Important Frequency of Under Damped Forced Vibrations Formulas PDF

Formulas
Examples
with Units

List of 15
Important Frequency of Under Damped Forced Vibrations Formulas

1) Complementary Function Formula

Evaluate Formula

Formula

$$x_1 = A \cdot \cos\left(\omega_d - \phi\right)$$

Example with Units

$$1.6897\,\text{m} = 5.25\,\text{m} \cdot \cos\left(6\,\text{Hz} - 55°\right)$$

2) Damping Coefficient Formula

Evaluate Formula

Formula

$$c = \frac{\tan\left(\phi\right) \cdot \left(k - m \cdot \omega^2\right)}{\omega}$$

Example with Units

$$4.9985\,\text{Ns/m} = \frac{\tan\left(55°\right) \cdot \left(60\,\text{N/m} - .25\,\text{kg} \cdot 10\,\text{rad/s}^2\right)}{10\,\text{rad/s}}$$

3) Deflection of System under Static Force Formula

Evaluate Formula

Formula

$$x_o = \frac{F_x}{k}$$

Example with Units

$$0.3333\,\text{m} = \frac{20\,\text{N}}{60\,\text{N/m}}$$

4) External Periodic Disturbing Force Formula

Evaluate Formula

Formula

$$F = F_x \cdot \cos\left(\omega \cdot t_p\right)$$

Example with Units

$$16.8771\,\text{N} = 20\,\text{N} \cdot \cos\left(10\,\text{rad/s} \cdot 1.2\,\text{s}\right)$$

5) Maximum Displacement of Forced Vibration Formula

Evaluate Formula

Formula

$$d_{max} = \frac{F_x}{\sqrt{\left(c \cdot \omega\right)^2 - \left(k - m \cdot \omega^2\right)^2}}$$

Example with Units

$$0.5601\,\text{m} = \frac{20\,\text{N}}{\sqrt{\left(5\,\text{Ns/m} \cdot 10\,\text{rad/s}\right)^2 - \left(60\,\text{N/m} - .25\,\text{kg} \cdot 10\,\text{rad/s}^2\right)^2}}$$

6) Maximum Displacement of Forced Vibration at Resonance Formula

Evaluate Formula

Formula

$$d_{max} = x_o \cdot \frac{k}{c \cdot \omega_n}$$

Example with Units

$$0.561\,\text{m} = 0.3333333\,\text{m} \cdot \frac{60\,\text{N/m}}{5\,\text{Ns/m} \cdot 7.13\,\text{rad/s}}$$

7) Maximum Displacement of Forced Vibration using Natural Frequency Formula

Evaluate Formula

Formula

$$d_{max} = \frac{x_o}{\sqrt{\frac{\left(c^2\right) \cdot \left(\omega^2\right)}{k^2} + \left(1 - \left(\frac{\omega^2}{\omega_n^2}\right)\right)^2}}$$

Example with Units

$$0.1885\,\text{m} = \frac{0.3333333\,\text{m}}{\sqrt{\frac{\left(5\,\text{Ns/m}^2\right) \cdot \left(10\,\text{rad/s}^2\right)}{60\,\text{N/m}^2} + \left(1 - \left(\frac{10\,\text{rad/s}^2}{7.13\,\text{rad/s}^2}\right)\right)^2}}$$

8) Maximum Displacement of Forced Vibration with Negligible Damping Formula

Evaluate Formula

Formula

$$d_{max} = \frac{F_x}{m \cdot \left(\omega_n^2 - \omega^2\right)}$$

Example with Units

$$-1.6272\,\text{m} = \frac{20\,\text{N}}{.25\,\text{kg} \cdot \left(7.13\,\text{rad/s}^2 - 10\,\text{rad/s}^2\right)}$$

9) Particular Integral Formula

Evaluate Formula

Formula

$$x_2 = \frac{F_x \cdot \cos\left(\omega \cdot t_p - \phi\right)}{\sqrt{\left(c \cdot \omega\right)^2 - \left(k - m \cdot \omega^2\right)^2}}$$

Example with Units

$$0.0249\,\text{m} = \frac{20\,\text{N} \cdot \cos\left(10\,\text{rad/s} \cdot 1.2\,\text{s} - 55°\right)}{\sqrt{\left(5\,\text{Ns/m} \cdot 10\,\text{rad/s}\right)^2 - \left(60\,\text{N/m} - .25\,\text{kg} \cdot 10\,\text{rad/s}^2\right)^2}}$$

10) Phase Constant Formula

Evaluate Formula

Formula

$$\phi = atan\left(\frac{c \cdot \omega}{k - m \cdot \omega^2}\right)$$

Example with Units

$$55.008° = atan\left(\frac{5\,\text{Ns/m} \cdot 10\,\text{rad/s}}{60\,\text{N/m} - .25\,\text{kg} \cdot 10\,\text{rad/s}^2}\right)$$

11) Static Force Formula

Evaluate Formula

Formula

$$F_x = x_o \cdot k$$

Example with Units

$$20\,\text{N} = 0.3333333\,\text{m} \cdot 60\,\text{N/m}$$

12) Static Force using Maximum Displacement or Amplitude of Forced Vibration Formula

Evaluate Formula

Formula

$$F_x = d_{max} \cdot \left(\sqrt{\left(c \cdot \omega \right)^2 - \left(k - m \cdot \omega^2 \right)^2} \right)$$

Example with Units

$$20.0317\,\text{N} = 0.561\,\text{m} \cdot \left(\sqrt{\left(5\,\text{Ns/m} \cdot 10\,\text{rad/s} \right)^2 - \left(60\,\text{N/m} - .25\,\text{kg} \cdot 10\,\text{rad/s}^2 \right)^2} \right)$$

13) Static Force when Damping is Negligible Formula

Evaluate Formula

Formula

$$F_x = d_{max} \cdot \left(m \cdot \omega_n^2 - \omega^2 \right)$$

Example with Units

$$-48.9701\,\text{N} = 0.561\,\text{m} \cdot \left(.25\,\text{kg} \cdot 7.13\,\text{rad/s}^2 - 10\,\text{rad/s}^2 \right)$$

14) Total Displacement of Forced Vibration given Particular Integral and Complementary Function Formula

Evaluate Formula

Formula

$$d_{tot} = x_2 + x_1$$

Example with Units

$$1.7\,\text{m} = 0.02\,\text{m} + 1.68\,\text{m}$$

15) Total Displacement of Forced Vibrations Formula

Evaluate Formula

Formula

$$d_{tot} = A \cdot \cos\left(\omega_d - \phi \right) + \frac{F_x \cdot \cos\left(\omega \cdot t_p - \phi \right)}{\sqrt{\left(c \cdot \omega \right)^2 - \left(k - m \cdot \omega^2 \right)^2}}$$

Example with Units

$$1.7146\,\text{m} = 5.25\,\text{m} \cdot \cos\left(6\,\text{Hz} - 55° \right) + \frac{20\,\text{N} \cdot \cos\left(10\,\text{rad/s} \cdot 1.2\,\text{s} - 55° \right)}{\sqrt{\left(5\,\text{Ns/m} \cdot 10\,\text{rad/s} \right)^2 - \left(60\,\text{N/m} - .25\,\text{kg} \cdot 10\,\text{rad/s}^2 \right)^2}}$$

Variables used in list of Frequency of Under Damped Forced Vibrations Formulas above

- **A** Amplitude of Vibration *(Meter)*
- **c** Damping Coefficient *(Newton Second per Meter)*
- d_{max} Maximum Displacement *(Meter)*
- d_{tot} Total Displacement *(Meter)*
- **F** External Periodic Disturbing Force *(Newton)*
- F_x Static Force *(Newton)*
- **k** Stiffness of Spring *(Newton per Meter)*
- **m** Mass suspended from Spring *(Kilogram)*
- t_p Time Period *(Second)*
- x_1 Complementary Function *(Meter)*
- x_2 Particular Integral *(Meter)*
- x_o Deflection under Static Force *(Meter)*
- ϕ Phase Constant *(Degree)*
- ω Angular Velocity *(Radian per Second)*
- ω_d Circular Damped Frequency *(Hertz)*
- ω_n Natural Circular Frequency *(Radian per Second)*

Constants, Functions, Measurements used in list of Frequency of Under Damped Forced Vibrations Formulas above

- Functions: **atan**, atan(Number)
  Inverse tan is used to calculate the angle by applying the tangent ratio of the angle, which is the opposite side divided by the adjacent side of the right triangle.
- Functions: **cos**, cos(Angle)
  Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- Functions: **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.
- Functions: **tan**, tan(Angle)
  The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.
- Measurement: **Length** in Meter (m)
  Length Unit Conversion
- Measurement: **Weight** in Kilogram (kg)
  Weight Unit Conversion
- Measurement: **Time** in Second (s)
  Time Unit Conversion
- Measurement: **Force** in Newton (N)
  Force Unit Conversion
- Measurement: **Angle** in Degree (°)
  Angle Unit Conversion
- Measurement: **Frequency** in Hertz (Hz)
  Frequency Unit Conversion
- Measurement: **Surface Tension** in Newton per Meter (N/m)
  Surface Tension Unit Conversion
- Measurement: **Angular Velocity** in Radian per Second (rad/s)
  Angular Velocity Unit Conversion
- Measurement: **Damping Coefficient** in Newton Second per Meter (Ns/m)
  Damping Coefficient Unit Conversion

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