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Torsional Vibrations Formulas

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List of 29 Torsional Vibrations Formulas

Torsional Vibrations

Effect of Inertia of Constraint on Torsional Vibrations



1) Angular Velocity of Element

$$fx \quad \omega = \frac{\omega_f \cdot X}{l}$$

Open Calculator 

$$ex \quad 11.23465 \text{ rad/s} = \frac{22.5 \text{ rad/s} \cdot 3.66 \text{ mm}}{7.33 \text{ mm}}$$

2) Angular Velocity of Free End using Kinetic Energy of Constraint

$$fx \quad \omega_f = \sqrt{\frac{6 \cdot KE}{I_c}}$$

Open Calculator 

$$ex \quad 22.5176 \text{ rad/s} = \sqrt{\frac{6 \cdot 900 \text{ J}}{10.65 \text{ kg} \cdot \text{m}^2}}$$



3) Kinetic Energy Possessed by Element

$$fx \quad KE = \frac{I_c \cdot (\omega_f \cdot x)^2 \cdot \delta x}{2 \cdot l^3}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$ex \quad 900.4226J = \frac{10.65kg \cdot m^2 \cdot (22.5rad/s \cdot 3.66mm)^2 \cdot 9.82mm}{2 \cdot (7.33mm)^3}$$

4) Mass Moment of Inertia of Element

$$fx \quad I = \frac{\delta x \cdot I_c}{l}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$ex \quad 14.2678kg \cdot m^2 = \frac{9.82mm \cdot 10.65kg \cdot m^2}{7.33mm}$$

5) Natural Frequency of Torsional Vibration due to Effect of Inertia of Constraint

$$fx \quad f = \frac{\sqrt{\frac{q}{I_{disc} + \frac{I_c}{3}}}}{2 \cdot \pi}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$ex \quad 0.118444Hz = \frac{\sqrt{\frac{5.4N/m}{6.2kg \cdot m^2 + \frac{10.65kg \cdot m^2}{3}}}}{2 \cdot \pi}$$



6) Torsional Stiffness of Shaft due to Effect of Constraint on Torsional Vibrations

$$\text{fx } q = (2 \cdot \pi \cdot f)^2 \cdot \left(I_{\text{disc}} + \frac{I_c}{3} \right)$$

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

$$\text{ex } 5.54277\text{N/m} = (2 \cdot \pi \cdot 0.120\text{Hz})^2 \cdot \left(6.2\text{kg}\cdot\text{m}^2 + \frac{10.65\text{kg}\cdot\text{m}^2}{3} \right)$$

7) Total Kinetic Energy of Constraint

$$\text{fx } \text{KE} = \frac{I_c \cdot \omega_f^2}{6}$$

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

$$\text{ex } 898.5938\text{J} = \frac{10.65\text{kg}\cdot\text{m}^2 \cdot (22.5\text{rad/s})^2}{6}$$

8) Total Mass Moment of Inertia of Constraint given Kinetic Energy of Constraint

$$\text{fx } I_c = \frac{6 \cdot \text{KE}}{\omega_f^2}$$

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

$$\text{ex } 10.66667\text{kg}\cdot\text{m}^2 = \frac{6 \cdot 900\text{J}}{(22.5\text{rad/s})^2}$$

Free Torsional Vibrations of Rotor Systems



Free Torsional Vibrations of Single Rotor System

9) Modulus of Rigidity of Shaft for Free Torsional Vibration of Single Rotor System

$$\text{fx } G = \frac{(2 \cdot \pi \cdot f)^2 \cdot L \cdot I_{\text{shaft}}}{J_{\text{shaft}}}$$

[Open Calculator !\[\]\(74d4806277d7e73349d8e8c0897931e9_img.jpg\)](#)

$$\text{ex } 39.79424\text{N/m}^2 = \frac{(2 \cdot \pi \cdot 0.120\text{Hz})^2 \cdot 7000\text{mm} \cdot 100\text{kg}\cdot\text{m}^2}{10\text{m}^4}$$

10) Natural Frequency of Free Torsional Vibration of Single Rotor System

$$\text{fx } f = \frac{\sqrt{\frac{G \cdot J_{\text{shaft}}}{L \cdot I_{\text{shaft}}}}}{2 \cdot \pi}$$

[Open Calculator !\[\]\(8bba887393ca45b761e5cb49e755e762_img.jpg\)](#)

$$\text{ex } 0.12031\text{Hz} = \frac{\sqrt{\frac{40\text{N/m}^2 \cdot 10\text{m}^4}{7000\text{mm} \cdot 100\text{kg}\cdot\text{m}^2}}}{2 \cdot \pi}$$



Free Torsional Vibrations of Two Rotor System

11) Distance of Node from Rotor A, for Torsional Vibration of Two Rotor System

$$\text{fx } l_A = \frac{I_B \cdot l_B}{I_{A \text{ rotor}}}$$

[Open Calculator !\[\]\(950a62bbddad88d64435fd35607dfc42_img.jpg\)](#)

$$\text{ex } 14.4\text{mm} = \frac{36\text{kg}\cdot\text{m}^2 \cdot 3.2\text{mm}}{8\text{kg}\cdot\text{m}^2}$$

12) Distance of Node from Rotor B, for Torsional Vibration of Two Rotor System

$$\text{fx } l_B = \frac{I_A \cdot l_A}{I_{B \text{ rotor}}}$$

[Open Calculator !\[\]\(73002692dd5e7a64e60946be3158e719_img.jpg\)](#)

$$\text{ex } 3.29771\text{mm} = \frac{18\text{kg}\cdot\text{m}^2 \cdot 14.4\text{mm}}{78.6\text{kg}\cdot\text{m}^2}$$

13) Mass Moment of Inertia of Rotor A, for Torsional Vibration of Two Rotor System

$$\text{fx } I_{A \text{ rotor}} = \frac{I_B \cdot l_B}{l_A}$$

[Open Calculator !\[\]\(104fbf564e2e5a8fbd84f31656d114c7_img.jpg\)](#)

$$\text{ex } 8\text{kg}\cdot\text{m}^2 = \frac{36\text{kg}\cdot\text{m}^2 \cdot 3.2\text{mm}}{14.4\text{mm}}$$



14) Mass Moment of Inertia of Rotor B, for Torsional Vibration of Two Rotor System

$$\text{fx } I_{B \text{ rotor}} = \frac{I_A \cdot l_A}{l_B}$$

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

$$\text{ex } 81\text{kg}\cdot\text{m}^2 = \frac{18\text{kg}\cdot\text{m}^2 \cdot 14.4\text{mm}}{3.2\text{mm}}$$

15) Natural Frequency of Free Torsional Vibration for Rotor A of Two Rotor System

$$\text{fx } f = \frac{\sqrt{\frac{G \cdot J}{l_A \cdot I_{A \text{ rotor}}}}}{2 \cdot \pi}$$

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

$$\text{ex } 0.296568\text{Hz} = \frac{\sqrt{\frac{40\text{N}/\text{m}^2 \cdot 0.01\text{m}^4}{14.4\text{mm} \cdot 8\text{kg}\cdot\text{m}^2}}}{2 \cdot \pi}$$

16) Natural Frequency of Free Torsional Vibration for Rotor B of Two Rotor System

$$\text{fx } f = \frac{\sqrt{\frac{G \cdot J}{l_B \cdot I_{B \text{ rotor}}}}}{2 \cdot \pi}$$

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

$$\text{ex } 0.200708\text{Hz} = \frac{\sqrt{\frac{40\text{N}/\text{m}^2 \cdot 0.01\text{m}^4}{3.2\text{mm} \cdot 78.6\text{kg}\cdot\text{m}^2}}}{2 \cdot \pi}$$



Natural Frequency of Free Torsional Vibrations

17) Accelerating Force

$$fx \quad F = I_{\text{disc}} \cdot \alpha$$

[Open Calculator !\[\]\(96cc62f861fdd6e50510c0224a756dff_img.jpg\)](#)

$$ex \quad 9.92\text{N} = 6.2\text{kg}\cdot\text{m}^2 \cdot 1.6\text{rad}/\text{s}^2$$

18) Angular Displacement of Shaft from Mean Position

$$fx \quad \theta = \frac{F_{\text{restoring}}}{q}$$

[Open Calculator !\[\]\(f95dab70c751fda7d824b8b03650f7aa_img.jpg\)](#)

$$ex \quad 12.03704\text{rad} = \frac{65\text{N}}{5.4\text{N}/\text{m}}$$

19) Angular Velocity of Shaft

$$fx \quad \omega = \sqrt{\frac{q_{\text{shaft}}}{I_{\text{disc}}}}$$

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c_img.jpg\)](#)

$$ex \quad 11.19476\text{rad}/\text{s} = \sqrt{\frac{777\text{N}/\text{m}}{6.2\text{kg}\cdot\text{m}^2}}$$



20) Moment of Inertia of Disc given Angular Velocity

$$fx \quad I_{\text{disc}} = \frac{Q_{\text{shaft}}}{\omega^2}$$

[Open Calculator !\[\]\(c3d993ca47bfe2a953c700506ce31fa0_img.jpg\)](#)

$$ex \quad 6.194196\text{kg}\cdot\text{m}^2 = \frac{777\text{N/m}}{(11.2\text{rad/s})^2}$$

21) Moment of Inertia of Disc given Time Period of Vibration

$$fx \quad I_{\text{disc}} = \frac{t_p^2 \cdot q}{(2 \cdot \pi)^2}$$

[Open Calculator !\[\]\(17413706fd4997a1a4bdf85c6864eee1_img.jpg\)](#)

$$ex \quad 1.231052\text{kg}\cdot\text{m}^2 = \frac{(3\text{s})^2 \cdot 5.4\text{N/m}}{(2 \cdot \pi)^2}$$

22) Moment of Inertia of Disc using Natural Frequency of Vibration

$$fx \quad I_{\text{disc}} = \frac{q}{(2 \cdot \pi \cdot f)^2}$$

[Open Calculator !\[\]\(4b7a79268f6ba26c1471d4232fffa85a_img.jpg\)](#)

$$ex \quad 9.498861\text{kg}\cdot\text{m}^2 = \frac{5.4\text{N/m}}{(2 \cdot \pi \cdot 0.120\text{Hz})^2}$$



23) Natural Frequency of Vibration

[Open Calculator !\[\]\(99f58673407353e96a019fbca558fd72_img.jpg\)](#)

$$fx \quad f = \frac{\sqrt{\frac{q}{I_{disc}}}}{2 \cdot \pi}$$

$$ex \quad 0.148532\text{Hz} = \frac{\sqrt{\frac{5.4\text{N/m}}{6.2\text{kg}\cdot\text{m}^2}}}{2 \cdot \pi}$$

24) Restoring Force for Free Torsional Vibrations

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

$$fx \quad F_{restoring} = q \cdot \theta$$

$$ex \quad 64.8\text{N} = 5.4\text{N/m} \cdot 12\text{rad}$$

25) Time Period for Vibrations

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

$$fx \quad t_p = 2 \cdot \pi \cdot \sqrt{\frac{I_{disc}}{q}}$$

$$ex \quad 6.732538\text{s} = 2 \cdot \pi \cdot \sqrt{\frac{6.2\text{kg}\cdot\text{m}^2}{5.4\text{N/m}}}$$

26) Torsional Stiffness of Shaft

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

$$fx \quad q = \frac{F_{restoring}}{\theta}$$

$$ex \quad 5.416667\text{N/m} = \frac{65\text{N}}{12\text{rad}}$$



27) Torsional Stiffness of Shaft given Angular Velocity

$$\text{fx } q_{\text{shaft}} = \omega^2 \cdot I_{\text{disc}}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235_img.jpg\)](#)

$$\text{ex } 777.728\text{N/m} = (11.2\text{rad/s})^2 \cdot 6.2\text{kg}\cdot\text{m}^2$$

28) Torsional Stiffness of Shaft given Natural Frequency of Vibration

$$\text{fx } q = (2 \cdot \pi \cdot f)^2 \cdot I_{\text{disc}}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0_img.jpg\)](#)

$$\text{ex } 3.524633\text{N/m} = (2 \cdot \pi \cdot 0.120\text{Hz})^2 \cdot 6.2\text{kg}\cdot\text{m}^2$$

29) Torsional Stiffness of Shaft given Time Period of Vibration

$$\text{fx } q = \frac{(2 \cdot \pi)^2 \cdot I_{\text{disc}}}{(t_p)^2}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f_img.jpg\)](#)

$$\text{ex } 27.19624\text{N/m} = \frac{(2 \cdot \pi)^2 \cdot 6.2\text{kg}\cdot\text{m}^2}{(3\text{s})^2}$$



Variables Used











- **f** Frequency (Hertz)
- **F** Force (Newton)
- **F_{restoring}** Restoring Force (Newton)
- **G** Modulus of Rigidity (Newton per Square Meter)
- **I** Moment of Inertia (Kilogram Square Meter)
- **I_{A rotor}** Mass Moment of Inertia of Rotor A (Kilogram Square Meter)
- **I_A** Mass Moment of Inertia of Mass Attached to Shaft A (Kilogram Square Meter)
- **I_{B rotor}** Mass Moment of Inertia of Rotor B (Kilogram Square Meter)
- **I_B** Mass Moment of Inertia of Mass Attached to Shaft B (Kilogram Square Meter)
- **I_C** Total Mass Moment of Inertia (Kilogram Square Meter)
- **I_{disc}** Mass Moment of Inertia of Disc (Kilogram Square Meter)
- **I_{shaft}** Moment of inertia of Shaft (Kilogram Square Meter)
- **J** Polar Moment of Inertia (Meter⁴)
- **J_{shaft}** Polar Moment of Inertia of Shaft (Meter⁴)
- **KE** Kinetic Energy (Joule)
- **l** Length of Constraint (Millimeter)
- **L** Length of Shaft (Millimeter)
- **l_A** Distance of Node from Rotor A (Millimeter)
- **l_B** Distance of Node from Rotor B (Millimeter)
- **q** Torsional Stiffness (Newton per Meter)





- Q_{shaft} Torsional Stiffness of Shaft (Newton per Meter)
- t_p Time Period (Second)
- x Distance between Small Element and Fixed End (Millimeter)
- α Angular Acceleration (Radian per Square Second)
- δx Length of Small Element (Millimeter)
- θ Angular Displacement of Shaft (Radian)
- ω Angular Velocity (Radian per Second)
- ω_f Angular Velocity of Free End (Radian per Second)



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:** **Time** in Second (s)
Time Unit Conversion 
- **Measurement:** **Pressure** in Newton per Square Meter (N/m²)
Pressure Unit Conversion 
- **Measurement:** **Energy** in Joule (J)
Energy Unit Conversion 
- **Measurement:** **Force** in Newton (N)
Force Unit Conversion 
- **Measurement:** **Angle** in Radian (rad)
Angle Unit Conversion 
- **Measurement:** **Frequency** in Hertz (Hz)
Frequency Unit Conversion 
- **Measurement:** **Angular Velocity** in Radian per Second (rad/s)
Angular Velocity Unit Conversion 
- **Measurement:** **Moment of Inertia** in Kilogram Square Meter (kg·m²)
Moment of Inertia Unit Conversion 
- **Measurement:** **Angular Acceleration** in Radian per Square Second (rad/s²)
Angular Acceleration Unit Conversion 



- **Measurement: Second Moment of Area** in Meter⁴ (m⁴)
Second Moment of Area Unit Conversion 
- **Measurement: Stiffness Constant** in Newton per Meter (N/m)
Stiffness Constant Unit Conversion 



Check other formula lists

- **Torsional Vibrations Formulas** 

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