Shaft Angle of Twist and Torsional Shear Stress

Angle of twist, maximum shear stress, polar moment of area and torsional stiffness of a solid or hollow circular shaft under torque, by elastic torsion theory.

Method: Elastic torsion of circular shafts (T/J = τ/r = Gθ/L)

Input parameters

Unit system: SI

Parameter	Value	Unit
Torque	2,000.0	N·m
Shaft length	2.0000	m
Outside diameter	60.000	mm
Inside diameter (0 for a solid shaft)	0	mm
Shear modulus of the material About 80 GPa for carbon steel; use your material's value.	80.000	GPa

Calculated results

Parameter	Value	Unit
Polar moment of area π(D⁴ − d⁴)/32	127.23	cm⁴
Angle of twist T L / (G J)	2.2516	°
Maximum shear stress T (D/2) / J	47.157	MPa
Torsional stiffness G J / L (torque per radian)	50,894	N·m
Twist per metre of length (per m in every unit system)	1.1258	°

Notes for this case

- Elastic torsion of a straight circular shaft; keyways and shoulders raise the stress locally.

Formula and method

$$J = \frac{\pi(D^4 - d^4)}{32}, \quad \theta = \frac{TL}{GJ}, \quad \tau_{max} = \frac{TD/2}{J}$$

Variables

T	Torque	N·m
L	Shaft length	m
D	Outside diameter	m
d	Inside diameter (0 for a solid shaft)	m
G	Shear modulus of the material	Pa
J	Polar moment of area π(D⁴ − d⁴)/32	m⁴
θ	Angle of twist T L / (G J)	rad
τ_{max}	Maximum shear stress T (D/2) / J	Pa
k_t	Torsional stiffness G J / L (torque per radian)	N·m
θ/L	Twist per metre of length	rad/m

Method and standards

Torsion equation for straight circular shafts.

Assumptions and limits

- Elastic, circular, uniform shaft.
- The twist per length is always given per metre, also when lengths are shown in feet (multiply by 0.3048 for per foot).

References

- Elastic torsion of circular shafts (T/J = τ/r = Gθ/L)

Report details

Report reference	FCC-21VR-PJXP (the same inputs always give the same reference)
Generated	17 November 2026, 19:50 UTC
Calculator	Shaft Angle of Twist and Torsional Shear Stress
Method last reviewed	12 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/mechanical/strength-of-materials/shaft-angle-of-twist

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.