SNS COLLEGE OF TECHNOLOGY

Coimbatore-35

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DEPARTMENT OF AEROSPACE ENGINEERING

16AE315-THEORY OF VIBRATIONS

III YEAR VI SEM

UNIT II – SINGLE DEGREE OF FREEDOM SYSTEMS

TOPIC 4 – VIBRATION MEASURES

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Harmonic Disturbances (Spring mass system)

The amplitude of the forced vibration is given by

$$x = \frac{F_o}{\sqrt{(s - m\omega^2)^2 + (c\omega)^2}} \sin(\omega t - \varphi)$$

F_o is the excited force and is the phase lag

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Harmonic Disturbances (Spring mass system)

1. Phase Lag ϕ

As the displacement takes place after applying force, the displacement vector lags the force vector by some angle ϕ. This angle is known as phase lag.

Mathematically,

$$\varphi = \tan^{-1}\left(\frac{2\epsilon r}{1 - r^2}\right)$$

where r is the frequency ratio

Harmonic Disturbances (Spring mass system)

2. Magnification factor or Dynamic Magnifier

The ratio of maximum displacement of the forced vibration (X_{max}) to the static deflection (X_o) due to static force and it is denoted by M.F.

$$M.F = \frac{X_{max}}{X_o}$$

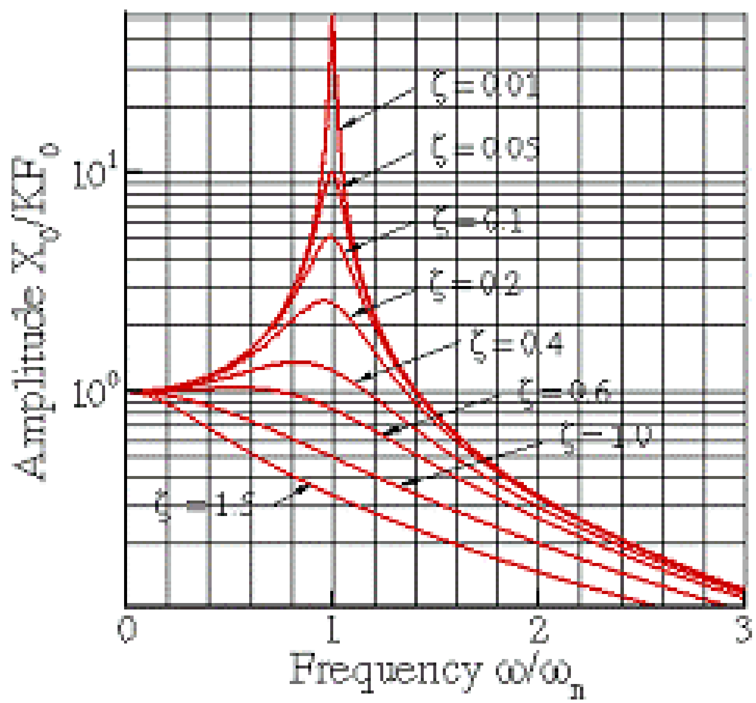
$$M.F = \frac{1}{\sqrt{(1-r^2)^2 + (2\varepsilon r)^2}}$$

QUESTIONS RELATED TO ABOVE SLIDES

Harmonic Disturbances – Characteristics Curve

1. Frequency response curve

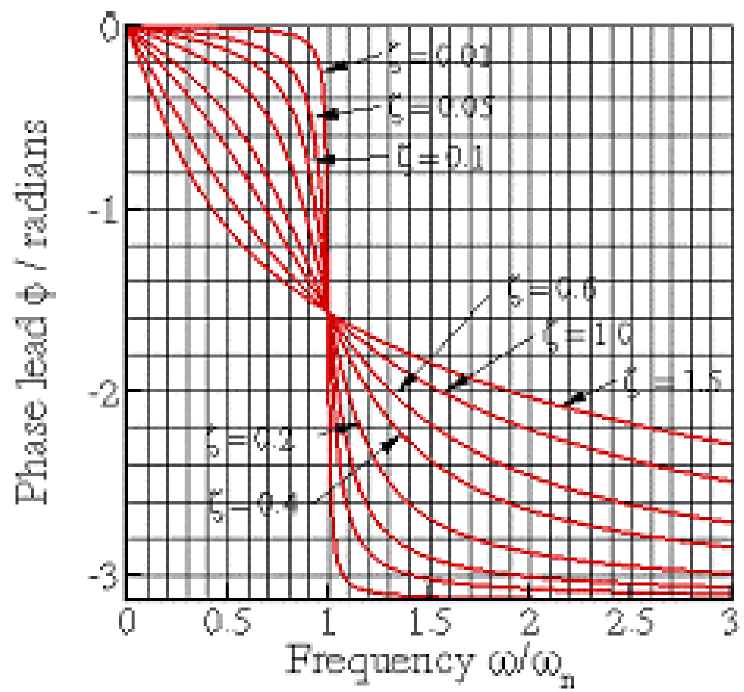
   A curve drawn between magnification factor and frequency ratio is known as frequency response curve.



Harmonic Disturbances – Characteristics Curve

2. Phase - frequency response curve

A curve drawn between phase angle and frequency ratio is known as phase frequency response curve.



Disturbance caused by unbalance

Almost in all rotating and reciprocating machinery like an electric motor, a turbine, an IC engine, etc have some amount of unbalanced force left in them even after correcting their unbalance on precision balancing machines. This unbalance produces the exciting force in a machine.

Disturbance caused by unbalance

The amplitude of the forced vibration is given by

$$x = \frac{m_u\,\omega^2 e}{\sqrt{(s - m\omega^2)^2 + (c\omega)^2}}\cos(\omega t - \varphi)$$

m_u - unbalanced mass, and e - eccentricity

The maximum amplitude of the forced vibration is given by

$$x_{max} = \frac{m_u\,\omega^2 e}{\sqrt{\sqrt{(s - m\omega^2)^2 - (c\omega)^2}}}$$

$$\frac{x_{max}}{\left(\frac{m_u . e}{m}\right)} = \frac{r^2}{\sqrt{(1 - r^2)^2 + (2\epsilon r)^2}}$$

Disturbance caused by unbalance

Phase Lag φ

As the displacement takes place after applying force, the displacement vector lags the force vector by some angle φ. This angle is known as phase lag.

Mathematically,

$$\varphi = \tan^{-1}\left(\frac{2\epsilon r}{1 - r^2}\right)$$

where r is the frequency ratio

Forced Vibration due to the excitation of the support (Support Motion)

- Absolute amplitude

The amplitude of the forced vibration is given by

$$x_{max} = \frac{Y\sqrt{s^2 + (c\omega)^2}}{\sqrt{\sqrt{(s - m\omega^2)^2 + (c\omega)^2}}}$$

$$\frac{x_{max}}{Y} = \frac{\sqrt{1 + (2 \in r)^2}}{\sqrt{(1 - r^2)^2 + (2\epsilon r)^2}}$$

where Y is the amplitude

$$Phase\ angle, \varphi = \tan^{-1}\left(\frac{2\epsilon r}{1 - r^2}\right)$$

Forced Vibration due to the excitation of the support (Support Motion)

- Relative amplitude

  In many cases, it is useful to know the response of the system relative to a moving system.

  The steady state relative amplitude of the forced vibration is given by

$$\frac{Z}{Y} = \frac{r^2}{\sqrt{(1-r^2)^2 + (2\epsilon r)^2}}$$

where z is the relative motion of the mass with respect to support

$$Phase\ angle, \varphi = \tan^{-1}\left(\frac{2\epsilon r}{1-r^2}\right)$$