Important Slope and Deflection Formulas PDF

Formulas
Examples
with Units

List of 28
Important Slope and Deflection Formulas

1) Cantilever Beam Formulas

1.1) Deflection at Any Point on Cantilever Beam carrying Couple Moment at Free End Formula

Evaluate Formula

Formula

$$\delta = \left(\frac{M_c \cdot x^2}{2 \cdot E \cdot I} \right)$$

Example with Units

$$1.4964\,\text{mm} = \left(\frac{85\,\text{kN*m} \cdot 1300\,\text{mm}^2}{2 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

1.2) Deflection at Any Point on Cantilever Beam carrying UDL Formula

Evaluate Formula

Formula

$$\delta = \left(\left(w' \cdot x^2 \right) \cdot \left(\frac{\left(x^2 \right) + \left(6 \cdot l^2 \right) - \left(4 \cdot x \cdot l \right)}{24 \cdot E \cdot I} \right) \right)$$

Example with Units

$$4.4253\,\text{mm} = \left(\left(24\,\text{kN/m} \cdot 1300\,\text{mm}^2 \right) \cdot \left(\frac{\left(1300\,\text{mm}^2 \right) + \left(6 \cdot 5000\,\text{mm}^2 \right) - \left(4 \cdot 1300\,\text{mm} \cdot 5000\,\text{mm} \right)}{24 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right) \right)$$

1.3) Deflection of Cantilever Beam carrying Point Load at Any Point Formula

Evaluate Formula

Formula

$$\delta = \frac{P \cdot \left(a^2 \right) \cdot \left(3 \cdot l - a \right)}{6 \cdot E \cdot I}$$

Example with Units

$$19.7227\,\text{mm} = \frac{88\,\text{kN} \cdot \left(2250\,\text{mm}^2 \right) \cdot \left(3 \cdot 5000\,\text{mm} - 2250\,\text{mm} \right)}{6 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}$$

1.4) Maximum Deflection of Cantilever Beam carrying Point Load at Free End Formula

Evaluate Formula

Formula

$$\delta = \frac{P \cdot \left(l^3 \right)}{3 \cdot E \cdot I}$$

Example with Units

$$76.3889\,\text{mm} = \frac{88\,\text{kN} \cdot \left(5000\,\text{mm}^3 \right)}{3 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}$$

1.5) Maximum Deflection of Cantilever Beam carrying UDL Formula

Evaluate Formula

Formula

$$\delta = \frac{w' \cdot \left(l^4\right)}{8 \cdot E \cdot I}$$

Example with Units

$$39.0625\,\text{mm} = \frac{24\,\text{kN/m} \cdot \left(5000\,\text{mm}^4\right)}{8 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}$$

1.6) Maximum Deflection of Cantilever Beam Carrying UVL with Maximum Intensity at Free End Formula

Evaluate Formula

Formula

$$\delta = \left(\frac{11 \cdot q \cdot \left(l^4\right)}{120 \cdot E \cdot I}\right)$$

Example with Units

$$44.7591\,\text{mm} = \left(\frac{11 \cdot 37.5\,\text{kN/m} \cdot \left(5000\,\text{mm}^4\right)}{120 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}\right)$$

1.7) Maximum Deflection of Cantilever Beam carrying UVL with Maximum Intensity at Support Formula

Evaluate Formula

Formula

$$\delta = \frac{q \cdot \left(l^4\right)}{30 \cdot E \cdot I}$$

Example with Units

$$16.276\,\text{mm} = \frac{37.5\,\text{kN/m} \cdot \left(5000\,\text{mm}^4\right)}{30 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}$$

1.8) Maximum Deflection of Cantilever Beam with Couple Moment at Free End Formula

Evaluate Formula

Formula

$$\delta = \frac{M_c \cdot \left(l^2\right)}{2 \cdot E \cdot I}$$

Example with Units

$$22.1354\,\text{mm} = \frac{85\,\text{kN*m} \cdot \left(5000\,\text{mm}^2\right)}{2 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}$$

1.9) Slope at Free End of Cantilever Beam Carrying Concentrated Load at Any Point from Fixed End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{P \cdot x^2}{2 \cdot E \cdot I}\right)$$

Example with Units

$$0.0015\,\text{rad} = \left(\frac{88\,\text{kN} \cdot 1300\,\text{mm}^2}{2 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}\right)$$

1.10) Slope at Free End of Cantilever Beam Carrying Concentrated Load at Free End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{P \cdot l^2}{2 \cdot E \cdot I}\right)$$

Example with Units

$$0.0229\,\text{rad} = \left(\frac{88\,\text{kN} \cdot 5000\,\text{mm}^2}{2 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}\right)$$

1.11) Slope at Free End of Cantilever Beam Carrying Couple at Free End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{M_c \cdot l}{E \cdot I}\right)$$

Example with Units

$$0.0089\,\text{rad} = \left(\frac{85\,\text{kN*m} \cdot 5000\,\text{mm}}{30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}\right)$$

1.12) Slope at Free End of Cantilever Beam carrying UDL Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{w' \cdot l^3}{6 \cdot E \cdot I} \right)$$

Example with Units

$$0.0104\,\text{rad} = \left(\frac{24\,\text{kN/m} \cdot 5000\,\text{mm}^3}{6 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

1.13) Slope at Free End of Cantilever Beam Carrying UVL with Maximum Intensity at Fixed End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{q \cdot l^3}{24 \cdot E \cdot I} \right)$$

Example with Units

$$0.0041\,\text{rad} = \left(\frac{37.5\,\text{kN/m} \cdot 5000\,\text{mm}^3}{24 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2) Simply Supported Beam Formulas

2.1) Center Deflection of Simply Supported Beam carrying Couple Moment at Right End Formula

Evaluate Formula

Formula

$$\delta = \left(\frac{M_c \cdot l^2}{16 \cdot E \cdot I} \right)$$

Example with Units

$$2.7669\,\text{mm} = \left(\frac{85\,\text{kN*m} \cdot 5000\,\text{mm}^2}{16 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.2) Center Deflection on Simply Supported Beam carrying UVL with Maximum Intensity at Right support Formula

Evaluate Formula

Formula

$$\delta = \left(0.00651 \cdot \frac{q \cdot \left(l^4 \right)}{E \cdot I} \right)$$

Example with Units

$$3.1787\,\text{mm} = \left(0.00651 \cdot \frac{37.5\,\text{kN/m} \cdot \left(5000\,\text{mm}^4 \right)}{30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.3) Deflection at Any Point on Simply Supported carrying Couple Moment at Right End Formula

Evaluate Formula

Formula

$$\delta = \left(\left(\frac{M_c \cdot l \cdot x}{6 \cdot E \cdot I} \right) \cdot \left(1 - \left(\frac{x^2}{l^2} \right) \right) \right)$$

Example with Units

$$1.7887\,\text{mm} = \left(\left(\frac{85\,\text{kN*m} \cdot 5000\,\text{mm} \cdot 1300\,\text{mm}}{6 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right) \cdot \left(1 - \left(\frac{1300\,\text{mm}^2}{5000\,\text{mm}^2} \right) \right) \right)$$

2.4) Deflection at Any Point on Simply Supported Beam carrying UDL Formula

Evaluate Formula

Formula

$$\delta = \left(\left(\left(\frac{w' \cdot x}{24 \cdot E \cdot I}\right) \cdot \left(\left(l^3\right) - \left(2 \cdot l \cdot x^2\right) + \left(x^3\right)\right)\right)\right)$$

Example with Units

$$2.9872\,\text{mm} = \left(\left(\left(\frac{24\,\text{kN/m} \cdot 1300\,\text{mm}}{24 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}\right) \cdot \left(\left(5000\,\text{mm}^3\right) - \left(2 \cdot 5000\,\text{mm} \cdot 1300\,\text{mm}^2\right) + \left(1300\,\text{mm}^3\right)\right)\right)\right)$$

2.5) Maximum and Center Deflection of Simply Supported Beam carrying Point Load at Center Formula

Evaluate Formula

Formula

$$\delta = \frac{P \cdot \left(l^3\right)}{48 \cdot E \cdot I}$$

Example with Units

$$4.7743\,\text{mm} = \frac{88\,\text{kN} \cdot \left(5000\,\text{mm}^3\right)}{48 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}$$

2.6) Maximum and Center Deflection of Simply Supported Beam carrying UDL over its Entire Length Formula

Evaluate Formula

Formula

$$\delta = \frac{5 \cdot w' \cdot \left(l^4\right)}{384 \cdot E \cdot I}$$

Example with Units

$$4.069\,\text{mm} = \frac{5 \cdot 24\,\text{kN/m} \cdot \left(5000\,\text{mm}^4\right)}{384 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}$$

2.7) Maximum Deflection of Simply Supported Beam carrying Couple Moment at Right End Formula

Evaluate Formula

Formula

$$\delta = \left(\frac{M_c \cdot l^2}{15.5884 \cdot E \cdot I}\right)$$

Example with Units

$$2.84\,\text{mm} = \left(\frac{85\,\text{kN*m} \cdot 5000\,\text{mm}^2}{15.5884 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}\right)$$

2.8) Maximum Deflection of Simply Supported Beam carrying Triangular Load with Max Intensity at Center Formula

Evaluate Formula

Formula

$$\delta = \left(\left(\frac{q \cdot \left(l^4\right)}{120 \cdot E \cdot I}\right)\right)$$

Example with Units

$$4.069\,\text{mm} = \left(\left(\frac{37.5\,\text{kN/m} \cdot \left(5000\,\text{mm}^4\right)}{120 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4}\right)\right)$$

2.9) Maximum Deflection on Simply Supported Beam carrying UVL Max Intensity at Right Support Formula

Evaluate Formula

Formula

$$\delta = \left(0.00652 \cdot \frac{q \cdot \left(l^4 \right)}{E \cdot I} \right)$$

Example with Units

$$3.1836\,\text{mm} = \left(0.00652 \cdot \frac{37.5\,\text{kN/m} \cdot \left(5000\,\text{mm}^4 \right)}{30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.10) Slope at Free Ends of Simply Supported Beam carrying Concentrated Load at Center Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{P \cdot l^2}{16 \cdot E \cdot I} \right)$$

Example with Units

$$0.0029\,\text{rad} = \left(\frac{88\,\text{kN} \cdot 5000\,\text{mm}^2}{16 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.11) Slope at Free Ends of Simply Supported Beam carrying UDL Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{w' \cdot l^3}{24 \cdot E \cdot I} \right)$$

Example with Units

$$0.0026\,\text{rad} = \left(\frac{24\,\text{kN/m} \cdot 5000\,\text{mm}^3}{24 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.12) Slope at Left End of Simply Supported Beam carrying Couple at Right End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{M_c \cdot l}{6 \cdot E \cdot I} \right)$$

Example with Units

$$0.0015\,\text{rad} = \left(\frac{85\,\text{kN*m} \cdot 5000\,\text{mm}}{6 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.13) Slope at Left End of Simply Supported Beam carrying UVL with Maximum Intensity at Right End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{7 \cdot q \cdot l^3}{360 \cdot E \cdot I} \right)$$

Example with Units

$$0.0019\,\text{rad} = \left(\frac{7 \cdot 37.5\,\text{kN/m} \cdot 5000\,\text{mm}^3}{360 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.14) Slope at Right End of Simply Supported Beam carrying Couple at Right End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{M_c \cdot l}{3 \cdot E \cdot I} \right)$$

Example with Units

$$0.003\,\text{rad} = \left(\frac{85\,\text{kN*m} \cdot 5000\,\text{mm}}{3 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

2.15) Slope at Right End of Simply Supported Beam carrying UVL with Maximum Intensity at Right End Formula

Evaluate Formula

Formula

$$\theta = \left(\frac{q \cdot l^3}{45 \cdot E \cdot I} \right)$$

Example with Units

$$0.0022\,\text{rad} = \left(\frac{37.5\,\text{kN/m} \cdot 5000\,\text{mm}^3}{45 \cdot 30000\,\text{MPa} \cdot 0.0016\,\text{m}^4} \right)$$

Variables used in list of Slope and Deflection Formulas above

- **a** Distance from Support A *(Millimeter)*
- **E** Elasticity Modulus of Concrete *(Megapascal)*
- **I** Area Moment of Inertia *(Meter⁴)*
- **l** Length of Beam *(Millimeter)*
- M_c Moment of Couple *(Kilonewton Meter)*
- **P** Point Load *(Kilonewton)*
- **q** Uniformly Varying Load *(Kilonewton per Meter)*
- **w'** Load per Unit Length *(Kilonewton per Meter)*
- **x** Distance x from Support *(Millimeter)*
- **δ** Deflection of Beam *(Millimeter)*
- **θ** Slope of Beam *(Radian)*

Constants, Functions, Measurements used in list of Slope and Deflection Formulas above

- Measurement: **Length** in Millimeter (mm)
  Length Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Angle** in Radian (rad)
  Angle Unit Conversion
- Measurement: **Surface Tension** in Kilonewton per Meter (kN/m)
  Surface Tension Unit Conversion
- Measurement: **Moment of Force** in Kilonewton Meter (kN*m)
  Moment of Force Unit Conversion
- Measurement: **Second Moment of Area** in Meter⁴ (m⁴)
  Second Moment of Area Unit Conversion
- Measurement: **Stress** in Megapascal (MPa)
  Stress Unit Conversion

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