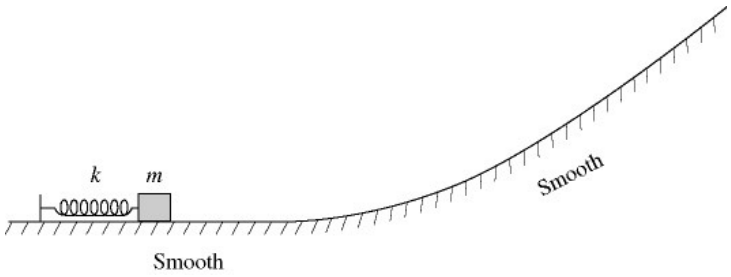
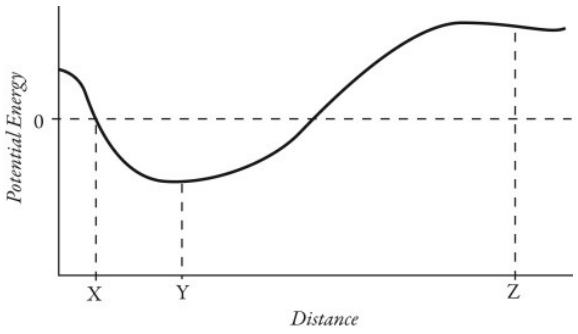
POTENTIAL ENERGY AND ENERGY CONSERVATION

1. **Shooting the box:** A box of mass m is pressed against (but is not attached to) an ideal spring of force constant k and negligible mass, compressing the spring a distance x. After it is released, the box slides up a frictionless incline as shown in the figure and eventually stops at height h. If we repeat this experiment but instead use a spring having force constant $2k$, how high will the box go up the plane?



2. **Friction:** Block 1 and block 2 have the same mass, m, and are released from the top of two inclined planes of the same height making 30° and 60° angles with the horizontal direction, respectively. If the coefficient of friction is the same in both cases, which of the blocks is going faster when it reaches the bottom of its respective incline?

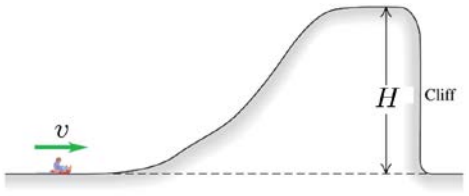
3. **Potential:** The plot in the figure shows the potential energy of a particle, due to the force exerted on it by another particle, as a function of distance.



   (a) At which of the three points labeled in the figure is the magnitude of the force on the particle greatest and why?

   (b) Draw on the figure range of motion for object released at rest from point X.

4. **Sled:** A sled with rider having a combined mass m travels over a perfectly smooth icy hill. Speed of the sled is v, maximum heigth of the hill is h.



   (a) How fast does the sled have to be moving tojust barely make it over the cliff?

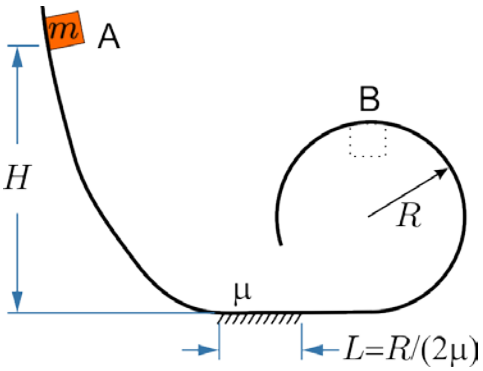
   (b) How far does the sled land from the foot of the cliff?

5. **Jet Car**: In 1964, after the 1250 kg jet-powered car *Spirit of America* lost its parachute and went out of control during a run at Bonneville Salt Flats, Utah, it left skid marks about 8.00 km long. (This earned a place in the Guiness Book of World Records for longest skid marks.)

   (a) If the car was moving initially at a speed of about 800 km/h, and was still going at about 300 km/h when it crashed into a brine pond, estimate the coefficient of kinetic friction μ_k.

   (b) What was the kinetic energy of the car 60 s alter the skid began?

6. **The loop:** A box of mass m is placed at the top of a gutter as shown below and released from rest. The surfaces are all frictionless except for a damaged part just before the circular part on the right side where the coefficient of friction is μ_k μk over a length $L = R/(2\mu_k)$, where R is the radius of the circular part. When the box reaches the top of the circular loop, it has a speed $v = \sqrt{gR}$ and does not lose contact with the gutter surface. Throughout the motion, the box slides without rolling. Express your answers below in terms of g, R, m, μ_k (not all may be necessary).



   (a) Find the work done by friction as the box crossed the rough patch before the gutter.

   (b) Find the height, H from which the marble should be released so that it reaches the speed v at the top of the circle.

7. **Roller-Coaster**: Your firm is designing a new roller-coaster ride. Each roller-coaster car will have a total mass (including passenger) of M and will travel freely along the winding frictionless track shown in the figure. Points A, E, and G are on horizontal straight sections, all at the same height of h above the ground. Point C is at a height of h above the ground on an inclined section of slope angle 30°. Point B is at the crest of a hill, while point D is at ground level at the bottom of a valley; the radius of curvature at both of these points is $R = 2h$. Point F is at the middle of a banked horizontal curve with a radius of curvature of $R = 3h$, and at the same height as points A, E, and G. At point A, the speed of the car is $v12$.

   (a) If the car is to just barely make it over the hill at point B, what must be the height of point B above the ground?

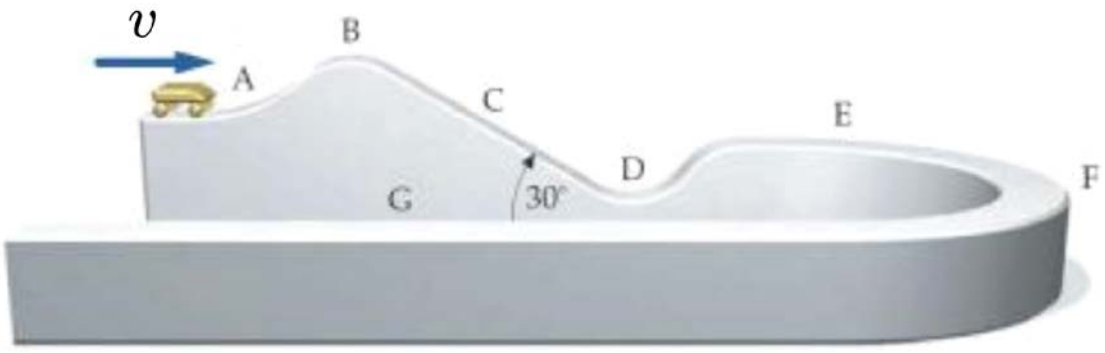
   (b) If the car is to just barely make it over the hill at point B, what should be the magnitude of the force exerted by the track on the car at that point?

   (c) What will be the acceleration of the car at point C?

   (d) What will be the magnitude and direction of the force exerted by the track on the car at point D?

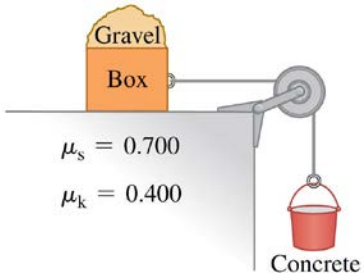
   (e) What will be the magnitude and direction of the force exerted by the track on the car at point F?

   (f) At point G, a constant braking force is to be applied to the car, bringing it to a halt in a distance at $L = 2.5h$. What is the magnitude of this required braking force?



8. **Mass on a String**: A small object of mass m moves in a horizontal circle of radius r on a rough table. It is attached to a horizontal string fixed at the center of the circle. The speed of the object is initially v_0. After completing one full trip around the circle, the speed of the object is $0.5\ v_0$.
   (a) Find the energy dissipated by friction during that one revolution in terms of m, v_0 and r.
   (b) What is the coefficient of kinetic friction?
   (c) How many more revolutions will the object make before coming to rest?

9. **Construction Site**: At a construction site, a 65.0 kg bucket of concrete hangs from a light (but strong) cable that passes over a light, friction-free pulley and is connected to an 80.0 kg box on a horizontal roof (see figure). The cable pulls horizontally on the box, and a 50.0 kg bag of gravel rests on top of the box. The coefficients of friction between the box and roof are shown.



   (a) Find the friction force on the bag of gravel and on the box.
   (b) Suddenly a worker picks up the bag of gravel. Use energy conservation to find the speed of the bucket after it has descended 2.00 m from rest. (Use Newton's laws to check your answer.)

10. **Pendulum**: A pendulum is suspended from the ceiling and attached to a spring fixed to the floor directly below the pendulum support (see figure). The mass of the pendulum bob is m, the length of the pendulum is L, and the force constant is k. The unstressed length of the spring is $L/2$ and the distance between the floor and ceiling is $1.5\ L$. The pendulum is pulled aside so that it makes an angle θ with the vertical and is then released from rest. Obtain an expression for the speed of the pendulum bob as the bob passes through a point directly below the pendulum support.