Work and Energy

# Energy

Energy refers to the system's ability to do work. Units are in Joules [$kg*m^2/s^2$]

- Kinetic Energy is the energy of motion: $K = \frac{1}{2}mv^2$
- Potential Energy is the energy associated with a given objects position in space, or other intrinsic properties. Has the potential to do work.
  - Gravitation Potential: *U=mgh*
  - Elastic Potential: Occurs when spring is stretch or compressed form equilibrium length. $U=0.5*k*x^2$ K is the spring constant
- Total Mechanical energy is the summation of the kinetic and potential energies of a system.
- Conservation of Mechanical Energy**:** mechanical energy will remain constant if there are no non-conservative forces such as friction present.
  - **Conservative Forces** are path independent and do not dissipate energy.
    - Most commonly encountered are gravitational and electrostatic forces

When there are only conservative forces in a system: $\Delta E = \Delta U + \Delta K = 0$

When there are nonconservative forces: $W_{nonconservative} = \Delta E = \Delta U + \Delta K$

# Work

Work is a process by which energy is transferred from one system to another. It is one of only two ways that it can be transferred.

- Only forces that are parallel or antiparallel to the displacement vector will do work.

$$W = \boldsymbol{F} \cdot \boldsymbol{d} = Fdcos\theta$$

## Pressure and Volume

- Work has been done when the volume of a system has changed due to an applied pressure.
- The amount of work can be calculated as the area under a p-v diagram.
- When a gas expands, we that was done by the gas and that work is positive.
- If volume stays constant as pressure changes, there is no work done. (**isovolumetric/isochoric process**)
- For an **isobaric process**, area under curve is simply a rectangle: $W = P\Delta V$

## Power

Refers to the rate at which energy is transferred form one system to another: $P = \frac{W}{t} = \frac{\Delta E}{t}$ [W]

A watt is equal to a J/s.

## Work-Energy Theorem

Offers direct relation between the work done by all forces acting on an object and the change in kinetic energy of that object. The net work done by forces acting on an object will result in an equal change in the objects kinetic energy:

$$W_{net} = \Delta K = K_f - K_i$$

## Mechanical Advantage

Any device that allows a smaller force to be applied than usual provides a mechanical advantage.

- Five **simple machines** for mechanical advantage: **inclined plane**, wedge, wheel and axle, **lever**, **pulley** and screw.

$$Mechanical\ Advantage = \frac{F_{out}}{F_{in}}$$

- Distance through which work is applied must always be increased in mechanical advantage devices.

### Pulleys

- The **effort** is decreased as the number of pulleys increases but the **effort distance** increases by the same multiple. **Load distance** is the height that the object must be lifted.

### Efficiency

- Simple machines can usually be approximated as conservative systems. However, small amounts of energy are usually lost to frictional forces.

$$Efficiency = \frac{W_{out}}{W_{in}} = \frac{(load)(load\ distance)}{(effort)(effort\ distance)}$$