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Euler and Rankine's Theory Formulas

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List of 19 Euler and Rankine's Theory Formulas

Euler and Rankine's Theory

1) Crippling Load by Euler's Formula

$$\text{fx } P_E = \frac{\pi^2 \cdot E \cdot I}{L_{\text{eff}}^2}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b_img.jpg\)](#)

$$\text{ex } 1491.407\text{kN} = \frac{\pi^2 \cdot 200000\text{MPa} \cdot 6800000\text{mm}^4}{(3000\text{mm})^2}$$

2) Crippling Load by Euler's Formula given Crippling Load by Rankine's Formula

$$\text{fx } P_E = \frac{P_c \cdot P_r}{P_c - P_r}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d_img.jpg\)](#)

$$\text{ex } 1491.407\text{kN} = \frac{1500\text{kN} \cdot 747.8456\text{kN}}{1500\text{kN} - 747.8456\text{kN}}$$

3) Crippling Load by Rankine's Formula

$$\text{fx } P_r = \frac{P_c \cdot P_E}{P_c + P_E}$$

[Open Calculator !\[\]\(f60b7a900783ac3fd531bfd9c111be6d_img.jpg\)](#)

$$\text{ex } 747.8456\text{kN} = \frac{1500\text{kN} \cdot 1491.407\text{kN}}{1500\text{kN} + 1491.407\text{kN}}$$



4) Crippling Load given Rankine's Constant

[Open Calculator !\[\]\(4729e517bc6a7cd81c8025b9646574fb_img.jpg\)](#)

$$fx \quad P = \frac{\sigma_c \cdot A}{1 + \alpha \cdot \left(\frac{L_{eff}}{r_{least}} \right)^2}$$

$$ex \quad 588.9524kN = \frac{750MPa \cdot 2000mm^2}{1 + 0.00038 \cdot \left(\frac{3000mm}{47.02mm} \right)^2}$$

5) Cross-Sectional Area of Column given Crippling Load and Rankine's Constant

[Open Calculator !\[\]\(e474458956c9a37fbf9586ddb60a7fa1_img.jpg\)](#)

$$fx \quad A = \frac{P \cdot \left(1 + \alpha \cdot \left(\frac{L_{eff}}{r_{least}} \right)^2 \right)}{\sigma_c}$$

$$ex \quad 2000mm^2 = \frac{588.9524kN \cdot \left(1 + 0.00038 \cdot \left(\frac{3000mm}{47.02mm} \right)^2 \right)}{750MPa}$$

6) Cross-Sectional Area of Column given Crushing Load

[Open Calculator !\[\]\(4fe57c3593bf1b21d272ae7ac8dfaf77_img.jpg\)](#)

$$fx \quad A = \frac{P_c}{\sigma_c}$$

$$ex \quad 2000mm^2 = \frac{1500kN}{750MPa}$$



7) Crushing Load by Rankine's Formula

$$fx \quad P_c = \frac{P_r \cdot P_E}{P_E - P_r}$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95_img.jpg\)](#)

$$ex \quad 1500kN = \frac{747.8456kN \cdot 1491.407kN}{1491.407kN - 747.8456kN}$$

8) Crushing Load given Ultimate Crushing Stress

$$fx \quad P_c = \sigma_c \cdot A$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2_img.jpg\)](#)

$$ex \quad 1500kN = 750MPa \cdot 2000mm^2$$

9) Effective Length of Column given Crippling Load and Rankine's Constant

$$fx \quad L_{eff} = \sqrt{\left(\sigma_c \cdot \frac{A}{P} - 1\right) \cdot \frac{r_{least}^2}{\alpha}}$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7_img.jpg\)](#)

$$ex \quad 3000mm = \sqrt{\left(750MPa \cdot \frac{2000mm^2}{588.9524kN} - 1\right) \cdot \frac{(47.02mm)^2}{0.00038}}$$



10) Effective Length of Column given Crippling Load by Euler's Formula



$$fx \quad L_{\text{eff}} = \sqrt{\frac{\pi^2 \cdot E \cdot I}{P_E}}$$

[Open Calculator](#)

$$ex \quad 3000\text{mm} = \sqrt{\frac{\pi^2 \cdot 200000\text{MPa} \cdot 6800000\text{mm}^4}{1491.407\text{kN}}}$$

11) Least Radius of Gyration given Crippling Load and Rankine's Constant



$$fx \quad r_{\text{least}} = \sqrt{\frac{\alpha \cdot L_{\text{eff}}^2}{\sigma_c \cdot \frac{A}{P} - 1}}$$

[Open Calculator](#)

$$ex \quad 47.02\text{mm} = \sqrt{\frac{0.00038 \cdot (3000\text{mm})^2}{750\text{MPa} \cdot \frac{2000\text{mm}^2}{588.9524\text{kN}} - 1}}$$

12) Modulus of Elasticity given Crippling Load by Euler's Formula



$$fx \quad E = \frac{P_E \cdot L_{\text{eff}}^2}{\pi^2 \cdot I}$$

[Open Calculator](#)

$$ex \quad 200000\text{MPa} = \frac{1491.407\text{kN} \cdot (3000\text{mm})^2}{\pi^2 \cdot 6800000\text{mm}^4}$$



13) Modulus of Elasticity given Rankine's Constant

$$fx \quad E = \frac{\sigma_c}{\pi^2 \cdot \alpha}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0_img.jpg\)](#)

$$ex \quad 199976MPa = \frac{750MPa}{\pi^2 \cdot 0.00038}$$

14) Moment of Inertia given Crippling Load by Euler's Formula

$$fx \quad I = \frac{P_E \cdot L_{eff}^2}{\pi^2 \cdot E}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5_img.jpg\)](#)

$$ex \quad 6.8E^6mm^4 = \frac{1491.407kN \cdot (3000mm)^2}{\pi^2 \cdot 200000MPa}$$

15) Rankine's Constant

$$fx \quad \alpha = \frac{\sigma_c}{\pi^2 \cdot E}$$

[Open Calculator !\[\]\(ab4e2b3fc7e7887b7a72f548aa6f5e60_img.jpg\)](#)

$$ex \quad 0.00038 = \frac{750MPa}{\pi^2 \cdot 200000MPa}$$

16) Rankine's Constant given Crippling Load

$$fx \quad \alpha = \left(\frac{\sigma_c \cdot A}{P} - 1 \right) \cdot \left(\frac{r_{least}}{L_{eff}} \right)^2$$

[Open Calculator !\[\]\(5abce1a84a655b073239ab33e1199487_img.jpg\)](#)

$$ex \quad 0.00038 = \left(\frac{750MPa \cdot 2000mm^2}{588.9524kN} - 1 \right) \cdot \left(\frac{47.02mm}{3000mm} \right)^2$$



17) Ultimate Crushing Stress given Crippling Load and Rankine's Constant

$$\text{fx } \sigma_c = \frac{P \cdot \left(1 + \alpha \cdot \left(\frac{L_{\text{eff}}}{r_{\text{least}}} \right)^2 \right)}{A}$$

[Open Calculator !\[\]\(9dfdaff1d86ba3c1f8353b4d1b61b8c5_img.jpg\)](#)

$$\text{ex } 750\text{MPa} = \frac{588.9524\text{kN} \cdot \left(1 + 0.00038 \cdot \left(\frac{3000\text{mm}}{47.02\text{mm}} \right)^2 \right)}{2000\text{mm}^2}$$

18) Ultimate Crushing Stress given Crushing Load

$$\text{fx } \sigma_c = \frac{P_c}{A}$$

[Open Calculator !\[\]\(2b376d1a92330ab09dad2665d2f89bf5_img.jpg\)](#)

$$\text{ex } 750\text{MPa} = \frac{1500\text{kN}}{2000\text{mm}^2}$$

19) Ultimate Crushing Stress given Rankine's Constant

$$\text{fx } \sigma_c = \alpha \cdot \pi^2 \cdot E$$

[Open Calculator !\[\]\(c444627dab9fee9a1550c053ffaaaae2_img.jpg\)](#)

$$\text{ex } 750.0899\text{MPa} = 0.00038 \cdot \pi^2 \cdot 200000\text{MPa}$$








Variables Used

- **A** Column Cross Sectional Area (Square Millimeter)
- **E** Modulus of Elasticity Column (Megapascal)
- **I** Moment of Inertia Column (Millimeter⁴)
- **L_{eff}** Effective Column Length (Millimeter)
- **P** Crippling Load (Kilonewton)
- **P_c** Crushing Load (Kilonewton)
- **P_E** Euler's Buckling Load (Kilonewton)
- **P_r** Rankine's Critical Load (Kilonewton)
- **r_{least}** Least Radius of Gyration Column (Millimeter)
- **α** Rankine's Constant
- **σ_c** Column Crushing Stress (Megapascal)









Constants, Functions, Measurements used

- **Constant:** **pi**, 3.14159265358979323846264338327950288
Archimedes' constant
- **Function:** **sqrt**, sqrt(Number)
Square root function
- **Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- **Measurement:** **Area** in Square Millimeter (mm²)
Area Unit Conversion 
- **Measurement:** **Pressure** in Megapascal (MPa)
Pressure Unit Conversion 
- **Measurement:** **Force** in Kilonewton (kN)
Force Unit Conversion 
- **Measurement:** **Second Moment of Area** in Millimeter⁴ (mm⁴)
Second Moment of Area Unit Conversion 



Check other formula lists

- [Columns With Eccentric Load Formulas](#) 
- [Columns With Initial Curvature Formulas](#) 
- [Effective Length of Column Formulas](#) 
- [Euler and Rankine's Theory Formulas](#) 
- [Expressions For Crippling Load Formulas](#) 
- [Failure of a Column Formulas](#) 
- [Formula By I.S. Code For Mild Steel Formulas](#) 
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