Temperature: \[ T(K) = T(\degree C) + 273.15 \]
\[ T(R) = T(\degree F) + 459.67 \]
\[ 9T(K) = 5T(R) \]

Pressure: \[ 1 \text{ atmo} = 101.325 \text{ kPa} = 14.696 \text{ psia} \]
\[ \Delta P = -\gamma \Delta h = -\rho g \Delta h \]

Volume-mass: \[ v = V/m = 1/\rho \]

Energy – Work: \[ e = u + V^2/2 + gz \]
\[ W_{\text{electrical}} = VI \Delta t \]
\[ W = \int \mathbf{F} \cdot d\mathbf{s} \]
\[ \Sigma q_{\text{in}} - \Sigma w_{\text{out}} = e_{\text{final}} - e_{\text{initial}} \]
\[ \eta = \frac{\text{Desired Output}}{\text{Required Input}} \]

Properties: \[ h = u + pv \]

Properties (Phase-Changers): \[ x = \frac{m_{\text{vapor}}}{m_{\text{mixture}}} \]
\[ z = z_i + x z_{fg} \text{ where } z = v, u, h, \text{ or } s \]

Properties (Ideal Gases): \[ PV = mRT \]
\[ R = \frac{\mathcal{R}}{M} \text{ where } \mathcal{R} = 8.3145 \text{ kJ/kmol-K} = 1545.4 \text{ ft-lbf/lbmol-R} \]
\[ \Delta u = c_v \Delta T \]
\[ \Delta h = c_p \Delta T \]
\[ \Delta s = c_i \ln(T_2/T_1) - R \ln(P_2/P_1) \]
\[ \Delta s = c_j \ln(T_2/T_1) + R \ln(v_2/v_1) \]
\[ P v^k = \text{constant} \]
\[ T_2/T_1 = (P_2/P_1)^{(k-1)/k} = (v_1/v_2)^{k-1} \]

Closed System Reversible Boundary Work: \[ W_{1-2} = \int_1^2 PdV \]

Polytropic Process: \[ P v^n = \text{constant} \]
Conservation of mass: \[ \sum_{in} \dot{m} - \sum_{out} \dot{m} = \frac{dm}{dt} \]
\[ \dot{m} = \frac{AV}{v} \]

Closed System First Law: \[ q_{1-2} - w_{1-2} = u_2 - u_1 + \Delta ke + \Delta pe \]

First law:
\[ Q - W + \sum_{in} \dot{m} (h + ke + pe) - \sum_{out} \dot{m} (h + ke + pe) = \frac{dE}{dt} \]
\[ q - w = \Delta h + \Delta ke + \Delta pe \]

Completely Reversible Cyclic Devices:
\[ \frac{Q_L}{Q_H} = \frac{T_L}{T_H} \]
\[ \eta_{car} = 1 - \frac{T_u}{T_H}, \quad \eta \leq \eta_{car} \]

Entropy:
\[ ds = \left| \frac{\delta q}{T} \right|_{rev} \]

Tfds Equations:
\[ Tds = du + Pdv \]
\[ Tds = dh - vdP \]

Steady-state, single-stream reversible work:
\[ w = - \int vdP - \Delta ke - \Delta pe \]

Entropy Balance (Rate Form):
\[ \frac{dS}{dt} = \sum \dot{Q} \frac{1}{T} + \sum \dot{m}_s - \sum \dot{m}_s + \dot{\phi} \]

Otto Cycle: Constant volume heat additions and rejection, isentropic compression and expansion

Diesel Cycle: Isobaric heat addition, constant volume heat rejection, and isentropic compression and expansion

Brayton Cycle: Isobaric heat addition and rejection, isentropic compression and expansion

Ideal regenerator: Combustor inlet temperature equals that at the turbine exhaust

Multi-staging: equal compressor outlet temperatures, equal turbine inlet temperatures

Rankine Cycle: Isobaric heat addition and rejection, Isentropic pumping and turbine.

Open Feedwater heater: Mixes steam from turbine with subcooled feedwater to form a saturated liquid

Closed feedwater heater: two-stream heat exchanger

Vapor compression refrigeration cycle: Isobaric heat addition and rejection, isentropic compression, and throttle expansion.
Closed-system Exergy:
\[ \phi = (u - u_o) + P_o (v - v_o) - T_o (s - s_o) + x_{ke} + x_{pe} \]

Flow Exergy:
\[ \psi = (h - h_o) - T_o (s - s_o) + x_{sw} + x_{pe} \]

Exergy Balance (Closed System):
\[ \sum (1 - \frac{T}{T_o}) \dot{Q} - (\dot{W} - P_o \frac{dV}{dt}) - T_o \dot{S}_{gen} = \frac{dX}{dt} \]

Exergy Balance (steady-flow System):
\[ \sum (1 - \frac{T}{T_o}) \dot{Q} - \dot{W} + \sum \dot{m}_\psi - \sum \dot{m}_\psi - \dot{X}_{dist} = 0 \]