Sec. 5.2 - Con't

Learning Goal: By the end of today, I will be able to calculate the gravitational potential energy of an object.

If I hold a book above the desk, and keep it from falling, it has ZERO Kinetic Energy.

If I let go of the book, the book goes from having Zero kinetic energy to suddenly having Kinetic energy. Where did that energy come from?

A Potential Energy Analogy

A spring can store both repulsive and attractive potential energy.

If you compress a spring, you have applied a force over a distance (work) and put energy into the system. This energy is stored in the spring until it is released. When the energy is released, the stored energy transforms to becomes kinetic energy.

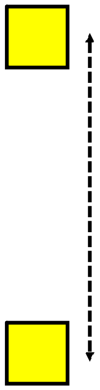
The same logic applies if you stretch a spring, there will be a stored energy that wants to return to its equilibrium location.

Gravity acts like a stretched spring near the surface of the Earth. When objects are raised off of the ground, gravity wants to pull them back, which we will call gravitational potential energy.

This is a very simplistic way of explaining this concept, your understanding of potential energy will expand with more learning.

Gravitational Potential Energy: A Stored Type of Energy

An object suspended in the air has Gravitational Potential Energy (work was done to raise object into the air), when it is released it starts moving, thus it has velocity and therefore kinetic energy.



V_i = 0 m/s E_g = ? E_k = 0

Height or distance (h or d)

Acceleration due to gravity = 9.8 m/s^2

V_f = ? m/s E_g = 0 $E_K = \frac{mv^2}{2}$

Let's work the problem backwards, from the bottom up.

$$E_K = \frac{mv_f^{\,2}}{2}$$

The kinetic energy at the bottom is base on V_f, but V_f is related to V_i , acceleration, and height, by the following kinematic equation.

$$V_f^2 = V_i^2 + 2a\cdot\Delta d$$

$$E = \frac{m(v_i^2 + 2ad)}{2}$$

If we replaced the V_f in the Kinetic energy equation...

$$E = \frac{m(0 + 2ah)}{2}$$

and replaced the V_i with Zero since we are starting from rest,

$$E = \frac{m(2gh)}{2}$$

and replaced the "d" with an "h" for height

and replaced the "a" with a "g" for acceleration due to gravity, simplified, we would come up with...

$$\boxed{E_g = mgh}$$

Mechanical Energy in a System

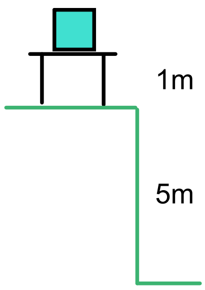
$$E_{mech} = E_k + E_g$$

We will do more with this in Sec. 5.3

Reference Line Importance

$$E_g = mgd$$

A 10kg mass sits on a 1m tall table by a 5m deep ditch, what is the gravitational potential energy when:



(a) reference line is the table top

(b) reference line is the ground

(c) reference line is bottom of the ditch.

Sample Problem 1

What is the gravitational potential energy of a 48 kg student at the top of a 110 m high drop tower ride relative to the ground?

In this Sample Problem, the student's mass and height above ground (the reference level) are given. Therefore, we may use the gravitational potential energy equation, $E_g = mgh$, to calculate the student's gravitational potential energy.

Given: $m = 48$ kg; $h = 110$ m; $g = 9.8$ N/kg

Required: E_g, gravitational potential energy

Practice

1. A 58 kg person walks down the flight of stairs shown in **Figure 7**. Use the ground as the reference level. T/I
   (a) Calculate the person's gravitational potential energy at the top of the stairs, on the landing, and at ground level.
   (b) What happens to gravitational potential energy as you go down a flight of stairs? What happens to gravitational potential energy as you climb a flight of stairs?

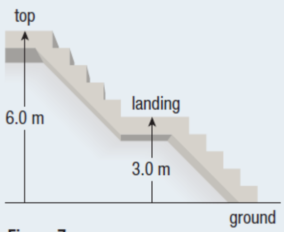


Figure 7

5.2 Summary

- Energy is the capacity (ability) to do work.
- Kinetic energy is energy possessed by moving objects. The kinetic energy of an object with mass, m, and speed, v, is given by $E_k = \frac{mv^2}{2}$.
- The total work, W_{net}, done on an object results in a change in the object's kinetic energy: $W_{net} = E_{k_f} - E_{k_i}$, where E_{k_f} and E_{k_i} represent the final and initial kinetic energy of the object, respectively. In other words, $W_{net} = \Delta E_k$.
- Gravitational potential energy is possessed by an object based on its position relative to a reference level, which is often the ground. $E_g = mgh$, where h is the height above the chosen reference level.
- Mechanical energy is the sum of kinetic energy and gravitational potential energy.

Three Gorges Dam Video

5.2 Questions

1. A bobsleigh with four people on board has a total mass of 610 kg. How fast is the sleigh moving if it has a kinetic energy of 40.0 kJ? T/I
2. A 0.160 kg hockey puck starts from rest and reaches a speed of 22 m/s when a hockey stick pushes on it for 1.2 m during a shot. T/I
   (a) What is the final kinetic energy of the puck?
   (b) Determine the average net force on the puck using two different methods.
3. A large slide is shown in **Figure 8**. A person with a mass of 42 kg starts from rest on the slide at position A and then slides down to positions B, C, and D. Complete the following using the ground as the reference level: T/I

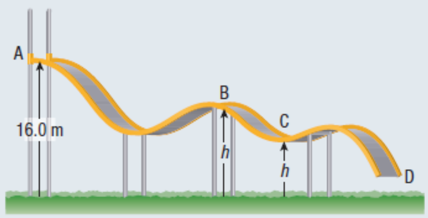


Figure 8

   (a) Calculate the gravitational potential energy of the person at position A.
   (b) The person has a gravitational potential energy of 4500 J at position B. How high above the ground is the person at position B?
   (c) The person loses 4900 J of gravitational potential energy when she moves from A to C. How high is the person at C?
   (d) What is the person's gravitational potential energy at ground level at D?
4. Forty 2.0 kg blocks 20.0 cm thick are used to make a retaining wall in a backyard. Each row of the wall will contain 10 blocks. You may assume that the first block is placed at the reference level. How much gravitational potential energy is stored in the wall when the blocks are set in place? T/I
5. You throw a basketball straight up into the air. Describe what happens to the kinetic energy and gravitational potential energy of the ball as it moves up and back down until it hits the floor. K/U C
6. Using the terms *work*, *kinetic energy*, and *gravitational potential energy*, describe what happens to people in a drop tower ride as they are slowly pulled to the top, released, and then safely slowed down at the bottom. K/U C

Section 5.2 #1, 2, 3