Important Principal Stresses Formulas PDF

Formulas
Examples
with Units

List of 22
Important Principal Stresses Formulas

1) Angle of Obliquity Formula

Evaluate Formula

Formula

$$\phi = atan\left(\frac{\tau}{\sigma_n}\right)$$

Example with Units

$$84.0531° = atan\left(\frac{2.4\,\text{MPa}}{0.250\,\text{MPa}}\right)$$

2) Major Principal Stress if Member is Subjected to Two Perpendicular Direct Stress and Shear Stress Formula

Evaluate Formula

Formula

$$\sigma_{major} = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$$

Example with Units

$$3.0547\,\text{MPa} = \frac{0.5\,\text{MPa} + 0.8\,\text{MPa}}{2} + \sqrt{\left(\frac{0.5\,\text{MPa} - 0.8\,\text{MPa}}{2}\right)^2 + 2.4\,\text{MPa}^2}$$

3) Maximum Axial Force Formula

Evaluate Formula

Formula

$$P_{axial} = \sigma \cdot A$$

Example with Units

$$0.0768\,\text{kN} = 0.012\,\text{MPa} \cdot 6400\,\text{mm}^2$$

4) Minor Principal Stress if Member is Subjected to Two Perpendicular Direct Stress and Shear Stress Formula

Evaluate Formula

Formula

$$\sigma_{minor} = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$$

Example with Units

$$-1.7547\,\text{MPa} = \frac{0.5\,\text{MPa} + 0.8\,\text{MPa}}{2} - \sqrt{\left(\frac{0.5\,\text{MPa} - 0.8\,\text{MPa}}{2}\right)^2 + 2.4\,\text{MPa}^2}$$

5) Resultant Stress on Oblique Section given Stress in Perpendicular Directions Formula

Evaluate Formula

Formula

$$\sigma_R = \sqrt{\sigma_n^2 + \tau^2}$$

Example with Units

$$2.413\,\text{MPa} = \sqrt{0.250\,\text{MPa}^2 + 2.4\,\text{MPa}^2}$$

6) Safe Stress given Safe Value of Axial Pull Formula

Evaluate Formula

Formula

$$\sigma = \frac{P_{safe}}{A}$$

Example with Units

$$0.1953\,\text{MPa} = \frac{1.25\,\text{kN}}{6400\,\text{mm}^2}$$

7) Safe Value of Axial Pull Formula

Evaluate Formula

Formula

$$P_{safe} = \sigma_w \cdot A$$

Example with Units

$$38.4\,\text{kN} = 6\,\text{MPa} \cdot 6400\,\text{mm}^2$$

8) Stress along Maximum Axial Force Formula

Evaluate Formula

Formula

$$\sigma = \frac{P_{axial}}{A}$$

Example with Units

$$0.1719\,\text{MPa} = \frac{1.1\,\text{kN}}{6400\,\text{mm}^2}$$

9) Normal Stress Formulas

9.1) Equivalent Stress by Distortion Energy Theory Formula

Evaluate Formula

Formula

$$\sigma_e = \frac{1}{\sqrt{2}} \cdot \sqrt{\left(\sigma_1 - \sigma_2\right)^2 + \left(\sigma_2 - \sigma_3\right)^2 + \left(\sigma_3 - \sigma_1\right)^2}$$

Example with Units

$$41.0513\,\text{N/m}^2 = \frac{1}{\sqrt{2}} \cdot \sqrt{\left(87.5 - 51.43\,\text{N/m}^2\right)^2 + \left(51.43\,\text{N/m}^2 - 96.1\,\text{N/m}^2\right)^2 + \left(96.1\,\text{N/m}^2 - 87.5\right)^2}$$

9.2) Normal Stress across Oblique Section Formula

Evaluate Formula

Formula

$$\sigma_n = \sigma \cdot \left(\cos\left(\theta_{oblique}\right)\right)^2$$

Example with Units

$$0.0112\,\text{MPa} = 0.012\,\text{MPa} \cdot \left(\cos\left(15°\right)\right)^2$$

9.3) Normal Stress for Principal Planes at Angle of 0 Degrees given Major and Minor Tensile Stress Formula

Evaluate Formula

Formula

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2}$$

Example with Units

$$124\,\text{MPa} = \frac{124\,\text{MPa} + 48\,\text{MPa}}{2} + \frac{124\,\text{MPa} - 48\,\text{MPa}}{2}$$

9.4) Normal Stress for Principal Planes at Angle of 90 degrees Formula

Evaluate Formula

Formula

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} - \frac{\sigma_1 - \sigma_2}{2}$$

Example with Units

$$48\,\text{MPa} = \frac{124\,\text{MPa} + 48\,\text{MPa}}{2} - \frac{124\,\text{MPa} - 48\,\text{MPa}}{2}$$

9.5) Normal Stress for Principal Planes when Planes are at Angle of 0 Degree Formula

Evaluate Formula

Formula

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2}$$

Example with Units

$$124\,\text{MPa} = \frac{124\,\text{MPa} + 48\,\text{MPa}}{2} + \frac{124\,\text{MPa} - 48\,\text{MPa}}{2}$$

9.6) Normal Stress on Oblique Section given Stress in Perpendicular Directions Formula

Evaluate Formula

Formula

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2} + \frac{\sigma_1 - \sigma_2}{2} \cdot \cos\left(2 \cdot \theta_{oblique}\right)$$

Example with Units

$$118.909\,\text{MPa} = \frac{124\,\text{MPa} + 48\,\text{MPa}}{2} + \frac{124\,\text{MPa} - 48\,\text{MPa}}{2} \cdot \cos\left(2 \cdot 15°\right)$$

9.7) Normal Stress using Obliquity Formula

Evaluate Formula

Formula

$$\sigma_n = \frac{\tau}{\tan(\phi)}$$

Example with Units

$$2.4\,\text{MPa} = \frac{2.4\,\text{MPa}}{\tan(45°)}$$

9.8) Stress Amplitude Formula

Evaluate Formula

Formula

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

Example with Units

$$-21.935\,\text{N/m}^2 = \frac{62.43\,\text{N/m}^2 - 106.3\,\text{N/m}^2}{2}$$

10) Shear Stress Formulas

10.1) Condition for Maximum or Minimum Shear Stress given Member under Direct and Shear Stress Formula

Evaluate Formula

Formula

$$\theta_{plane} = \frac{1}{2} \cdot atan\left(\frac{\sigma_x - \sigma_y}{2 \cdot \tau}\right)$$

Example with Units

$$-1.7882° = \frac{1}{2} \cdot atan\left(\frac{0.5\,\text{MPa} - 0.8\,\text{MPa}}{2 \cdot 2.4\,\text{MPa}}\right)$$

10.2) Maximum Shear Stress given Major and Minor Tensile Stress Formula

Evaluate Formula

Formula

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$$

Example with Units

$$38\,\text{MPa} = \frac{124\,\text{MPa} - 48\,\text{MPa}}{2}$$

10.3) Maximum Shear Stress given Member is under Direct and Shear Stress Formula

Evaluate Formula

Formula

$$\tau_{max} = \frac{\sqrt{\left(\sigma_x - \sigma_y\right)^2 + 4 \cdot \tau^2}}{2}$$

Example with Units

$$2.4047\,\text{MPa} = \frac{\sqrt{\left(0.5\,\text{MPa} - 0.8\,\text{MPa}\right)^2 + 4 \cdot 2.4\,\text{MPa}^2}}{2}$$

10.4) Shear Stress using Obliquity Formula

Evaluate Formula

Formula

$$\tau = \tan\left(\phi\right) \cdot \sigma_n$$

Example with Units

$$0.25\,\text{MPa} = \tan\left(45°\right) \cdot 0.250\,\text{MPa}$$

11) Tangential Stress Formulas

11.1) Tangential Stress across Oblique Section Formula

Evaluate Formula

Formula

$$\sigma_t = \frac{\sigma}{2} \cdot \sin\left(2 \cdot \theta_{oblique}\right)$$

Example with Units

$$0.003\,\text{MPa} = \frac{0.012\,\text{MPa}}{2} \cdot \sin\left(2 \cdot 15°\right)$$

11.2) Tangential Stress on Oblique Section given Stress in Perpendicular Directions Formula

Evaluate Formula

Formula

$$\sigma_t = \sin\left(2 \cdot \theta_{oblique}\right) \cdot \frac{\sigma_1 - \sigma_2}{2}$$

Example with Units

$$19\,\text{MPa} = \sin\left(2 \cdot 15°\right) \cdot \frac{124\,\text{MPa} - 48\,\text{MPa}}{2}$$

Variables used in list of Principal Stresses Formulas above

- **A** Area of Cross-Section *(Square Millimeter)*
- P_{axial} Maximum Axial Force *(Kilonewton)*
- P_{safe} Safe Value of Axial Pull *(Kilonewton)*
- $\theta_{oblique}$ Angle made by Oblique Section with Normal *(Degree)*
- θ_{plane} Plane Angle *(Degree)*
- σ Stress in Bar *(Megapascal)*
- σ_1 Normal Stress 1
- σ_1 Major Tensile Stress *(Megapascal)*
- σ_2 Normal Stress 2 *(Newton per Square Meter)*
- σ_2 Minor Tensile Stress *(Megapascal)*
- σ_3 Normal Stress 3 *(Newton per Square Meter)*
- σ_a Stress Amplitude *(Newton per Square Meter)*
- σ_e Equivalent Stress *(Newton per Square Meter)*
- σ_{major} Major Principal Stress *(Megapascal)*
- σ_{max} Maximum Stress at Crack Tip *(Newton per Square Meter)*
- σ_{min} Minimum Stress *(Newton per Square Meter)*
- σ_{minor} Minor Principal Stress *(Megapascal)*
- σ_n Normal Stress *(Megapascal)*
- σ_R Resultant Stress *(Megapascal)*
- σ_t Tangential Stress *(Megapascal)*
- σ_w Safe Stress *(Megapascal)*
- σ_x Stress acting along x-direction *(Megapascal)*
- σ_y Stress acting along y-direction *(Megapascal)*
- ϕ Angle of Obliquity *(Degree)*
- τ Shear Stress *(Megapascal)*
- τ_{max} Maximum Shear Stress *(Megapascal)*

Constants, Functions, Measurements used in list of Principal Stresses Formulas above

- Functions: **atan**, atan(Number)
  Inverse tan is used to calculate the angle by applying the tangent ratio of the angle, which is the opposite side divided by the adjacent side of the right triangle.
- Functions: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- Functions: **sin**, sin(Angle)
  Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Functions: **tan**, tan(Angle)
  The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Megapascal (MPa), Newton per Square Meter (N/m²)
  Pressure Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

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