

Tensile Test Cheat Sheet

Stress-strain curve, key properties and formulas

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Engineering stress	$\sigma = P / A_0$	P = load, A_0 = original area ($A = \pi d^2/4$ for round)
Engineering strain	$\epsilon = (L - L_0) / L_0 = \Delta L / L_0$	L_0 = original gage length
Young's modulus	$E = \sigma / \epsilon$	Slope of the elastic region
Ultimate tensile strength	$TS = F_{\max} / A_0$	Stress at the start of necking
Elongation	$\%EL = [(L_f - L_0) / L_0] \times 100$	Ductility measure
Reduction in area	$\%RA = [(A_0 - A_f) / A_0] \times 100$	Measure the neck diameter after fracture
0.2% offset yield	$\sigma = E (\epsilon - 0.002)$	Intersection with the curve = yield when no distinct yield point
Modulus of resilience	$u_r = \sigma_y^2 / (2E)$	Energy absorbed up to yield
True stress / strain	$\sigma_t = \sigma(1 + \epsilon); \epsilon_t = \ln(1 + \epsilon)$	Valid only up to necking
Power-law hardening	$\sigma_t = K \epsilon_t^n$	K = strength coefficient, n = hardening exponent

Key takeaways

- A specimen (usually a **dogbone**) is pulled along one axis until it breaks. Force and elongation become a stress-strain curve.
- Use the right standard: metals **ASTM E8/E8M, ISO 6892-1**; plastics ASTM D638; composites ASTM D3039; rubber ASTM D412.
- Yield strength is the design limit. UTS is the peak engineering stress. Fracture stress is lower than UTS for ductile metals.
- Engineering stress falls after necking because it uses the original area. True stress keeps rising.
- Alignment matters: bending forces damage results, especially for brittle materials and anisotropic composites.
- Tensile data feeds CAE models, body-in-white material selection and sheet-metal stamping limits.

Typical room-temperature properties (check datasheets)

Material	E	Yield	UTS	Elong.
AISI 1018 steel (cold drawn)	205 GPa	370 MPa	440 MPa	15%
6061-T6 aluminum	69 GPa	276 MPa	310 MPa	12-17%
Ti-6Al-4V (annealed)	114 GPa	880 MPa	950 MPa	14%
Copper (annealed)	117 GPa	70 MPa	220 MPa	45%