Energy

- **Identify** several forms of energy
- **Calculate** kinetic energy for an object
- **Apply** the work-kinetic energy theorem to solve problems
- **Distinguish** between kinetic & potential energy
- **Classify** different types of potential energy
- **Calculate** the potential energy associated with an object's position

Energy

- **Energy** is "something" that enables an object to do work
- What is that something?
  - Energy is associated with heat, light, electricity, mechanical motion, sound, and the nature of a chemical reaction
- Objects/systems can have energy and can **transfer** energy or **transform** it
- Energy can be transferred between objects/systems, which we call "doing work." Work done on a system is equal to the amount of energy given or taken away from a system.

  $W = \Delta E$

Types of Energy

- $K = \frac{1}{2}mv^2$ Kinetic Energy
- $U_s = \frac{1}{2}kx^2$ Potential Spring Energy
- $U_g = mg\Delta y$ or mgh Potential Gravity Energy
- $\Delta E_{thermal} = F_k d$ Thermal energy
  - heat energy from friction/air resistance
- $E_{mechanical} = K + U_g + U_s$ (doesn't not include thermal energy)
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Important points

- Kinematic eqns can ONLY be used when a=constant (free fall)
- Energy equations can be used when

  a ≠ constant (roller coaster)e4l
- Sound, heat, deformation, etc are common examples of energy loss

Kinetic Energy

- **Kinetic Energy** depends on speed and mass
  - Units – Joules (used for all forms of energy)
    - kg•m^2/s^2 or N•m or J

kinetic energy

$$K = \frac{1}{2}mv^2$$

K = kinetic energy
m = mass
v = velocity

Kinetic Example Problem

- A 100. Kg Linebacker moves at 8.90 m/s (runs 100m in 11.2 secs). How much KE does the linebacker have? How fast does a 54.5 Kg wide receiver have to run to have the same KE as the linebacker?

Given:

Linebacker	Wide Receiver
V_L = 8.90 m/s	V_w = ?
M_L = 100. kg	M_w = 54.5 kg
KE_L = ?	

Soln:

$KE_L = ½ M_L V_L^2$

$= ½ (100.\ Kg) (8.90\ m/s)^2$

$KE_L = 3.96 \times 10^3$ J

$KE_W = KE_L$

$½ M_w V_w^2 = KE_L$

$V_w^2 = 2KE_L / M_w$

$V_w^2 = 2\ (3.96\times10^3\ J) / (54.5\ kg)$

$V^w = 12.1$ m/s

note: wide receiver would have to run 100m in 8.26 secs

Work-Kinetic Energy Theorem

- Another way of defining work is in terms of what it does: work done on an object changes the energy of that object. This is called the **Work-Energy Theorem**
- The net work (W_{net}) done on an object is equal to the change in the KE of the object

WORK–KINETIC ENERGY THEOREM

$$W_{net} = \Delta KE$$

net work = change in kinetic energy

$$\mathbf{W_{net} = \Delta\ KE = \tfrac{1}{2} mv_f^2 - \tfrac{1}{2} mv_i^2}$$

When Velocity is constant ΔKE =0 then work is zero

Potential Energy

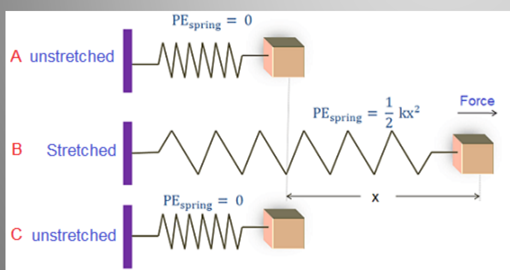
- **Potential Energy** is the energy associated with an object because of the position, shape, or condition of the object.
  - Stored energy
    - Chemical energy
    - Object due to its position (Gravitational, ex: rock on hilltop)
    - Elastic potential energy
- **Gravitational potential energy** is the potential energy stored in the gravitational fields of interacting bodies.
  - depends on height from a zero level (zero level is arbitrary)

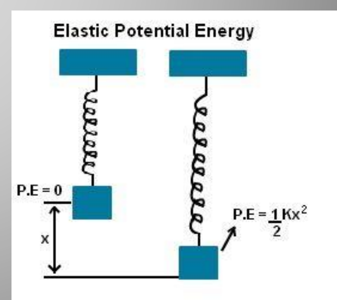
$$U_g = mgh$$

$U_{gravitational}$ = mass × free-fall acceleration × height

Potential Energy

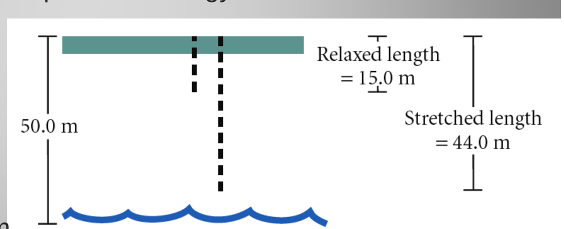
- Elastic Potential energy
  - The energy available for use in deformed elastic objects
    - Rubber bands, springs in trampolines, pole-vault poles, muscles
  - For springs, the distance compressed or stretched = Δx





Sample Problem: Elastic potential energy

A 70.0 kg stuntman is attached to a bungee cord with an unstretched length of 15.0 m. He jumps off a bridge spanning a river from a height of 50.0 m. When he finally stops, the cord has stretched a length of 44.0 m. Disregard the weight of the bungee cord. Assuming the spring constant of the bungee cord is 71.8 N/m, what is the total potential energy relative to the water when the man stops falling?



Given:

m = 70.0 kg

k = 71.8 N/m

g = 9.8 m/s^2

h = 50.0 m – 44.0 m = 6.0 m

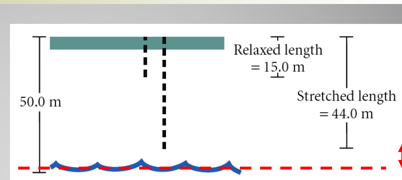
x = 44.0 m – 15.0 m = 29.0 m

U_g = 0 J at river level

U_{tot} = ?

Sample Problem: Elastic potential energy

The zero level for U_g is chosen to be at the surface of the water.



h= 6.0 m

h = 50.0 m – 44.0 m = 6.0 m

The total Potential Energy is the sum of PE_g and $PE_{elastic}$

$U_{tot} = U_g + U_{elastic}$

$U_g = mgh$

$= (70.0\ kg)(9.81 m/s^2)(6.0 m) = 4.1x10^3\ J$

$U_{elastic} = ½\ kx^2$

$= ½\ (71.8\ N/m)(29.0 m)^2 = 3.02x10^4 J$

$U_{tot} = 4.1x10^3 J + 3.02x10^4 J$

$U_{tot} = 3.43x10^4 J$