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Principal Stress Formulas

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List of 32 Principal Stress Formulas

Principal Stress

Combined Bending and Torsion Condition

1) Angle of Twist in Combined Bending and Torsion

$$\text{fx } \theta = \frac{\arctan\left(\frac{T}{M}\right)}{2}$$

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

$$\text{ex } 29.99995^\circ = \frac{\arctan\left(\frac{0.116913\text{MPa}}{67.5\text{kN}\cdot\text{m}}\right)}{2}$$

2) Angle of Twist in Combined Bending and Torsional Stress

$$\text{fx } \theta = 0.5 \cdot \arctan\left(2 \cdot \frac{T}{\sigma_b}\right)$$

[Open Calculator !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

$$\text{ex } 8.995819^\circ = 0.5 \cdot \arctan\left(2 \cdot \frac{0.116913\text{MPa}}{0.72\text{MPa}}\right)$$

3) Bending Moment given Combined Bending and Torsion

$$\text{fx } M = \frac{T}{\tan(2 \cdot \theta)}$$

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d_img.jpg\)](#)

$$\text{ex } 67.49975\text{kN}\cdot\text{m} = \frac{0.116913\text{MPa}}{\tan(2 \cdot 30^\circ)}$$

4) Bending Stress given Combined Bending and Torsional Stress

$$\text{fx } \sigma_b = \frac{T}{\frac{\tan(2 \cdot \theta)}{2}}$$

[Open Calculator !\[\]\(166772600a13ad0a433053f90fe45649_img.jpg\)](#)

$$\text{ex } 0.135\text{MPa} = \frac{0.116913\text{MPa}}{\frac{\tan(2 \cdot 30^\circ)}{2}}$$

5) Torsional Moment when Member is subjected to both Bending and Torsion

$$\text{fx } T = M \cdot (\tan(2 \cdot \theta))$$

[Open Calculator !\[\]\(a8ff699ced33317c53c86f9bf3171905_img.jpg\)](#)


$$\text{ex } 0.116913\text{MPa} = 67.5\text{kN}\cdot\text{m} \cdot (\tan(2 \cdot 30^\circ))$$



6) Torsional Stress given Combined Bending and Torsional Stress [Open Calculator](#) 


$$fx \quad T = \left(\frac{\tan(2 \cdot \theta)}{2} \right) \cdot \sigma_b$$

$$ex \quad 0.623538MPa = \left(\frac{\tan(2 \cdot 30^\circ)}{2} \right) \cdot 0.72MPa$$

Complementary Induced Stress 7) Angle of Oblique Plane using Normal Stress when Complementary Shear Stresses Induced [Open Calculator](#) 

$$fx \quad \theta = \frac{a \sin\left(\frac{\sigma_\theta}{\tau}\right)}{2}$$

$$ex \quad 44.4537^\circ = \frac{a \sin\left(\frac{54.99MPa}{55MPa}\right)}{2}$$

8) Angle of Oblique Plane using Shear Stress when Complementary Shear Stresses Induced [Open Calculator](#) 

$$fx \quad \theta = 0.5 \cdot \arccos\left(\frac{\tau_\theta}{\tau}\right)$$

$$ex \quad 29.61052^\circ = 0.5 \cdot \arccos\left(\frac{28.145MPa}{55MPa}\right)$$

9) Normal Stress when Complementary Shear Stresses Induced [Open Calculator](#) 


$$fx \quad \sigma_\theta = \tau \cdot \sin(2 \cdot \theta)$$

$$ex \quad 47.6314MPa = 55MPa \cdot \sin(2 \cdot 30^\circ)$$

10) Shear Stress along Oblique Plane when Complementary Shear Stresses Induced [Open Calculator](#) 

$$fx \quad \tau_\theta = \tau \cdot \cos(2 \cdot \theta)$$


$$ex \quad 27.5MPa = 55MPa \cdot \cos(2 \cdot 30^\circ)$$

11) Shear Stress due to Effect of Complementary Shear Stresses and Shear Stress in Oblique Plane [Open Calculator](#) 

$$fx \quad \tau = \frac{\tau_\theta}{\cos(2 \cdot \theta)}$$

$$ex \quad 56.29MPa = \frac{28.145MPa}{\cos(2 \cdot 30^\circ)}$$




12) Shear Stress due to Induced Complementary Shear Stresses and Normal Stress on Oblique Plane 

$$\text{fx } \tau = \frac{\sigma_{\theta}}{\sin(2 \cdot \theta)}$$

Open Calculator 


$$\text{ex } 63.49698\text{MPa} = \frac{54.99\text{MPa}}{\sin(2 \cdot 30^{\circ})}$$

Equivalent Bending Moment & Torque 13) Bending Stress of Circular Shaft given Equivalent Bending Moment 

$$\text{fx } \sigma_b = \frac{32 \cdot M_e}{\pi \cdot (\Phi^3)}$$

Open Calculator 


$$\text{ex } 0.724332\text{MPa} = \frac{32 \cdot 30\text{kN} \cdot \text{m}}{\pi \cdot ((750\text{mm})^3)}$$

14) Diameter of Circular Shaft for Equivalent Torque and Maximum Shear Stress 

$$\text{fx } \Phi = \left(\frac{16 \cdot T_e}{\pi \cdot (\tau_{\max})} \right)^{\frac{1}{3}}$$

Open Calculator 

$$\text{ex } 157.1413\text{mm} = \left(\frac{16 \cdot 32\text{kN} \cdot \text{m}}{\pi \cdot (42\text{MPa})} \right)^{\frac{1}{3}}$$

15) Diameter of Circular Shaft given Equivalent Bending Stress 

$$\text{fx } \Phi = \left(\frac{32 \cdot M_e}{\pi \cdot (\sigma_b)} \right)^{\frac{1}{3}}$$

Open Calculator 

$$\text{ex } 751.5011\text{mm} = \left(\frac{32 \cdot 30\text{kN} \cdot \text{m}}{\pi \cdot (0.72\text{MPa})} \right)^{\frac{1}{3}}$$

16) Equivalent Bending Moment of Circular Shaft 

$$\text{fx } M_e = \frac{\sigma_b}{\frac{32}{\pi \cdot (\Phi^3)}}$$

Open Calculator 

$$\text{ex } 29.82059\text{kN} \cdot \text{m} = \frac{0.72\text{MPa}}{\frac{32}{\pi \cdot ((750\text{mm})^3)}}$$



17) Equivalent Torque given Maximum Shear Stress 

$$fx \quad T_e = \frac{\tau_{\max}}{\frac{16}{\pi \cdot (\Phi^3)}}$$

Open Calculator 


$$ex \quad 3479.068 \text{ kN} \cdot \text{m} = \frac{42 \text{ MPa}}{\frac{16}{\pi \cdot (750 \text{ mm})^3}}$$

18) Location of Principal Planes 

$$fx \quad \theta = \left(\left(\left(\frac{1}{2} \right) \cdot a \tan \left(\frac{2 \cdot \tau_{xy}}{\sigma_y - \sigma_x} \right) \right) \right)$$

Open Calculator 



$$ex \quad 6.245735^\circ = \left(\left(\left(\frac{1}{2} \right) \cdot a \tan \left(\frac{2 \cdot 7.2 \text{ MPa}}{110 \text{ MPa} - 45 \text{ MPa}} \right) \right) \right)$$

19) Maximum Shear Stress due to Equivalent Torque 

$$fx \quad \tau_{\max} = \frac{16 \cdot T_e}{\pi \cdot (\Phi^3)}$$

Open Calculator 


$$ex \quad 0.38631 \text{ MPa} = \frac{16 \cdot 32 \text{ kN} \cdot \text{m}}{\pi \cdot ((750 \text{ mm})^3)}$$

Maximum Shear Stress on the Biaxial Loading 20) Maximum Shear Stress when Member is Subjected to like Principal Stresses 

$$fx \quad \tau_{\max} = \frac{1}{2} \cdot (\sigma_y - \sigma_x)$$

Open Calculator 

$$ex \quad 32.5 \text{ MPa} = \frac{1}{2} \cdot (110 \text{ MPa} - 45 \text{ MPa})$$

21) Stress along X-Axis when Member is Subjected to like Principal Stresses and Max Shear Stress 

$$fx \quad \sigma_x = \sigma_y - (2 \cdot \tau_{\max})$$

Open Calculator 

$$ex \quad 26 \text{ MPa} = 110 \text{ MPa} - (2 \cdot 42 \text{ MPa})$$

22) Stress along Y-Axis when Member is Subjected to like Principal Stresses and Max Shear Stress 

$$fx \quad \sigma_y = 2 \cdot \tau_{\max} + \sigma_x$$

Open Calculator 

$$ex \quad 129 \text{ MPa} = 2 \cdot 42 \text{ MPa} + 45 \text{ MPa}$$



Stresses in Bi-Axial Loading 23) Normal Stress Induced in Oblique Plane due to Biaxial Loading [Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$\text{fx } \sigma_{\theta} = \left(\frac{1}{2} \cdot (\sigma_x + \sigma_y) \right) + \left(\frac{1}{2} \cdot (\sigma_x - \sigma_y) \cdot (\cos(2 \cdot \theta)) \right) + (\tau_{xy} \cdot \sin(2 \cdot \theta))$$

ex


$$67.48538\text{MPa} = \left(\frac{1}{2} \cdot (45\text{MPa} + 110\text{MPa}) \right) + \left(\frac{1}{2} \cdot (45\text{MPa} - 110\text{MPa}) \cdot (\cos(2 \cdot 30^\circ)) \right) + (7.2\text{MPa} \cdot \sin(2 \cdot 30^\circ))$$

24) Shear Stress Induced in Oblique Plane due to Biaxial Loading [Open Calculator !\[\]\(73002692dd5e7a64e60946be3158e719_img.jpg\)](#)

$$\text{fx } \tau_{\theta} = - \left(\frac{1}{2} \cdot (\sigma_x - \sigma_y) \cdot \sin(2 \cdot \theta) \right) + (\tau_{xy} \cdot \cos(2 \cdot \theta))$$

ex


$$31.74583\text{MPa} = - \left(\frac{1}{2} \cdot (45\text{MPa} - 110\text{MPa}) \cdot \sin(2 \cdot 30^\circ) \right) + (7.2\text{MPa} \cdot \cos(2 \cdot 30^\circ))$$

25) Stress along X- Direction with known Shear Stress in Bi-Axial Loading [Open Calculator !\[\]\(aab88c0d099e5d18d6533a97b13ec28d_img.jpg\)](#)

$$\text{fx } \sigma_x = \sigma_y - \left(\frac{\tau_{\theta} \cdot 2}{\sin(2 \cdot \theta)} \right)$$

ex


$$45.00191\text{MPa} = 110\text{MPa} - \left(\frac{28.145\text{MPa} \cdot 2}{\sin(2 \cdot 30^\circ)} \right)$$

26) Stress along Y- Direction using Shear Stress in Bi-Axial Loading [Open Calculator !\[\]\(f9f168a9979beed8b01f8750d577d508_img.jpg\)](#)

$$\text{fx } \sigma_y = \sigma_x + \left(\frac{\tau_{\theta} \cdot 2}{\sin(2 \cdot \theta)} \right)$$

ex

$$109.9981\text{MPa} = 45\text{MPa} + \left(\frac{28.145\text{MPa} \cdot 2}{\sin(2 \cdot 30^\circ)} \right)$$


Stresses of Members Subjected to Axial Loading 27) Angle of Oblique Plane using Shear Stress and Axial Load [Open Calculator !\[\]\(608bfbc50031d613907ec08333d4afc7_img.jpg\)](#)

$$\text{fx } \theta = \frac{ar \sin \left(\left(\frac{2 \cdot \tau_{\theta}}{\sigma_y} \right) \right)}{2}$$

ex


$$15.38948^\circ = \frac{ar \sin \left(\left(\frac{2 \cdot 28.145\text{MPa}}{110\text{MPa}} \right) \right)}{2}$$



28) Angle of Oblique plane when Member Subjected to Axial Loading [Open Calculator !\[\]\(feabb98897b440bc8695a03336a6e2df_img.jpg\)](#)

$$\text{fx } \theta = \frac{a \cos\left(\frac{\sigma_{\theta}}{\sigma_y}\right)}{2}$$

$$\text{ex } 30.00301^{\circ} = \frac{a \cos\left(\frac{54.99\text{MPa}}{110\text{MPa}}\right)}{2}$$

29) Normal Stress when Member Subjected to Axial Load [Open Calculator !\[\]\(642aa997563f9a325b310230bb5078b7_img.jpg\)](#)

$$\text{fx } \sigma_{\theta} = \sigma_y \cdot \cos(2 \cdot \theta)$$

$$\text{ex } 55\text{MPa} = 110\text{MPa} \cdot \cos(2 \cdot 30^{\circ})$$

30) Shear Stress when Member Subjected to Axial Load [Open Calculator !\[\]\(51514032c8ca341817228f39f1307b05_img.jpg\)](#)

$$\text{fx } \tau_{\theta} = 0.5 \cdot \sigma_y \cdot \sin(2 \cdot \theta)$$

$$\text{ex } 47.6314\text{MPa} = 0.5 \cdot 110\text{MPa} \cdot \sin(2 \cdot 30^{\circ})$$

31) Stress along Y-direction given Shear Stress in Member subjected to Axial Load [Open Calculator !\[\]\(f219cfc00b8db0cd1a81ae1fc9afaf28_img.jpg\)](#)

$$\text{fx } \sigma_y = \frac{\tau_{\theta}}{0.5 \cdot \sin(2 \cdot \theta)}$$

$$\text{ex } 64.99809\text{MPa} = \frac{28.145\text{MPa}}{0.5 \cdot \sin(2 \cdot 30^{\circ})}$$

32) Stress along Y-direction when Member Subjected to Axial Load [Open Calculator !\[\]\(8aa05b4b06c05d58ddd90cdbf335b307_img.jpg\)](#)

$$\text{fx } \sigma_y = \frac{\sigma_{\theta}}{\cos(2 \cdot \theta)}$$

$$\text{ex } 109.98\text{MPa} = \frac{54.99\text{MPa}}{\cos(2 \cdot 30^{\circ})}$$





Variables Used

- **M** Bending Moment (Kilonewton Meter)
- **M_e** Equivalent Bending Moment (Kilonewton Meter)
- **T** Torsion (Megapascal)
- **T_e** Equivalent Torque (Kilonewton Meter)
- **θ** Theta (Degree)
- **σ_b** Bending Stress (Megapascal)
- **σ_x** Stress along x Direction (Megapascal)
- **σ_y** Stress along y Direction (Megapascal)
- **σ_θ** Normal Stress on Oblique Plane (Megapascal)
- **τ** Shear Stress (Megapascal)
- **τ_{max}** Maximum Shear Stress (Megapascal)
- **τ_{xy}** Shear Stress xy (Megapascal)
- **τ_θ** Shear Stress on Oblique Plane (Megapascal)
- **Φ** Diameter of Circular Shaft (Millimeter)



Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Function:** **acos**, acos(Number)
Inverse trigonometric cosine function
- **Function:** **arccos**, arccos(Number)
Inverse trigonometric cosine function
- **Function:** **arctan**, arctan(Number)
Inverse trigonometric tangent function
- **Function:** **arsin**, arsin(Number)
Inverse trigonometric sine function
- **Function:** **asin**, asin(Number)
Inverse trigonometric sine function
- **Function:** **atan**, atan(Number)
Inverse trigonometric tangent function
- **Function:** **cos**, cos(Angle)
Trigonometric cosine function
- **Function:** **ctan**, ctan(Angle)
Trigonometric cotangent function
- **Function:** **sin**, sin(Angle)
Trigonometric sine function
- **Function:** **tan**, tan(Angle)
Trigonometric tangent function
- **Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- **Measurement:** **Angle** in Degree (°)
Angle Unit Conversion 
- **Measurement:** **Torque** in Kilonewton Meter (kN*m)
Torque Unit Conversion 
- **Measurement:** **Moment of Force** in Kilonewton Meter (kN*m)
Moment of Force Unit Conversion 
- **Measurement:** **Stress** in Megapascal (MPa)
Stress Unit Conversion 



Check other formula lists

- [Mohr's Circle of Stresses Formulas](#) 
- [Beam Moments Formulas](#) 
- [Bending Stress Formulas](#) 
- [Combined Axial and Bending Loads Formulas](#) 
- [Elastic Stability of Columns Formulas](#) 
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