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Beam deflection: formulas for 6 cases, Young’s modulus, examples

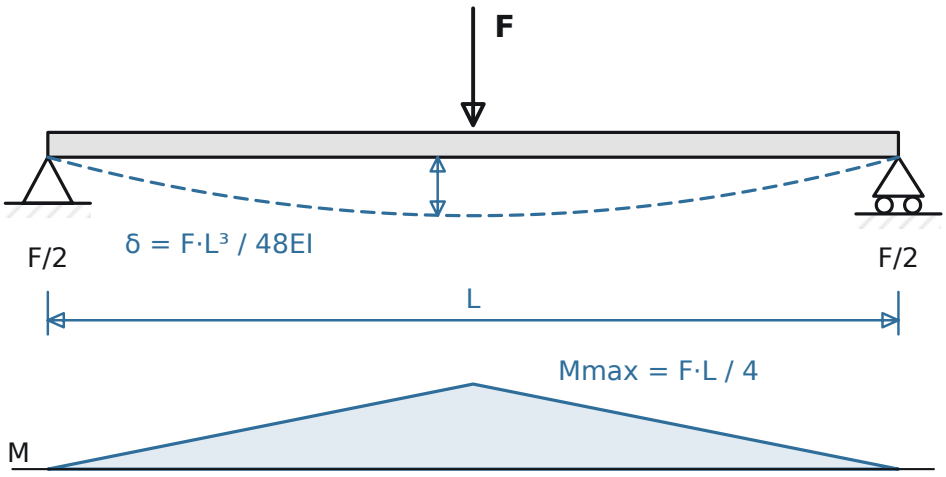
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Version of November 9, 2026

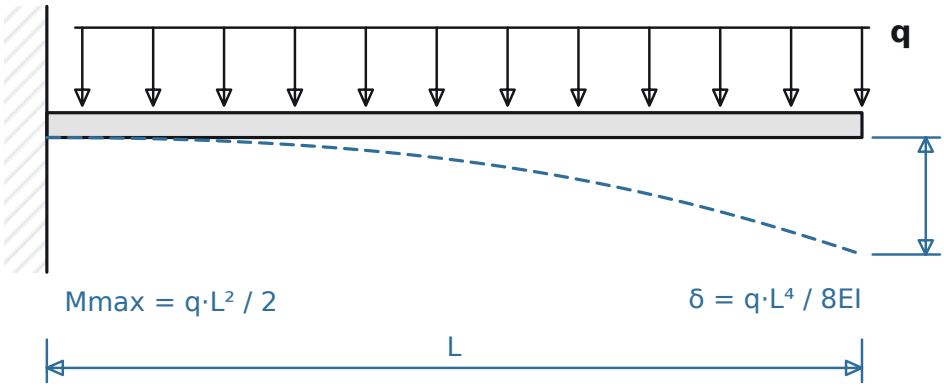
2. Formulas for the 6 common cases

Straight beam of constant section, elastic material, small deflections (Euler-Bernoulli theory). F: point load; q: uniform load per unit length; L: span; E: Young's modulus; I: area moment of inertia about the bending axis.

Supports and load	Maximum deflection δ	Where	Maximum moment M	Where
Simply supported, F at mid-span	$F \cdot L^3 / (48 \cdot E \cdot I)$	mid-span	$F \cdot L / 4$	mid-span
Simply supported, uniform q	$5 \cdot q \cdot L^4 / (384 \cdot E \cdot I)$	mid-span	$q \cdot L^2 / 8$	mid-span
Cantilever, F at free end	$F \cdot L^3 / (3 \cdot E \cdot I)$	free end	$F \cdot L$	fixed end
Cantilever, uniform q	$q \cdot L^4 / (8 \cdot E \cdot I)$	free end	$q \cdot L^2 / 2$	fixed end
Fixed-fixed, F at mid-span	$F \cdot L^3 / (192 \cdot E \cdot I)$	mid-span	$F \cdot L / 8$	fixed ends and mid-span
Fixed-fixed, uniform q	$q \cdot L^4 / (384 \cdot E \cdot I)$	mid-span	$q \cdot L^2 / 12$	fixed ends ($q \cdot L^2/24$ at mid-span)

The support reactions of a symmetric beam are half the total load (F/2 or q·L/2); a cantilever takes the whole load at the fixed end (F or q·L), plus the moment. The uniform load q includes self-weight if you want to account for it: q = mass per unit length × g.





3. Young's modulus and allowable deflection

Deflection depends on Young's modulus E, not on strength: an S355 steel deflects exactly like an S235. Usual design values:

Material	E (MPa)	E (psi)	Deflection relative to steel
Structural steel (Eurocode 3)	210 000	30 500 000	× 1
Structural steel (US practice, AISC)	200 000	29 000 000	× 1.05
Austenitic stainless (304, 316)	200 000	29 000 000	× 1.05
Aluminium alloys	70 000	10 150 000	× 3

Allowable deflection. There is no universal value: it is a serviceability criterion. In buildings, L/200 to L/300 is common depending on the member, with the values set by Eurocode 3 and its national annex; in the US, the IBC uses L/360 for floor members under live load. For a machine frame, a guide or a sensor bracket, the limit comes from the required accuracy and is often far stricter: start from the position tolerance to be held.

Reference values taken from the article https://www.baouch.fr/en/blog/fleche-poutre-calcul-formules/, which explains the assumptions, formulas and edge cases. For critical use, check the current standard or the manufacturer's documentation. Free to print and share with credit to the source.