Unit 6 -- Conservation of Energy

Energy conservation is a powerful idea – let's practice using it.

Virtually any energy problem can be solved by applying the general energy-conservation equation:

$U_i + K_i + W_{nc} = U_f + K_f$

Where U_i is the initial potential energy; K_i is the initial kinetic energy, W_{nc} is the work done by non-conservative forces (such as friction); U_f is the final potential energy; and K_f is the final kinetic energy.

Use the energy-conservation equation to solve the following problems. Use **g = 10 m/s^2** to keep the calculations simple.

A small block with a mass of 1.0 kg is dropped from rest from a height of 1.8 m above the ground. Neglecting air resistance find the speed of the block just before it hits the ground. Don't put in any numbers until step 4! Use variables until that point.

Step 1 – Define a zero level for gravitational potential energy. Where is your zero level?

Step 2 – Write down the full five-term energy conservation equation (see above) and then cross out all the terms that are zero. Briefly justify why the terms you crossed out are zero.

Step 3 – Expand the terms that remain, using relations like $U = mgh$ and $K = \frac{1}{2}mv^2$.

Step 4 – Solve for what you're trying to solve for. First come up with an expression for the speed in terms of variables and then plug in the numbers given above.

If we doubled the mass of the block how would that affect the final speed?

If we doubled the height from which we let the block go how would that affect the final speed?

Let's apply the same step-by-step analysis to solve this problem. A block with a mass of 1.0 kg is released from rest from the top of a ramp that has the shape of a 3-4-5 triangle. The ramp measures 1.8 m high by 2.4 m wide, with the hypotenuse of the ramp measuring 3.0 m. What is the speed of the block when it reaches the bottom assuming there is no friction between the block and the ramp?

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It turns out that we can't neglect friction for the block, because we find that the block's speed at the bottom of the ramp is 2.0 m/s less than the value we calculated above. Use the energy-conservation equation to find a numerical value for the work done by friction on the block.

Use the definition of work, $W = F\,\Delta r \cos\phi$, (where ϕ is the angle between the force $\vec{F}$ and the displacement $\Delta\vec{r}$) to come up with an expression for the work done by friction in this situation.

Put your results together to solve for the coefficient of kinetic friction associated with the interaction between the block and the ramp. Express your answer as a ratio of integers (e.g., $\mu_K = \frac{3}{7}$).

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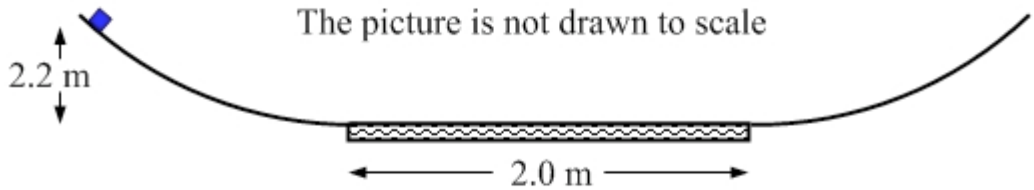
A small block of mass *m* is placed on a track and released from rest from a point 2.2 m above the bottom of the track. The track is frictionless except for a horizontal part that is 2.0 m wide. After passing once through this horizontal part the block reaches a maximum height of 1.7 m above of the bottom of the track on the right side.



Use the energy conservation equation to determine an expression for the work done by friction on the block the first time the block passes through the horizontal part of the track.

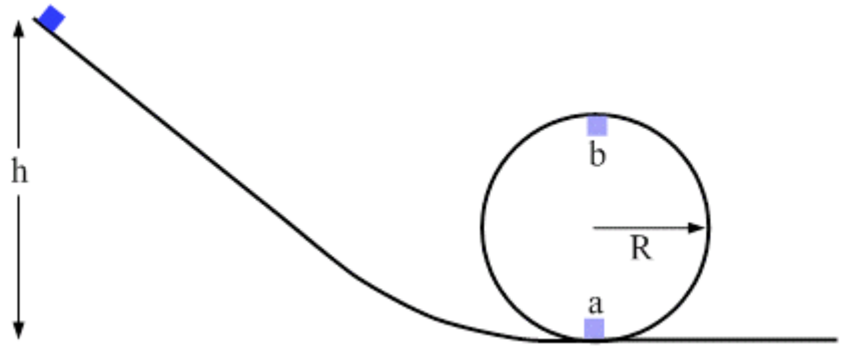
Use the definition of work to determine an expression for the work done by friction on the block the first time the block passes through the horizontal part of the track.

Set your two expressions equal and solve for the coefficient of kinetic friction between the block and the part of the track where there is friction.

How many times will the block completely pass through the horizontal part of the track?

Where does the block come to rest?

A block of mass m is placed on a loop-the-loop track and released from rest from a height h above the bottom of the track. If the loop has a radius R what is the minimum value of h such that the block makes it completely around the loop without losing touch with the track?



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Energy is not enough to solve for the minimum height. We also need to do a circular-motion analysis to help us find the minimum kinetic energy the block needs to have at the most critical part of the track. Where is this most critical point? (i.e., where is it in most danger of falling off?) Do a circular motion analysis, analyzing the forces on the block at this critical point to find an expression that should help you solve the energy equation above.