• Energy Forms
  o Kinetic Energy
    ▪ KE = \( m \frac{V^2}{2} \)
  o Specific Kinetic Energy
    ▪ \( ke = \frac{V^2}{2} \)
  o Potential Energy
    ▪ \( PE = mgz \)
  o Specific Potential energy
    ▪ \( pe = gz \)
  o Internal Energy
    ▪ \( U \)
  o Specific Internal Energy
    ▪ \( u \)

Example: A 4000 kg automobile traveling at 100 km/hr is brought to rest by application of the brakes. Assuming there is no heat transfer, how much does the internal energy of the automobile increase as it is brought to rest?

System: The automobile
Sketches: None required
Conditions: Adiabatic (no heat transfer) deceleration of an automobile.
Physical Laws: Conservation of energy, \( -\Delta U = \Delta KE \)
                 Kinetic Energy, \( KE = mV^2 / 2 \)
Properties: Velocity, \( V = 100 \) km/hr = 27.78 m/s
                Mass, \( m = 4000 \) kg
Calculations:
  According to the kinetic energy definition, \( KE_1 = (4000/2000)[100(1000)/3600]^2 = 1543 \) kJ, \( KE_2 = 0 \) kJ

Conservation of energy, \( \Delta U = -\Delta KE = 1543 - 0 = 1543 \) kJ

• Work
  o Definition – The system interaction which transfers energy between a system and its surroundings that can be reduced to a force acting through a distance.
  o Symbols
    ▪ \( W \) – Total work transfer in kJ, BTU, …
    ▪ \( w \) – Work transfer per unit of system mass in kJ/kg, BTU/lbm, …
- $\dot{W}$ - Rate of work transfer (power) in kW, hp, …
- $\overline{W}$ - Work transfer per mole of system substance in kJ/kmol, BTU/lbm-mol, …
  - **Formal sign convention**
    - - Work done on the system
    - + - Work done by the system
  - **Informal sign convention**
    - $W_{in}$ – Work done on the system
    - $W_{out}$ – work done by the system
- **Electrical Power**
  - $\dot{W} = i\Delta V$
  - Electrical power is always work, never heat.

- **Mechanical Work**
  - The dot product of a force vector and its differential displacement vector
    $$\delta W = \overline{F} \cdot d\overline{s}$$
  - Work requires both a force and a displacement. If either one is missing or zero, no work can be transferred.
  - Closed system work due to an elevation change
    $$W = -m\Delta pe = -mg\Delta z$$
  - Closed system work due to a velocity change
    $$W = -m\Delta ke = -m\frac{\Delta V^2}{2}$$

- **Spring Work**
  - Linear spring - $F = k\Delta x$, where $k$ is the spring constant
  - Substituting this into the boundary work integral yields:
    $$\int_{x_1}^{x_2} F \, dx = -k \frac{x_2^2 - x_1^2}{2}$$

- **Electrical Power**
  $$\dot{W} = i\Delta V$$

**Example:** An 8-cylinder automobile engine has 16 valves (2 per cylinder) that are closed by springs whose spring constant is 20 N/cm. One-half of these springs are compressed 0.5 cm every time the engine completes 1 revolution. How much power (in horsepower) is required to compress these springs when the engine is operated at ____ RPM?

**System:** One valve spring

**Sketches:** None required

**Conditions:** We will neglect the return of the springs to their original position since this work is not useful for moving the automobile.

**Physical Laws:** Spring work which is force times displacement: $W = -k\Delta(x^2) / 2$

- Definition of power, $W_{dot} = \Delta W / \Delta t$

**Properties:** Spring depressions = 8 per revolution
- Engine speed = ____ RPM
- Spring constant = 20 N/cm
- Spring deflection = 0.5 cm
Calculations:

According to the spring work equation, \( W = \quad = \quad \text{kJ} \)

According to the power definition, \( W_{\text{dot}} = \quad = \quad \text{hp} \)