

Area moment of inertia: section formulas, examples and units

2. Formulas for common sections

Moments of inertia about the centroidal x axis (through the centroid), bending acting in the direction of h, H or D. $W = I / c$, c being the distance from the axis to the extreme fibre. J: polar moment of inertia, for the torsion of round sections.

Section	Area A	Moment of inertia I_x	Section modulus W_x	Polar J
Solid rectangle b × h	$b \cdot h$	$b \cdot h^3 / 12$	$b \cdot h^2 / 6$	—
Square, side a	a^2	$a^4 / 12$	$a^3 / 6$	—
Rectangular tube B × H, inside b × h	$B \cdot H - b \cdot h$	$(B \cdot H^3 - b \cdot h^3) / 12$	$I / (H / 2)$	—
Solid round, diameter D	$\pi \cdot D^2 / 4$	$\pi \cdot D^4 / 64$	$\pi \cdot D^3 / 32$	$\pi \cdot D^4 / 32$
Round tube D × d	$\pi \cdot (D^2 - d^2) / 4$	$\pi \cdot (D^4 - d^4) / 64$	$\pi \cdot (D^4 - d^4) / (32 \cdot D)$	$\pi \cdot (D^4 - d^4) / 32$
Symmetric I-section B × H, web t_w, flanges t_f	$2 \cdot B \cdot t_f + (H - 2 \cdot t_f) \cdot t_w$	$(B \cdot H^3 - (B - t_w) \cdot (H - 2 \cdot t_f)^3) / 12$	$I / (H / 2)$	—
Triangle, base b, height h	$b \cdot h / 2$	$b \cdot h^3 / 36$	$b \cdot h^2 / 24$ (apex)	—

3. Worked examples

Dimensions in millimetres. The same 20 × 40 rectangle is four times stiffer on edge than flat: the moment of inertia varies with the cube of the depth.

Section	A (mm ²)	I_x (cm ⁴)	W_x (cm ³)
Rectangle 20 × 40 on edge (h = 40)	800.0	10.67	5.33
The same, flat (h = 20)	800.0	2.67	2.67
Solid round Ø 20	314.2	0.79	0.79
Round tube Ø 40 × 2	238.8	4.32	2.16
Square tube 40 × 40 × 2	304.0	7.34	3.67
I-section 100 × 200, web 5.6, flanges 8.5 (no fillets)	2 724.8	1 845.59	184.56

Rolled profiles (IPE, HEA...) have root fillets between web and flanges, which the formula ignores: their actual moment of inertia is slightly higher. Use the manufacturer's catalogue value.

5. Units and conversions

The moment of inertia is expressed in mm⁴ or cm⁴ (profile catalogues), the section modulus in mm³ or cm³. Exact conversions, 1 inch being 25.4 mm:

Unit	Equals
1 cm ⁴	10 000 mm ⁴
1 in ⁴	416 231.4 mm ⁴ = 41.62 cm ⁴
1 cm ³	1 000 mm ³
1 in ³	16 387.064 mm ³ = 16.39 cm ³

Reference values taken from the article <https://www.baouch.fr/en/blog/moment-quadratique-inertie-section-calcul/>, 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.