

Thermodynamics Crash Course Cheat Sheet

Laws, closed-system balance, work, polytropic, properties

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
First law, closed system (rate)	$dE/dt = \dot{Q} - \dot{W}$	$\dot{Q} > 0$ into the system, $\dot{W} > 0$ by the system
First law, finite change	$\Delta E = E_2 - E_1 = Q - W$	The article also writes $\Delta U = Q + W$ (work-on-system convention); pick one convention and stay with it
Moving boundary work	$W = \int P dV$	Area under the P-V curve; path dependent
Polytropic process	$P V^n = \text{constant}$	$n = 0$ isobaric, 1 isothermal (ideal gas), γ adiabatic/isentropic, ∞ isochoric
Ideal gas polytropic work	$W = (P_2 V_2 - P_1 V_1) / (1 - n) \quad (n \neq 1)$	$n = 1$: $W = P_1 V_1 \ln(V_2/V_1)$
Quality (wet region)	$x = m_{\text{vapor}} / m_{\text{total}}, \quad 0 \leq x \leq 1$	Only inside the vapor dome
Mixture properties	$v = v_f + x(v_g - v_f)$ same form for u, h, s	f = saturated liquid, g = saturated vapor
Specific heats	$c_v = (\partial u / \partial T)_v \quad c_p = (\partial h / \partial T)_p$	Basis for Δu and Δh of gases and liquids
Compressed liquid approximation	$u \approx u_f(T) \quad v \approx v_f(T) \quad h \approx h_f(T) + v_f[P - P_{\text{sat}}(T)]$	Last resort if CL tables are unavailable

Key takeaways

- Zeroth law: thermal equilibrium (basis of temperature). First law: energy is conserved. Second law: entropy increases in real processes, so conversion is never perfect.
- A closed system exchanges energy (heat, work) but not mass. A cooling pizza loses moisture, so it is not closed.
- Heat and work are path functions that cross the boundary; they are not properties of the system.
- Heat transfer modes: conduction (solids, still fluids), convection (solid to moving fluid), radiation (electromagnetic emission).
- State principle: two independent intensive properties fix the state of a simple compressible substance.
- Property procedure: find two known properties, identify the phase (compressed liquid, saturated liquid, mixture, saturated vapor, superheated), then use the matching table.
- Critical point: saturated liquid and vapor become indistinguishable. T-v, P-v and T-s diagrams show phase regions and process paths.