More Work - Gravitation

1. Easton lifts a 100 kg bar from the ground to a height of 2.0 meters above the ground.
    a. Calculate the amount of work the gravitational force did on the bar as he raised the bar.
    b. Determine the amount of work done by Easton to hold the bar above his head.
    c. Calculate the amount of work the gravitational force did on the bar as he lowered it to the ground.

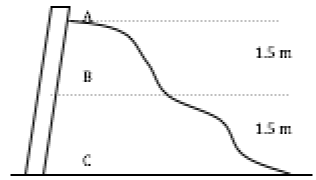
2. In order to lift a 2000 N piano directly onto a platform that is 1.5 meters above the ground, a force of 2000 N must be applied vertically on the piano. Suppose that this is not possible for the movers concerned, but they do have a ramp with a 15° incline and the piano has surprisingly good wheels on the bottom.
    a. Calculate the amount of force do the movers have to apply in order for the piano to move up the ramp at a constant speed.
    b. Calculate the amount of work the workers did on the piano.
    c. Calculate the amount of work the gravitational force did on the piano as the movers lifted it up the ramp.
    d. Determine the amount of work would the movers would have done if they had been able to lift the piano directly up in the air.
    e. Determine the amount of work the gravitational force would have done if they had lifted the piano directly up in the air.

Potential energy is the energy due to the arrangement of objects. It is defined as the amount of work the force would do to return the system to the arrangement that has been defined as zero potential energy.

The gravitational force is always directed downward. Since the work done by a force is calculated by using the dot product, only the vertical part of the motion matters for the calculation. The amount of work done the gravitational force is independent of the path the object takes and is the opposite value if the path is reversed. For this reason, the gravitational force is considered a conservative force and we can define a quantity of **Gravitational Potential Energy** as the energy of an arrangement of a system of objects. The system of objects for gravitational potential energy includes the object and the Earth. There is no absolute zero point for gravitational potential energy, so we mathematically describe the change in the gravitational potential energy instead of the value.

$$\Delta E_P = m\,g\,\Delta h$$

3. Danny (m = 75 kg) slides down the slide pictured.



   a. Choose h = 0 at height C. Calculate:
      i. His potential energy at A.
      ii. His potential energy at C.
      iii. His change in potential energy in moving from A to C.
   b. Choose h = 0 at height B. Find:
      i. His potential energy at A.
      ii. His potential energy at C.
      iii. His change in potential energy in moving from A to C.
   c. Choose h = 0 at height A. Find:
      i. His potential energy at A.
      ii. His potential energy at C.
      iii. His change in potential energy in moving from A to C.

4. A 0.20 kg ball is launched directly up in the air with 50 J of energy. Determine the maximum height the ball can reach if all of the energy is transferred to gravitational potential energy.

5. The Millennium Force was the first roller coaster with a 300 ft (91 m) drop. A fully loaded train has a mass of approximately 4000 kg.
   a. Setting the bottom of the motion as zero gravitational potential energy, determine the amount of gravitational potential energy the train-Earth system have at the top of the first hill.
   b. Assume that all of the potential energy at the top of the hill is converted to kinetic energy. Determine how fast the train traveling at the bottom of the hill.

6. You are going to push a toddler in a swing at the park. She has a mass of 20 kg and the swing has a rope length of 2.5 meters. She wants to go “high”, so you agree to push her up to an angle of 60 degrees to the vertical.
   a. Determine how high the toddler will go.
   b. Calculate the amount of work you have to do to make the swing travel to that height.
   c. Calculate the speed at the bottom of the swing.