Work and Energy

In this activity we will explore the concepts of work, kinetic energy, and potential energy. First, some definitions and principles.

Work: Work is the action of a force on an object as it moves through a distance. Specifically, in one dimension, $W = F_{ave}d$. If F_{ave} is in the same direction as the displacement, then W is positive. If F_{ave} is opposite the displacement, then W is negative (e.g. friction).

Kinetic energy: Kinetic energy is defined as $KE = ½ mv^2$. It is always non-negative and is independent of direction.

Work-energy theorem: If you include the work done by all forces on an object, then W_{net} = change in KE = $KE_f - KE_i$

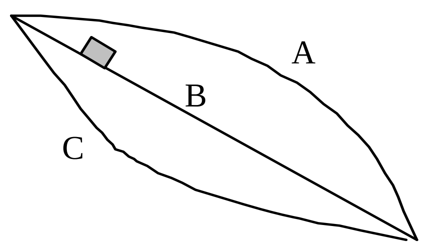
Gravitational potential energy: If an object has elevation h, then it has potential energy given by $PE_g = mgh$. This assumes that we define $PE_g = 0$ when $h = 0$. If $h < 0$, then PE_g is negative.

Elastic potential energy: A typical spring or rubber band has potential energy $PE_{el} = ½ kx^2$, where k =the spring stiffness constant. This assumes that the force exerted by the spring is proportional to its stretch or compression (x) from its equilibrium position ($x = 0$).

Conservative of mechanical energy: If there are no dissipative forces acting on an object (e.g., friction), then the total mechanical energy stays constant. E = KE + PE. If there is friction, then the work done by friction is negative and reduces the total mechanical energy. $W_f = \Delta E$.

Preliminary Questions:

1. A block can be released from any of the three frictionless inclined tracks shown to the right. Which results in the greatest speed when the block reaches the bottom?



   (a) A (b) B (c) C (d) same for all

2. A block slides down a frictionless incline. If we double the mass, then the speed when it reaches the bottom of the incline
   (a) increases (b) decreases (c) doesn't change

3. A sling shot is used to launch a rock straight up into the air to a maximum height h. If the rock is now launched after doubling its stretch, then the maximum elevation of the rock is

   (a) 2h (b) 3h (c) 4h

Activity 1 – Inclined plane

Raise one end of the aluminum track by about 10 cm or so to form an inclined plane. Release the low friction cart from the top of the track and measure the time to roll down the track using a stop watch and the distance it travels. Repeat a couple of times to get better results. Calculate the average speed of the cart. Since the acceleration of the cart is constant, then the final speed of the cart at the base of the incline should be $v = 2v_{avg}$.

Calculate the initial PE and the final KE. Are they nearly the same? What do you expect?

Repeat using a different elevation.

Now use the motion sensor to measure the speed of the cart as is rolls down the track for one of the elevations you used in the 'manual' measurements. Is the acceleration constant? From the speed versus time graph, determine the final speed. Again, check to see if mechanical energy is conserved.

Activity 2 – Rubber band launcher

Clamp the rubber band launcher to the end of the (level) track. Launch the wooden block by pulling the block against the rubber band one-half the maximum possible stretch. Measure the distance the block slides from its initial launch position.

Now, before making any other measurements *predict* the slide distance if the block is launched from the full stretch position.

Now launch the block and check your prediction. Explain your results.

What do you think would happen if you double the mass of the block while launching from the same stretch? Explain.

Launch two blocks together and see what happens. Is this what you predicted?

Final questions and reflections:

1. In the rubber band launcher activity, is mechanical energy conserved? If not, is this a violation of the law of conservation of energy? Explain.

2. Can you think of one or two other hands-on activities in which students could explore the law of conservation of mechanical energy?

3. Look at the “Energy Skate Park” PhET simulation (http://phet.colorado.edu). Can you think of ways in which this might be used in a physical science class to explore energy?