Conservation of Energy

Four Questions:

1) What is it?

a) Kinetic energy
   \[ KE = \frac{1}{2} m v^2 \]

b) Gravitational potential energy
   \[ PE = m g z \]

c) Internal energy
   \[ U = m U \]

   - Electrical
   - Meso nuclear
   - Spring energy
   — More to come!

d) Chemical energy

   - In bonds
   - In nuclear bonds

2) How can it be stored? (What is \( E_{sys} \)?)

   - System of particles
   \[ E_{sys} = \sum m e \]

   - Continuum
   \[ E_{sys} = \int (\epsilon d\mathbf{V}) e \]

   But, usually….

   \[ E_{sys} = KE_{sys} + PE_{sys} + U + \ldots \]

3) How can it be transported? (How does it cross system boundaries?)
Flow boundaries

a) Kinetic
   
   \[ \frac{\text{Rate of KE Transport}}{\text{KE}} = \frac{m}{2} \frac{\text{d}(v^2)}{\text{dt}} = \text{Specific KE} \]

b) Gravitational potential
   
   \[ \text{Rate of PE Transport} = mgz \rightarrow \text{Specific PE} \]

c) Internal
   
   \[ (\dot{m})(\bar{u}) \text{ OK ?!} \]

d) Others
   
   \[ \dot{m} \text{ (Specific Other Energy)} \]

Non-flow boundaries

a) Work
   
   \[ W = \int \vec{F} \cdot \vec{d}\vec{s} \]
   
   - Mechanical work
   - Shaft
   - Electrical
   - Compression/Expansion

b) Heat transfer
   
   Transport of energy due to a temperature difference only

\[ Q \neq 0 \]

Between system & surroundings!

More to come!

4) How is it generated and/or consumed?

\[ \frac{d}{dt}(E_{sys}) = \dot{Q}_{net, w} + \dot{W}_{h, net} + \sum \dot{m}(u + \frac{v^2}{2} + gz) \cdots - \sum \dot{m}(u + \frac{v^2}{2} + gz + \cdots) \]

\[ E_{sys} = KE_{sys} + PE_{sys} + \cdots \]