Physics November 25, 2009

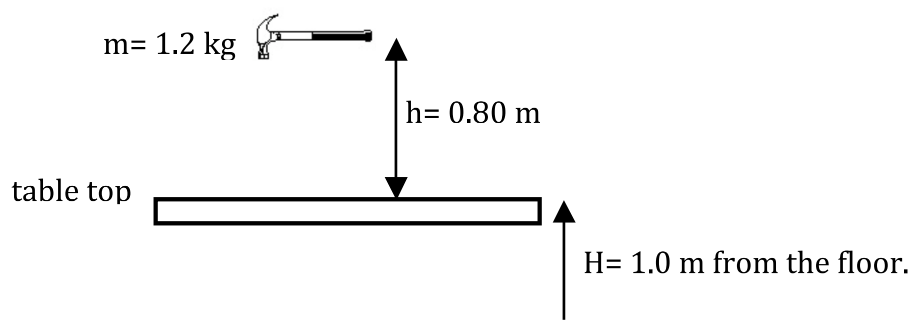
POTENTIAL ENERGY

Yesterday we considered the mechanical energy an object has because it is in motion. Today we will consider how much work and object can do because of position or configuration of a system.

For example and 2.0 kg object that is being held 3.0 m above a desk top has a force pulling down on it because of the gravitation of 2kg(9.8m/s^2) = 19.6 N. An object placed beneath it could perhaps be pushed by this force down to the table top. Gravitation would then do 19.6 N (3.0m) or 58.8 J. We could therefore say the mass in its original position and under the influence of gravitation could do 58.8 J of work or, in other words, had 58.8 J of energy. This type of mechanical energy is called gravitational potential energy. Clearly if the mass were allowed to move further down it could do more work so we are always talking about a potential energy relative to a certain point or level. Your book uses PE for potential energy. Here we will use the more usual capital U for potential energy. The gravitational potential energy of a mass at one position relative to that at another is given by

$$\Delta U = mgh.$$

Here is one example of the calculation of gravitational potential energy.



The hammer, mass 1.2 kg is at a position 0.80 m above the top of the table, which in turn is 1.0 m above the floor.

a) If you want the potential energy of the hammer with respect to the table top you get ΔU = mgh = 1.2kg(9.8m/s^2)(0.80m) = 9.4 J.
b) If you want the potential energy of the hammer with respect to the floor your calculation becomes ΔU=mgh = 1.2kg(9.8m/s^2)(1.8m) = 21 J.

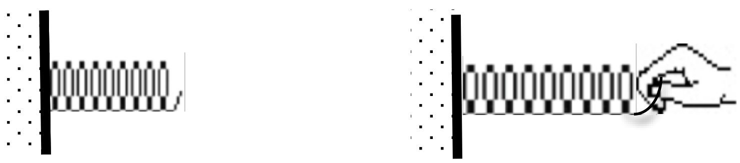
Remember that the gravitational potential energy is always relative to some reference level.

If you have ever stretch a spring or a rubber band you know that it can exert a force as a result of the configuration or position of the two ends. This type of potential energy is call elastic potential energy.

In the case of the ideal spring Robert Hooke found that the force exerted by the spring was opposed to the compression or elongation and proportional to it. In an equation that means the force exerted by a spring is given by Hooke's Law which is ***F=-kx***. Here the "*k*" depends on the stiffness of the particular spring and has units of N/m. The *x* is the elongation (stretch) or compression from its rest length. If it is stretched to the right the force of the spring is to the left, and if it is compressed to the left the force of the spring will be to the right.

For example if the spring shown below is stretched 0.20 meters as shown on the right, and this new position requires a force of 5.0 N to hold it there, the force exerted back by the spring must be 5.0N to the left.

From Hooke's Law we have k = 5.0N/0.20m = 25 N/m.



Now the amount of work the spring can do because it is stretched or compressed would be its elastic potential energy or simply the spring potential energy. To calculate this value consider that the force exerted by the spring will go from its maximum size when it is stretched (or compressed) by x to zero when it is unstreched (or uncompressed). The size of the average force is then given by $F_{av} = \frac{0 + kx}{2}$ and the work that can be done is given by $W = \vec{F} \cdot \vec{d} = \frac{kx}{2} x = \frac{1}{2} kx^2$. Therefore we can write the spring potential energy as

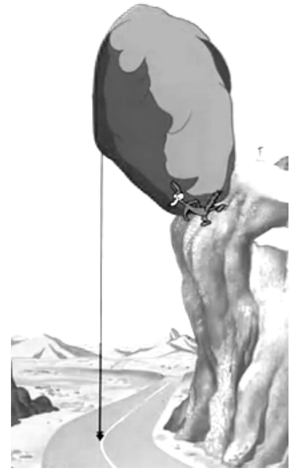
$$U_s = \frac{1}{2} kx^2$$

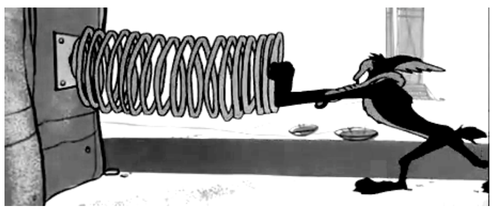
Do the following problems neatly one separate paper so they can be turned in at the end of the period. In each case show your work and clearly indicate your answers. Since this is a learning exercise you may seek help if you have trouble. In some cases the answers will be provided in brackets at the right in order to make sure you are on the right track.

1) A 2.0 kg cement block is held 0.60 m above the floor. How much gravitational potential energy does it have? [12 J]

2) A spring with a constant *k* = 500.N/m, is stretched 0.20 m. How much elastic potential energy does it have? [10. J]

3) Wile E. Coyote gets the idea to drop a boulder on the road runner as shown here. If the mass of the boulder is 500.kg and it is 15 m above the road, how much gravitational potential energy will it have with respect to the road? [74 000 J]





4) In another misadventure Wile E. Coyote decides to use a spring to do his work. If at maximum compression he is exerting a force of 600.N and the spring is compressed 2.4 m calculate…

a) The spring constant k. [3 000 N/m]

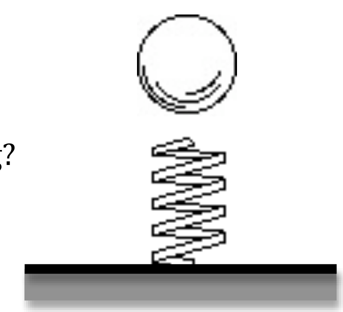
b) The potential energy of the spring. [8 600 J]

5) On the moon the acceleration due to gravitation is only about 1.6 m/s^2. How much potential energy would a 4.0 kg rock located 5.0 m above the surface of the moon have relative to the surface?

6) A 2.0 kg ball is sitting on top of a vertical spring as shown here. The spring constant k = 500. N/m.

a) How much is the spring compressed?

b) How much elastic potential energy is stored in the spring?



Your copies of these solutions are to be turned in at then end of the period. Enjoy your Thanksgiving break.