STUDENT SUCCESS CENTER
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

THERMODYNAMICS I: BASICS, ENERGY, & THERMAL EFFICIENCY

Introduction:

- There are seven basic properties to describe a state: enthalpy, entropy, internal energy, temperature, pressure, density, and specific volume. If two are known, the others can be calculated.
- Intensive properties are independent of amount of mass, denoted with lowercase
- Extensive properties are dependent on the amount of mass, denoted with uppercase.
- The four tools used in introductory thermodynamics are the 1st and 2nd laws of thermodynamics, conservation of mass, and equations of state.
- Temperature scale conversions are as follows:

$T(°C)$	=	$\left(\frac{5}{9}\right) * [T(°F) - 32]$
$T(K)$	=	$T(°C) + 273.15$
$T(°R)$	=	$T(°F) + 459.67$

Energy:

- There are 5 forms of energy: kinetic (KE), potential (PE), internal (U), work (W), and heat (Q)
- A change in energy of a system occurs through work done or heat transferred
- Energy sign convention:

W	> 0	*positive*	Work done **by** the system
	< 0	*negative*	Work done **on** the system
Q	> 0	*positive*	Heat transferred **into** system
	< 0	*negative*	Heat transferred **out of** system

- Energy balance equation:

$$\Delta E = E_2 - E_1 = \Delta U + \Delta KE + \Delta PE = (Q_{in} + W_{in} - Q_{out} - W_{out}) + \Delta KE + \Delta PE$$

Rates of Change:

The energy balance equation also applied to rates of change of energy, with a superscript dot centered over a letter signifying the derivative with respect to time:

$$\dot{E} = \frac{dE}{dt}$$

The subscript "cv" is used to notate the system is a control volume ($\Delta V = 0$).

- Mass balance:

$$\frac{dm_{cv}}{dt} = \sum_{in} \dot{m}_{in} - \sum_{exit} \dot{m}_{exit}$$

- Energy balance:

$$\frac{dE_{cv}}{dt} = \dot{E}_{in} - \dot{E}_{out} = \dot{Q} - \dot{W} + \dot{m}_{in}\left(h_{in} + \frac{V_{in}^2}{2} + gz_{in}\right) - \dot{m}_{out}\left(h_{out} + \frac{v_{out}^2}{2} + gz_{out}\right)$$

Based on the assumptions of a given problem, many terms will cancel out to simplify the equation. For example, $\frac{v_{in}^2}{2} - \frac{v_{out}^2}{2}$ and $gz_{in} - gz_{out}$ = 0 when changes in kinetic and potential energy are assumed to be zero. It is good practice to start every relevant problem with the entire equation before canceling out any terms.

Thermal Efficiency:

The following table notes three types of thermal processes and their respective thermal efficiencies. *Carnot* refers to a perfectly reversible processes, such that $\Delta s = 0$

Type	C.O.P	General	Expansion	Carnot Equivalent
Power Cycle	η	$= \frac{w_{cycle}}{Q_{in}}$	$= 1 - \frac{Q_{out}}{Q_{in}}$	$1 - \frac{T_C}{T_H}$
Refrigeration	β	$= \frac{Q_{in}}{W_{cycle}}$	$= \frac{Q_{in}}{Q_{out} - Q_{in}}$	$\frac{T_C}{T_H - T_C}$
Heat Pump	γ	$= \frac{Q_{out}}{W_{cycle}}$	$= \frac{Q_{out}}{\left(Q_{out} - Q_{in}\right)}$	$\frac{T_H}{T_H - T_C}$