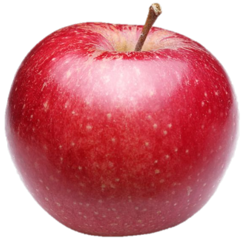
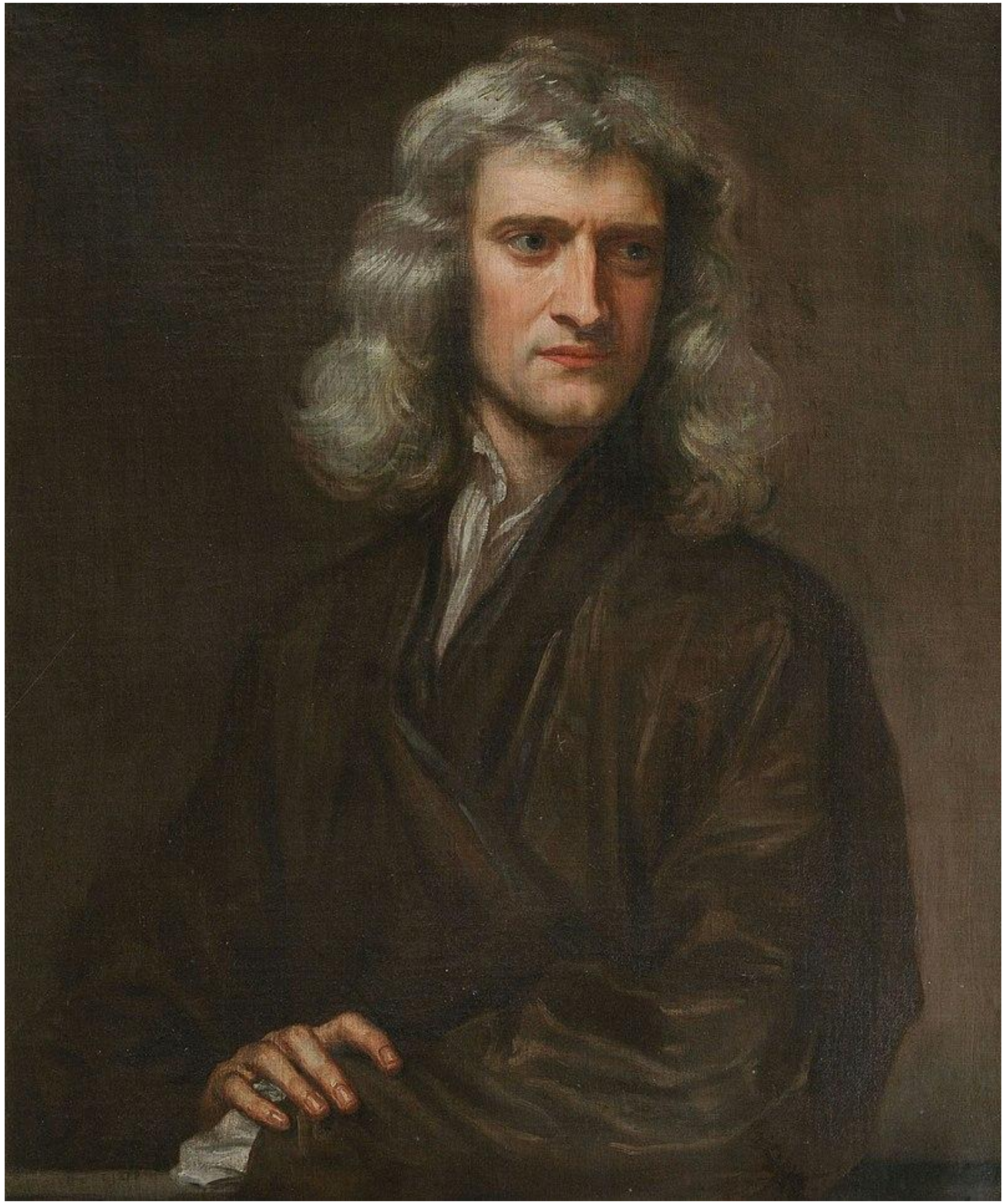


Physics 1 tutorial class

(Um, actually… it’s calculus 1)



1. Work and kinetic energy

- Kinetic energy = motion

Motion = kinetic energy

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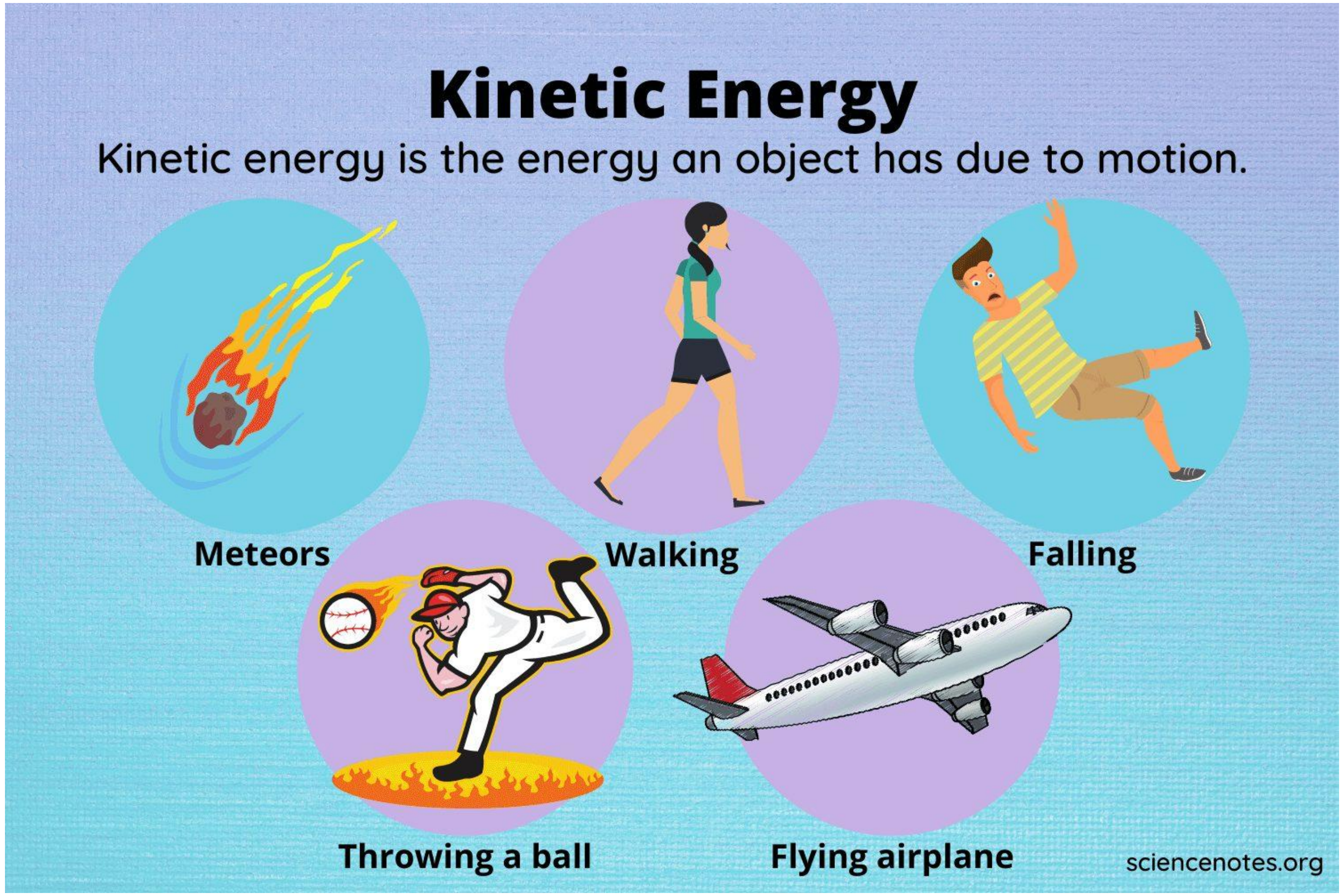
$$K = \frac{1}{2}mv^2$$



1. Work and kinetic energy

- Work = Energy transferred
  - Work done by constant force:

$$W = \vec{F}.\vec{d}\ (J)$$

  - Work done by ANY force:

$$W = \int_{x_i}^{x_f} F(x)dx$$

Example: You fling a suitcase with a force equals 500N. It travels 5m horizontally. What is the work done by air friction?

1. Work and kinetic energy

- Power is the **rate** at which work is done:

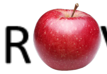
$$P = \frac{dW}{dt}; P_{avg} = \frac{\Delta W}{\Delta t} \; (W)$$

Q: Would P be zero if the object does not displace?

A: Actually, no. Because W = ΔKE

1. Work and kinetic energy

- Work-kinetic energy theorem: $W = \Delta \mathrm{K}$

- Work done by GRVITY: $W_g = \pm mgd$

- Work done by a spring: $W_s = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 \left(= \frac{1}{2}k\Delta x^2 \ if \ x_i = 0\right)$

- Work done by an applied force:

$$W_a = \Delta K - W_s$$

$$W_a = -W_s \ if \ the \ block \ is \ initially \ at \ rest$$

1. Work and kinetic energy

Example problem: ___ lifts a 0.3-kg cup of milk tea 0.5m vertically up at a constant speed of 0.5 m/s. Find her work done on the cup. Find the net work done on the cup.

2. Work and potential energy

- Gravitational potential energy:

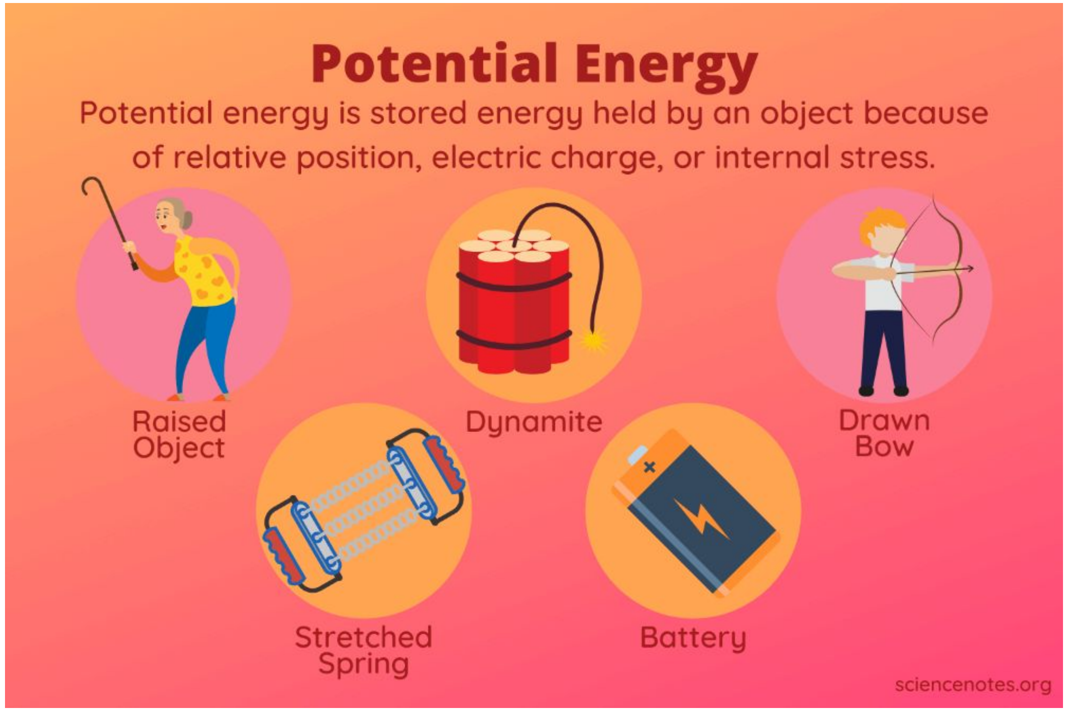
$$U = mgh$$

*U(y) depends only on **the vertical position y of the object** relative to the reference point y=0.

- Elastic potential energy:

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

*$U_e(x)$ depends on **the position x of the mass** relative to the reference point x=0.



3. Conservation of mechanical energy

- Mechanical energy:

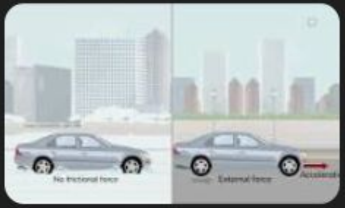
$$E_{mec} = K + U_g + U_e$$

- No external force:

$$\Delta E_{mec} = \Delta K + \Delta U_g + \Delta U_e = 0$$

→ Chotto, what's an external force?

External forces generally include the **applied force, normal force, tension force, friction force, and air resistance force**. On the other hand, the internal forces include gravitational force, magnetic force, electric force, and spring force.



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3. Conservation of mechanical energy

Example problem #2: A 1.0-kg block is initially moving to the left on a horizontal frictionless surface at a speed of 5.0 m/s. The block then compresses a horizontal spring of k = 200 N/m.

(a) Find the maximum compression of the spring

(b) What is the mechanical energy of the block-spring system

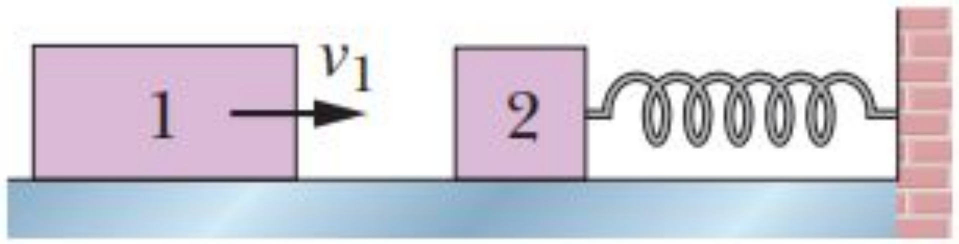


Figure 9-62 Problem 58.

3. Conservation of mechanical energy

Example problem #3:

A skier is moving down from the top of a hill to the ground. The skier's mass is 55kg, and the height of the hill is 25m. The length of the hill is 100m. If his speed at the top of the hill is 7.5 m/s, determine his kinetic energy at the ground.

Ignore friction

3. Work done on a system by an external force.

The work done by an external force on a system is equal to the change in mechanical energy plus the increase in thermal energy by friction, plus internal transfers (like biochemical energy):

$$W = \Delta E_{mec} + \Delta E_{thermal} + \Delta E_{internal}$$

$$\Delta E_{thermal} = f_k d$$

3. Work done on a system by an external force.

Example problem #4: A 3.0-kg otter starts at a height h=0.6 m on a plane that has an inclination angle of 30 degrees (as will be shown by me). Upon reaching the bottom, the otter starts to skid uncontrollably along a horizontal surface. If the coefficient of kinetic friction on both surfaces is 0.3, how far does the it slide on the horizontal surface before coming to rest?

4. The center of mass

The center of mass:

·If the system has n particles that are strung out along the x axis:

$$\boxed{x_{com} = \frac{m_1x_1 + m_2x_2 + \ldots + m_nx_n}{M} = \frac{1}{M}\sum_{i=1}^{n} m_ix_i}$$

·If the n particles are distributed in three dimensions:

$$\boxed{x_{com} = \frac{1}{M}\sum_{i=1}^{n} m_ix_i, \quad y_{com} = \frac{1}{M}\sum_{i=1}^{n} m_iy_i, \quad z_{com} = \frac{1}{M}\sum_{i=1}^{n} m_iz_i}$$

·If the position of particle i is given by a vector:

$$\vec{r}_i = x_i\hat{i} + y_i\hat{j} + z_i\hat{k}$$

$$\vec{r}_{com} = x_{com}\hat{i} + y_{xom}\hat{j} + z_{com}\hat{k}$$

·The center of mass of the system is determined by:

$$\boxed{\vec{r}_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i\vec{r}_i}$$

4. The center of mass

The center of mass:

b. Solid Bodies

$$\boxed{x_{com} = \frac{1}{M}\int x\,dm, \quad y_{com} = \frac{1}{M}\int y\,dm, \quad z_{com} = \frac{1}{M}\int z\,dm}$$

where M is the mass of the object

·For uniform objects, their density are:

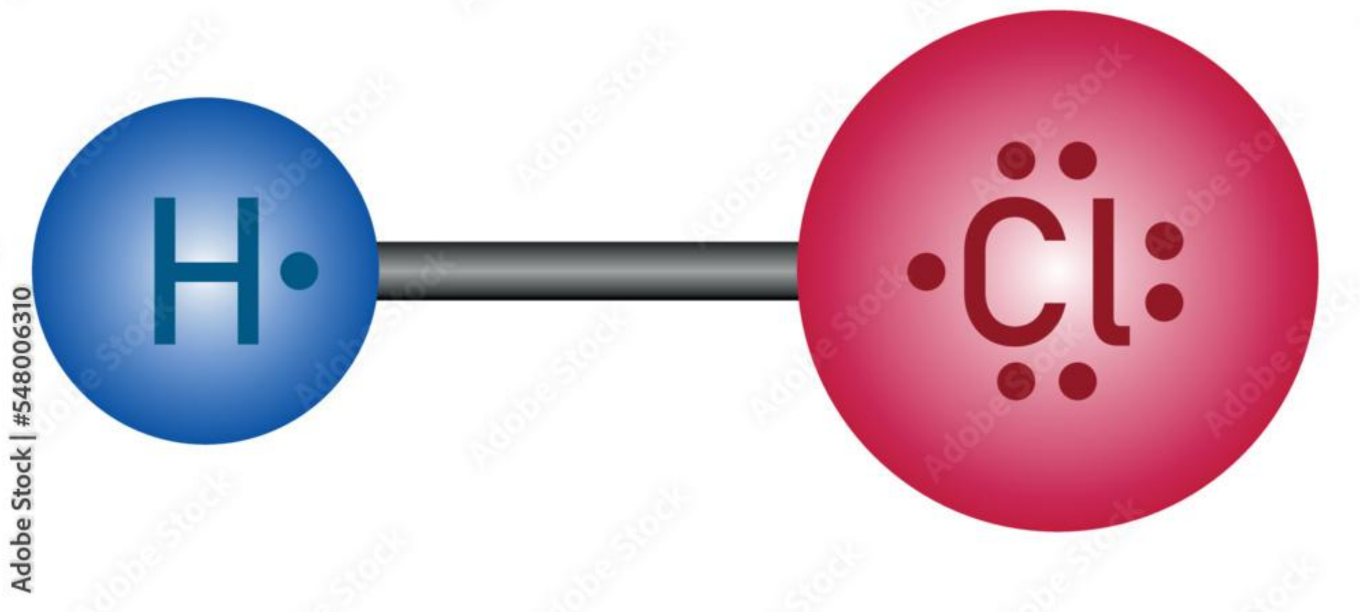
$$\rho = \frac{dm}{dV} = \frac{M}{V}$$

$$\Rightarrow dm = \left(\frac{M}{V}\right)dV$$

$$\boxed{x_{com} = \frac{1}{V}\int x\,dV, \quad y_{com} = \frac{1}{V}\int y\,dV, \quad z_{com} = \frac{1}{V}\int z\,dV}$$

4. The center of mass

Example problem #5: The separation between the hydrogen and chlorine atoms in the HCl molecule is about 1.3×10^{-10}(m). Determine the location of the COM of the molecule as measured from the chlorine atom. Chlorine is 35 times more massive than hydrogen.



5. Linear momentum

Linear momentum is a **vector** quantity:

$$\vec{p} = m\vec{v} \left(\frac{kg.m}{s}\right)$$

If expresses as net external force on the particle, the momentum is:

$$\vec{F}_{net} = \frac{d\vec{p}}{dt}$$

For a system of particles:

$$\vec{P} = M\vec{v}_{com}; \vec{F}_{net} = \frac{d\vec{P}}{dt}$$