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Castigliano's Theorem for Deflection in Complex Structures Formulas

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List of 14 Castigliano's Theorem for Deflection in Complex Structures Formulas

Castigliano's Theorem for Deflection in Complex Structures

1) Cross-sectional Area of Rod given Strain Energy stored in Rod

Open Calculator

fx $$A = P^2 \cdot \frac{L}{2 \cdot U \cdot E}$$

ex $$552.6987\text{mm}^2 = (55000\text{N})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 37.13919\text{J} \cdot 105548.9\text{N/mm}^2}$$

2) Force Applied on Rod given Strain Energy Stored in Tension Rod

Open Calculator

fx $$P = \sqrt{U \cdot 2 \cdot A \cdot \frac{E}{L}}$$

ex $$55000\text{N} = \sqrt{37.13919\text{J} \cdot 2 \cdot 552.6987\text{mm}^2 \cdot \frac{105548.9\text{N/mm}^2}{1432.449\text{mm}}}$$

3) Length of Rod given Strain Energy Stored

Open Calculator

fx $$L = U \cdot 2 \cdot A \cdot \frac{E}{P^2}$$

ex $$1432.449\text{mm} = 37.13919\text{J} \cdot 2 \cdot 552.6987\text{mm}^2 \cdot \frac{105548.9\text{N/mm}^2}{(55000\text{N})^2}$$

4) Length of Shaft given Strain Energy Stored in Shaft Subjected to Bending Moment

Open Calculator

$$L = 2 \cdot U \cdot E \cdot \frac{I}{M_b^2}$$

$$1431.882\text{mm} = 2 \cdot 37.13919\text{J} \cdot 105548.9\text{N/mm}^2 \cdot \frac{552.5\text{mm}^4}{(55001\text{N*mm})^2}$$

5) Length of Shaft when Strain Energy in Shaft Subjected to External Torque

Open Calculator

$$L = \frac{2 \cdot U \cdot J \cdot G}{\tau^2}$$

$$1433.541\text{mm} = \frac{2 \cdot 37.13919\text{J} \cdot 553\text{mm}^4 \cdot 105591\text{N/mm}^2}{(55005\text{N*mm})^2}$$

6) Modulus of Elasticity given Strain Energy Stored in Shaft Subjected to Bending Moment

Open Calculator

$$E = M_b^2 \cdot \frac{L}{2 \cdot U \cdot I}$$

$$105590.7\text{N/mm}^2 = (55001\text{N*mm})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 37.13919\text{J} \cdot 552.5\text{mm}^4}$$

7) Modulus of Elasticity of Rod given Strain Energy Stored

Open Calculator

$$E = P^2 \cdot \frac{L}{2 \cdot A \cdot U}$$

$$105548.9\text{N/mm}^2 = (55000\text{N})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 552.6987\text{mm}^2 \cdot 37.13919\text{J}}$$

8) Modulus of Rigidity of Rod given Strain Energy in Rod

Open Calculator

$$G = \tau^2 \cdot \frac{L}{2 \cdot J \cdot U}$$

$$105510.6\text{N/mm}^2 = (55005\text{N*mm})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 553\text{mm}^4 \cdot 37.13919\text{J}}$$

9) Moment of Inertia of Shaft when Strain Energy Stored in Shaft Subjected to Bending Moment

Open Calculator

$$I = M_b^2 \cdot \frac{L}{2 \cdot E \cdot U}$$

$$552.7188\text{mm}^4 = (55001\text{N*mm})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 105548.9\text{N/mm}^2 \cdot 37.13919\text{J}}$$

10) Polar Moment of Inertia of Rod given Strain Energy in Rod

Open Calculator

$$J = \tau^2 \cdot \frac{L}{2 \cdot U \cdot G}$$

$$552.5788\text{mm}^4 = (55005\text{N*mm})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 37.13919\text{J} \cdot 105591\text{N/mm}^2}$$

11) Strain Energy in Rod when it is Subjected to External Torque

Open Calculator

$$U = \tau^2 \cdot \frac{L}{2 \cdot J \cdot G}$$

$$37.1109\text{J} = (55005\text{N*mm})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 553\text{mm}^4 \cdot 105591\text{N/mm}^2}$$

12) Strain Energy Stored in Rod Subjected to Bending Moment

Open Calculator

$$U = M_b^2 \cdot \frac{L}{2 \cdot E \cdot I}$$

$$37.1539\text{J} = (55001\text{N*mm})^2 \cdot \frac{1432.449\text{mm}}{2 \cdot 105548.9\text{N/mm}^2 \cdot 552.5\text{mm}^4}$$

13) Strain Energy Stored in Tension Rod

Open Calculator

$$U = \frac{P^2 \cdot L}{2 \cdot A \cdot E}$$

$$37.13919\text{J} = \frac{(55000\text{N})^2 \cdot 1432.449\text{mm}}{2 \cdot 552.6987\text{mm}^2 \cdot 105548.9\text{N/mm}^2}$$

14) Torque given Strain Energy in Rod Subjected to External Torque

Open Calculator

$$\tau = \sqrt{2 \cdot U \cdot J \cdot \frac{G}{L}}$$

$$55025.96\text{N*mm} = \sqrt{2 \cdot 37.13919\text{J} \cdot 553\text{mm}^4 \cdot \frac{105591\text{N/mm}^2}{1432.449\text{mm}}}$$

Variables Used

- **A** Cross Sectional Area of Rod *(Square Millimeter)*
- **E** Modulus of Elasticity *(Newton per Square Millimeter)*
- **G** Modulus of Rigidity *(Newton per Square Millimeter)*
- **I** Area Moment of Inertia *(Millimeter⁴)*
- **J** Polar Moment of Inertia *(Millimeter⁴)*
- **L** Length of Rod or Shaft *(Millimeter)*
- M_b Bending Moment *(Newton Millimeter)*
- **P** Axial Force on Beam *(Newton)*
- **U** Strain Energy *(Joule)*
- **τ** Torque *(Newton Millimeter)*

Constants, Functions, Measurements used

- Function: **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.
- Measurement: **Length** in Millimeter (mm)
  Length Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Energy** in Joule (J)
  Energy Unit Conversion
- Measurement: **Force** in Newton (N)
  Force 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 Newton per Square Millimeter (N/mm²)
  Stress Unit Conversion

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