

Beam Bending Cheat Sheet

Stress, deflection and the bending test

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Flexure formula	$\sigma = M y / I$	Zero at the neutral axis, max at the outer fibre
Curvature	$1/\rho = M / (E I)$	EI = flexural rigidity
Simply supported, centre load	$\delta_{\max} = P L^3 / (48 E I)$	Standard textbook form
Simply supported, uniform load	$\delta_{\max} = 5 w L^4 / (384 E I)$	
Cantilever, end load	$\delta_{\max} = P L^3 / (3 E I)$	
Rectangular section	$I = b h^3 / 12$	Depth h counts cubed
Percent error	$\% \text{ error} = \text{theory} - \text{measured} / \text{theory} \times 100$	Used in the lab

Key takeaways

- Bending puts one side in compression and the other in tension; the neutral axis carries neither.
- Deflection scales with L^3 for a point load, so halving span cuts it by 8 times, and with $1/I$, so depth matters most.
- Automotive beams (e.g. a rocker) are thin-walled, non-symmetric sections, unlike a civil I-beam.
- Lab (Widener Mechanical Measurements): steel, aluminum and brass bars at 600 mm span, loads 100–600 g; span varied 300–600 mm; sections 3×20, 4×15, 5×10 mm.
- Reported errors: steel 4–16.1%, aluminum 4.7–17.6%, brass 5.4–15.6%; span test 5.4–9.3%; section test 3.4–22.2% with beam 9 an outlier. Load vs deflection was linear (R^2 near 1).
- Three-point bending has its peak moment at one point; four-point bending has a constant peak moment between the loads.
- The article's equations are images; the forms above are standard textbook equivalents.