

2nd Law of Thermodynamics

2nd law of thermodynamics:

- Some processes that would be "legal" under the first law of thermodynamics can not actually occur in reality.
- 2nd law addresses the restrictions that heat engines must follow
 - i.e. the rules that must be followed in order to convert heat energy into mechanical energy

Impossible processes...

- Spontaneous transfer of heat from a cold body to a hotter body (i.e. without the action of another agent)
- The air in a room suddenly occupying just one half of the room and leaving the other half completely empty
- A glass of water, at room temperature, suddenly freezing, causing the temp. of the room to rise.

Order vs. Disorder

- **"Ordered" energy:**
 - i.e. Kinetic energy of a moving ball
 - The energy is all associated with motion in the same direction—"ordered motion" of the body as a whole
- **"Disordered" energy:**
 - i.e. thermal energy, internal energy
 - The energy is associated with random motion of molecules within a body

Quick example to think about...

- Visualize a 1.0 kg mass moving forward at $10.0 \text{ m}\cdot\text{s}^{-1}$. The friction between it and the floor brings it to a stop.
 - What happened to its energy?

Energy Conversions...

- Some types of energy conversions are ***irreversible***, such as:
 - Mechanical kinetic energy into internal energy
- Any time that an *ordered* energy is converted into a form of *disordered* energy, an irreversible conversion has occurred.
 - i.e. the original kinetic energy cannot be recovered from the internal energy into which it was converted.
 - The kinetic energy has been ***degraded***

So how is this applied to engines?

- The purpose of heat engines is to convert heat (disordered energy) into mechanical energy (ordered energy)
- The second law of thermodynamics deals with the limitations/requirements that heat engines must follow in order to work (and do work ☺)

Reversibility...

- What are some examples of reversible processes that you've encountered?
- What are some examples of irreversible processes that you've encountered?

Reversibility...

- All natural processes tend to be irreversible
- Irreversible processes have an end result that is more disordered (chaotic) than the original state.
- A gas expanding isothermally IS reversible

Entropy

- The quantification of irreversibility of processes
- Entropy is a *state function*—it depends on the thermodynamic state of a system.
 - It does NOT depend on how the system got to that particular state
- **2nd Law of Thermodynamics:**
 - **The entropy of an isolated system never decreases**

Equivalent statements...

- There are other ways to state the 2nd law of thermodynamics—all can be proven to be true as long as one of them is accepted as fact.
 - It is impossible for heat to (spontaneously) flow from a cold object to a hot object.
 - It is impossible for a heat engine working *in a cycle* to absorb heat and perform an equal amount of work
 - The most efficient heat engine operating between two given temperatures is the Carnot engine
