<table>
<thead>
<tr>
<th>Symbol</th>
<th>Represents</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δx, Δy, Δz</td>
<td>change in length in x, y or z direction</td>
<td>length, meters</td>
</tr>
<tr>
<td>A</td>
<td>area = xy (or πr² if area of a circle)</td>
<td>length², meters²</td>
</tr>
<tr>
<td>V</td>
<td>volume = xyz (or πr²l if volume of a cylinder)</td>
<td>length³, meters³</td>
</tr>
<tr>
<td>v</td>
<td>velocity, ( \frac{dx}{dt} )</td>
<td>length/time, meters/second</td>
</tr>
<tr>
<td>a</td>
<td>acceleration (rate of change of velocity, ( \frac{dv}{dt} ))</td>
<td>length/time², m/sec²</td>
</tr>
<tr>
<td>g</td>
<td>acceleration due to earth’s gravity, approximately 9.8 m/sec²</td>
<td>m/sec²</td>
</tr>
<tr>
<td>m</td>
<td>mass (amount of material)</td>
<td>grams or kilograms</td>
</tr>
</tbody>
</table>

\[ F = ma \quad \text{force = mass x acceleration} \]

\[ \text{weight} = mg \quad \text{(mass x acceleration due to earth’s gravity)} \]

\[ E_k \quad \text{(or KE)} \quad \text{kinetic energy} = \frac{1}{2}mv^2 \]

\[ E_{pg} \quad \text{(or PE)} \quad \text{potential energy due to gravity} = mgΔz \quad \text{(weight x height)} \]

\[ W = \Delta(E_k + E_p) \quad \text{mechanical work = change in energy:} \]

\[ W = FΔx \quad \text{mechanical work is also equal to force x distance (1 joule = 1 newton x 1 meter)} \]

\[ E_T \quad \text{(or TE)} \quad \text{thermal energy, a function of an objects mass and its temperature} \]

\[ T \quad \text{temperature (ΔT = T_2-T_1, change in temperature,)} \]

\[ Q \quad \text{heat flow (a transfer of thermal energy, from hot to cold)} \]

1 calorie = amount of heat needed to raise the temperature of 1 gram of water 1°C

\[ Q = mcΔT \quad \text{heat flow as a consequence of changing an object’s temperature (ΔT = \frac{Q}{mc})} \]

\[ c \quad \text{specific heat (heat capacity); for water, c is defined as 1 calorie per gram per °C} \]

\[ W + Q = \Delta(E_k + E_p + E_T) \quad \text{work done + heat flow = change in energy} \]

\[ P \quad \text{power or rate of energy use:} \quad \text{power} = \frac{\text{work done}}{\text{time taken}} = \frac{\text{energy used}}{\text{time}} \quad 1 \text{ watt} = \frac{1 \text{ joule}}{1 \text{ second}} \]

energy used = power applied x time in use (e.g. kilowatt-hour)
$$Q_c = \frac{K \Delta T}{\Delta x} A$$  Conductive heat flow

**Rate of heat flow by conduction**

$$Q_{\text{r}} = \sigma \varepsilon A T^4$$  Radiative heat flow (Stefan-Boltzman Law)

**Rate of heat flow by radiation**

\( \sigma \)  universal constant (fudge factor)

\( \varepsilon \)  emissivity, a property of the material doing the radiation and its surface characteristics

\( A \)  surface area of the radiator  \( \text{meter}^2 \)

\( T^4 \)  absolute temperature, raised to the fourth power  \( ^{\circ}\text{K} \)

\( W = Q_{\text{hot}} - Q_{\text{cold}} \)  Work done by a “Heat Engine”

from a flow of heat between source (hot or input) and sink (cold or output)

$$\frac{Q_{\text{in}} - Q_{\text{out}}}{Q_{\text{in}}} = \frac{W}{Q_{\text{in}}}$$  Efficiency = useful work done / total energy input

$$\frac{T_{\text{hot}} - T_{\text{cold}}}{T_{\text{hot}}}$$  Carnot’s theoretical maximum Heat Engine efficiency (\( T \) in \( ^{\circ}\text{K} \))

1st Law: Conservation of Energy: input = output + change in storage

2nd Law: Energy Conversion: input = useful output + heat (heat—increase in entropy—must be > 0)

Efficiency = useful work done / total energy input

a consequence of the 2nd law is that Efficiency will always be < 100%

Energy Consumption= intensity of use x level of activity  (power x time)