

Internal Combustion Engine Cheat Sheet

Cycles, power relations, subsystems and layouts

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Compression ratio	$r = (V_d + V_c) / V_c$	V_d = displaced volume, V_c = clearance volume
Ideal Otto efficiency	$\eta = 1 - 1 / r^{\gamma-1}$	Spark-ignition ideal cycle. $\gamma \approx 1.4$ for air. Real engines are lower
Cylinder displacement	$V = (\pi/4) B^2 S$	B = bore, S = stroke. Multiply by cylinder count
Brake power	$P = T \cdot 2\pi N / 60$	T in N·m, N in RPM, P in W
Four-stroke power	$P = \text{BMEP} \cdot V_d \cdot N / 120$	BMEP in Pa, V_d in m^3 , N in RPM. Strokes: intake, compression, power, exhaust
Boost rule of thumb	2× atmospheric charge pressure → about 2× power	~1 bar (14.7 psi) of boost. Heat, knock and strength limit it

Key takeaways

- An ICE burns fuel with an oxidizer inside a combustion chamber; the hot, high-pressure gas pushes pistons that turn the crankshaft.
- **Spark ignition** (gasoline) needs volatile, knock-resistant fuel. **Compression ignition** (diesel) needs fuel that ignites easily from compression heat.
- Four-stroke is the standard automotive engine (two crank revolutions per cycle). Two-stroke is mostly small equipment.
- Subsystems: structure (block), power conversion (pistons, crank), valvetrain, lubrication, cooling, fuel, air intake and exhaust, ignition, timing, electronics.
- A turbocharger compresses intake air so more fuel can burn per cycle. Intercoolers fight the heating that compression causes.
- Low-displacement turbo and cylinder deactivation cut fuel use while keeping performance.
- About 95% of ICEs still run on fossil fuels, which is why efficiency and emissions control matter.

Cylinder layouts

Layout	Arrangement	Typical use
Inline	Single row	Inline-4 and inline-6, compact width
V-type	Two banks, one crank	V6 and V8, shorter than inline
Flat (boxer)	Horizontally opposed	Low center of gravity
Wankel	Triangular rotor	Rotary engines such as Mazda RX