

Thermodynamic Cycles Cheat Sheet

Carnot, Rankine, Otto, Diesel, Brayton and vapor-compression: efficiency and COP

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Power cycle efficiency	$\eta_{th} = W_{net} / Q_H = 1 - Q_L / Q_H$	
Carnot efficiency	$\eta_{Carnot} = 1 - T_L / T_H$	Absolute temperatures. Upper limit for any engine
Rankine efficiency	$\eta = (w_{turb} - w_{pump}) / q_{boiler} = [(h_1 - h_2) - (h_4 - h_3)] / (h_1 - h_4)$	State numbering as in the article: 1 turbine inlet, 2 exit, 3 condenser exit, 4 pump exit
Compression ratio	$r = V_1 / V_2 = V_{BDC} / V_{TDC}$	Typical gasoline engine about 9:1 to 10:1
Otto, cold-air standard	$\eta_{Otto} = 1 - 1 / r^{k-1}$	$k = c_p / c_v \approx 1.4$ for air
Cutoff ratio (Diesel)	$r_c = V_3 / V_2$	Volume after / before heat addition
Diesel, cold-air standard	$\eta_{Diesel} = 1 - [1 / r^{k-1}] \cdot [(r_c^k - 1) / (k(r_c - 1))]$	Approaches Otto as $r_c \rightarrow 1$
Brayton pressure ratio	$r_p = P_2 / P_1$	
Brayton, cold-air standard	$\eta_{Brayton} = 1 - 1 / r_p^{(k-1)/k}$	Rises with pressure ratio
Back work ratio	$bwr = w_{comp} / w_{turb}$	Article quotes about 0.4 to 0.8 for gas turbines
Refrigerator COP	$COP_R = Q_L / W_{in}$	Reverse Carnot: $T_L / (T_H - T_L)$
Heat pump COP	$COP_{HP} = Q_H / W_{in} = COP_R + 1$	Reverse Carnot: $T_H / (T_H - T_L)$

Key takeaways

- Every cycle returns the working fluid to its starting state. Power cycles turn heat into work; heat-pump cycles use work to move heat.
- Carnot: two isothermal and two isentropic steps. It sets the limit but a real Carnot engine would run too slowly to give useful power.
- Rankine (steam): pump, boiler, turbine, condenser. Superheating raises the average heat-addition temperature and reduces moisture at the turbine exit.
- Otto: constant-volume heat addition (spark ignition). Diesel: constant-pressure heat addition (compression ignition), allowing higher compression ratios and efficiency.
- Brayton (gas turbine, jet): isentropic compression and expansion with constant-pressure heat addition and rejection.
- Vapor-compression: compressor, condenser, throttle, evaporator. Use COP, not efficiency; higher COP means less work per unit of heat moved.
- Formulas on this sheet are the standard textbook forms; the article presents them as images, so check the image equations there for your own course conventions.