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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

Open Calculator

fx $$\omega = \frac{\omega_f \cdot x}{l}$$

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

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

Open Calculator

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

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

## 3) Kinetic Energy Possessed by Element

Open Calculator

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

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

## 4) Mass Moment of Inertia of Element

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

## 7) Total Kinetic Energy of Constraint

Open Calculator

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

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

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

Open Calculator

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

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

# 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

Open Calculator

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

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

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

Open Calculator

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

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

## Free Torsional Vibrations of Two Rotor System

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

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

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

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

# Natural Frequency of Free Torsional Vibrations

## 17) Accelerating Force

Open Calculator

$$F = I_{disc} \cdot \alpha$$

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

## 18) Angular Displacement of Shaft from Mean Position

Open Calculator

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

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

## 19) Angular Velocity of Shaft

Open Calculator

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

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

## 20) Moment of Inertia of Disc given Angular Velocity

Open Calculator

$$I_{disc} = \frac{q_{shaft}}{\omega^2}$$

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

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

Open Calculator

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

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

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

Open Calculator

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

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

## 23) Natural Frequency of Vibration

Open Calculator

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

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

## 24) Restoring Force for Free Torsional Vibrations

Open Calculator

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

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

## 25) Time Period for Vibrations

Open Calculator

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

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

## 26) Torsional Stiffness of Shaft

Open Calculator

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

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

## 27) Torsional Stiffness of Shaft given Angular Velocity

Open Calculator

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

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

## 28) Torsional Stiffness of Shaft given Natural Frequency of Vibration

Open Calculator

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

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

## 29) Torsional Stiffness of Shaft given Time Period of Vibration

Open Calculator

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

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

## 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)*
- $\omega_f$ 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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