First Law of Thermodynamics
("Conservation of Energy")

\[ E_i + E_{add} = E_f + E_{out} \]

- Work or mass with energy
- Heat or mass with energy

Second Law of Thermodynamics
- Refers to quality of energy

Thermodynamics - Science of heat and work
- First formulated in 1850s
- Want to get heat to do work for us.

Dimensions and units

- Length
- Two systems of units:
  - SI
  - English
- Mass
<table>
<thead>
<tr>
<th>SI</th>
<th></th>
<th>English</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>m</td>
<td>ft</td>
<td>(0.3048 \text{ m} = 1 \text{ ft})</td>
</tr>
<tr>
<td>Mass</td>
<td>Kg</td>
<td>lbm</td>
<td>(2.2 \text{ lbm} = 1 \text{ Kg})</td>
</tr>
<tr>
<td>Time</td>
<td>s</td>
<td>s</td>
<td>(1 \text{ s} = 1 \text{ s})</td>
</tr>
<tr>
<td>Force</td>
<td>N</td>
<td>lbf</td>
<td></td>
</tr>
</tbody>
</table>

\[1 \text{ lbm} = 4 \text{ pounds masses}\]

→ **Newton's second law**  \(F = ma\)

**SI:** Newton of force

\[1 \text{ N} = 1 \text{ kg} \times 1 \text{ m/s}^2 \rightarrow \frac{1 \text{ N}}{1 \text{ N}} = 1 \text{ kgm/s}^2\]

**English system:**

\[1 \text{ lbm} = \text{ slugs}\]

\[1 \text{ lbm} = 4 \text{ lbf} \text{ is the force required to accelerate}

\[1 \text{ slug} \text{ at } 1 \text{ ft/s}^2\]

\[1 \text{ lbf} = 1 \text{ slug} \times 1 \text{ ft/s}^2 \rightarrow 1 \text{ lbf} = 1 \text{ slug} \times \frac{\text{ ft}}{\text{s}^2}\]

\(1 \text{ lbm} = \text{ weight of } 1 \text{ lbm at standard level } (g = 32.174 \text{ ft}/\text{s}^2)\)

\[1 \text{ lbm} = 1 \text{ lbm} \times 32.174 \text{ ft}/\text{s}^2 \rightarrow \frac{1 \text{ lbm}}{1 \text{ lbm}} = 32.174 \text{ ft}/\text{lbf}\]

\[\frac{1 \text{ lbm}}{1 \text{ lbm}} = 1 = \frac{1 \text{ kg} \cdot \text{m}}{\text{N} \cdot \text{s}^2} = \frac{1 \text{ lbf}}{1 \text{ lbf}} = 1 = \frac{32.174 \text{ ft}}{1 \text{ lbm}} \times \frac{1 \text{ lbm}}{1 \text{ lbf} \cdot \text{s}^2}\]
Always "follow the units." Write out units and make sure they cancel.

Given: \(1 \text{ Btu} = 778 \text{ ft-lbf} \)

Convert \(3742 \text{ ft-lbf} \) to Btu:

\[
3742 \text{ ft-lbf} \times \frac{1 \text{ Btu}}{778 \text{ ft-lbf}} = \text{ ______ Btu}
\]

Calculate weight of 100 lbm:

\(\vec{F} = \vec{ma} = mg = 100 \text{ lbm} \times 32 \frac{\text{ft}}{\text{s}^2} \times \frac{1.16 \text{ ft}}{32.174 \text{ lbm}} \)

Conversion factor

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Systems and control volumes:

A system is any object or region on which attention is focused for analysis.

System boundary separates system from surroundings/environment.

Two types of systems:

Closed system or control mass:
- Total mass fixed and no mass crosses system boundary.

Open system or control volume:
- Region fixed in space, mass usually crosses system boundary.