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Torsion of Bars Formulas

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List of 13 Torsion of Bars Formulas

Torsion of Bars

Elastic Perfectly Plastic Materials

1) Elasto Plastic Yielding Torque for Hollow Shaft

$$T_{ep} = \pi \cdot \tau_0 \cdot \left(\frac{\rho^3}{2} \cdot \left(1 - \left(\frac{r_1}{\rho} \right)^4 \right) + \left(\frac{2}{3} \cdot r_2^3 \right) \cdot \left(1 - \left(\frac{\rho}{r_2} \right)^3 \right) \right)$$

[Open Calculator !\[\]\(de95854c7ee024cfadc48187bbb781b2_img.jpg\)](#)

ex

$$2.6E^8 N \cdot mm = \pi \cdot 145 MPa \cdot \left(\frac{(80mm)^3}{2} \cdot \left(1 - \left(\frac{40mm}{80mm} \right)^4 \right) + \left(\frac{2}{3} \cdot (100mm)^3 \right) \cdot \left(1 - \left(\frac{80mm}{100mm} \right)^3 \right) \right)$$

2) Elasto Plastic Yielding Torque for Solid Shaft

$$T_{ep} = \frac{2}{3} \cdot \pi \cdot r_2^3 \cdot \tau_0 \cdot \left(1 - \frac{1}{4} \cdot \left(\frac{\rho}{r_2} \right)^3 \right)$$

[Open Calculator !\[\]\(9c2e8d1b5bd77cb5c9f83b7a9cff79fd_img.jpg\)](#)

$$2.6E^8 N \cdot mm = \frac{2}{3} \cdot \pi \cdot (100mm)^3 \cdot 145 MPa \cdot \left(1 - \frac{1}{4} \cdot \left(\frac{80mm}{100mm} \right)^3 \right)$$

3) Full Yielding Torque for Hollow Shaft

$$T_f = \frac{2}{3} \cdot \pi \cdot r_2^3 \cdot \tau_0 \cdot \left(1 - \left(\frac{r_1}{r_2} \right)^3 \right)$$

[Open Calculator !\[\]\(235bfe13ebf007ce2eea9e689707fac7_img.jpg\)](#)

$$2.8E^8 N \cdot mm = \frac{2}{3} \cdot \pi \cdot (100mm)^3 \cdot 145 MPa \cdot \left(1 - \left(\frac{40mm}{100mm} \right)^3 \right)$$

4) Full Yielding Torque for Solid Shaft

$$T_f = \frac{2}{3} \cdot \pi \cdot \tau_0 \cdot r_2^3$$

[Open Calculator !\[\]\(291e070cef6c4d5e78fefe4696ef53be_img.jpg\)](#)

$$3E^8 N \cdot mm = \frac{2}{3} \cdot \pi \cdot 145 MPa \cdot (100mm)^3$$



5) Incipient Yielding Torque for Hollow Shaft [Open Calculator](#) 

$$\text{fx } T_i = \frac{\pi}{2} \cdot r_2^3 \cdot \tau_0 \cdot \left(1 - \left(\frac{r_1}{r_2} \right)^4 \right)$$

$$\text{ex } 2.2E^8N^*mm = \frac{\pi}{2} \cdot (100mm)^3 \cdot 145MPa \cdot \left(1 - \left(\frac{40mm}{100mm} \right)^4 \right)$$

6) Incipient Yielding Torque for Solid Shaft [Open Calculator](#) 

$$\text{fx } T_i = \frac{\pi \cdot r_2^3 \cdot \tau_0}{2}$$

$$\text{ex } 2.3E^8N^*mm = \frac{\pi \cdot (100mm)^3 \cdot 145MPa}{2}$$

Elastic Work Hardening Material 7) Elasto Plastic Yielding Torque in Work Hardening for Hollow Shaft [Open Calculator](#) 

$$\text{fx } T_{ep} = \frac{2 \cdot \pi \cdot \tau_{\text{nonlinear}} \cdot r_2^3}{3} \cdot \left(\frac{3 \cdot \rho^3}{r_2^3 \cdot (n+3)} - \left(\frac{3}{n+3} \right) \cdot \left(\frac{r_1}{\rho} \right)^n \cdot \left(\frac{r_1}{r_2} \right)^3 + 1 - \left(\frac{\rho}{r_2} \right)^3 \right)$$

$$\text{ex } 3.3E^8N^*mm = \frac{2 \cdot \pi \cdot 175MPa \cdot (100mm)^3}{3} \cdot \left(\frac{3 \cdot (80mm)^3}{(100mm)^3 \cdot (0.25+3)} - \left(\frac{3}{0.25+3} \right) \cdot \left(\frac{40mm}{80mm} \right)^{0.25} \cdot \left(\frac{4}{10} \right) \right)$$

8) Elasto Plastic Yielding Torque in Work Hardening for Solid Shaft [Open Calculator](#) 

$$\text{fx } T_{ep} = \frac{2 \cdot \pi \cdot \tau_{\text{nonlinear}} \cdot r_2^3}{3} \cdot \left(1 - \left(\frac{n}{n+3} \right) \cdot \left(\frac{\rho}{r_2} \right)^3 \right)$$


$$\text{ex } 3.5E^8N^*mm = \frac{2 \cdot \pi \cdot 175MPa \cdot (100mm)^3}{3} \cdot \left(1 - \left(\frac{0.25}{0.25+3} \right) \cdot \left(\frac{80mm}{100mm} \right)^3 \right)$$



9) Full Yielding Torque in Work Hardening for Hollow Shaft [Open Calculator](#) 

$$\text{fx } T_f = \frac{2 \cdot \pi \cdot \tau_{\text{nonlinear}} \cdot r_2^3}{3} \cdot \left(1 - \left(\frac{r_1}{r_2} \right)^3 \right)$$

$$\text{ex } 3.4 \text{E}^8 \text{N} \cdot \text{mm} = \frac{2 \cdot \pi \cdot 175 \text{MPa} \cdot (100 \text{mm})^3}{3} \cdot \left(1 - \left(\frac{40 \text{mm}}{100 \text{mm}} \right)^3 \right)$$

10) Full Yielding Torque in Work Hardening for Solid Shaft [Open Calculator](#) 

$$\text{fx } T_f = \frac{2 \cdot \pi \cdot \tau_{\text{nonlinear}} \cdot r_2^3}{3}$$

$$\text{ex } 3.7 \text{E}^8 \text{N} \cdot \text{mm} = \frac{2 \cdot \pi \cdot 175 \text{MPa} \cdot (100 \text{mm})^3}{3}$$

11) Incipient Yielding Torque in Work Hardening for Hollow Shaft [Open Calculator](#) 

$$\text{fx } T_i = \frac{\tau_{\text{nonlinear}} \cdot J_n}{r_2^n}$$

$$\text{ex } 1804.954 \text{N} \cdot \text{mm} = \frac{175 \text{MPa} \cdot 5800 \text{mm}^4}{(100 \text{mm})^{0.25}}$$

12) Incipient Yielding Torque in Work Hardening Solid Shaft [Open Calculator](#) 

$$\text{fx } T_i = \frac{\tau_{\text{nonlinear}} \cdot J_n}{r_2^n}$$

$$\text{ex } 1804.954 \text{N} \cdot \text{mm} = \frac{175 \text{MPa} \cdot 5800 \text{mm}^4}{(100 \text{mm})^{0.25}}$$

13) Nth Polar Moment of Inertia [Open Calculator](#) 

$$\text{fx } J_n = \left(\frac{2 \cdot \pi}{n + 3} \right) \cdot (r_2^{n+3} - r_1^{n+3})$$

$$\text{ex } 1 \text{E}^9 \text{mm}^4 = \left(\frac{2 \cdot \pi}{0.25 + 3} \right) \cdot ((100 \text{mm})^{0.25+3} - (40 \text{mm})^{0.25+3})$$





Residual Stresses for Idealized Stress Strain Law Residual Stresses for Non-Linear stress strain Law 

Variables Used

- J_n Nth Polar Moment of Inertia (Millimeter⁴)
- n Material Constant
- r_1 Inner Radius of Shaft (Millimeter)
- r_2 Outer Radius of Shaft (Millimeter)
- T_{ep} Elasto Plastic Yielding Torque (Newton Millimeter)
- T_f Full Yielding Torque (Newton Millimeter)
- T_i Incipient Yielding Torque (Newton Millimeter)
- ρ Radius of Plastic Front (Millimeter)
- τ_0 Yield Stress in Shear (Megapascal)
- $\tau_{\text{nonlinear}}$ Yield Shear Stress(non-linear) (Megapascal)




Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- **Measurement:** **Torque** in Newton Millimeter (N*mm)
Torque Unit Conversion 
- **Measurement:** **Second Moment of Area** in Millimeter⁴ (mm⁴)
Second Moment of Area Unit Conversion 
- **Measurement:** **Stress** in Megapascal (MPa)
Stress Unit Conversion 



Check other formula lists

- [Nonlinear Behavior of Beams Formulas](#) 
- [Plastic Bending of Beams Formulas](#) 
- [Residual Stresses for Non-Linear Stress Strain Relations Formulas](#) 
- [Residual Stresses in Plastic Bending Formulas](#) 
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