5.2

* Vibration Isolator

①

Vibration isolator is used to reduce the unwanted vibration by isolating our system from the source of vibration

* Done by adding ① Damping
  ② Stiffness

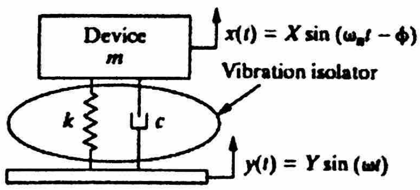
* we reduce "displacement transmissibility" or "Force transmissibility"

Two types ① Moving base : Base excitation ($y(t)$)
② Fixed base : Forced vibration ($F(t)$)

Window 5.1 text book

The moving-base model on the left is used in designing isolation to protect the device from motion of its point of attachment (base). The model on the right is used to protect the point of attachment (ground) from vibration of the mass.

Base Excitation ← **Displacement Transmissibility**



Moving base (source of vibration)

Vibration source modeled as base motion

Here $y(t) = Y \sin \omega t$ is the disturbance and from equation (2.71)

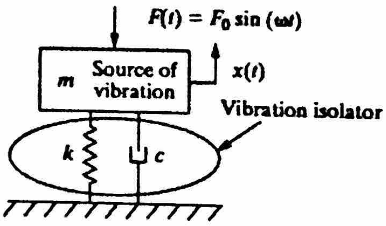
$$\frac{X}{Y} = \left[\frac{1 + (2\zeta r)^2}{(1 - r^2)^2 + (2\zeta r)^2}\right]^{1/2}$$

defines the displacement transmissibility and is plotted in Figure 2.13. From equation (2.77),

$$\frac{F_T}{kY} = r^2\left[\frac{1 + (2\zeta r)^2}{(1 - r^2)^2 + (2\zeta r)^2}\right]^{1/2}$$

defines the related force transmissibility and is plotted in Figure 2.15.

Force Transmissibility → Forced Vibration "Fixed base"



Fixed base

Vibration source mounted on isolator

Here $F(t) = F_0 \sin \omega t$ is the disturbance and

$$\frac{F_T}{F_0} = \left[\frac{1 + (2\zeta r)^2}{(1 - r^2)^2 + (2\zeta r)^2}\right]^{1/2}$$

defines the force transmissibility for isolating the source of vibration as derived in Section 5.2.

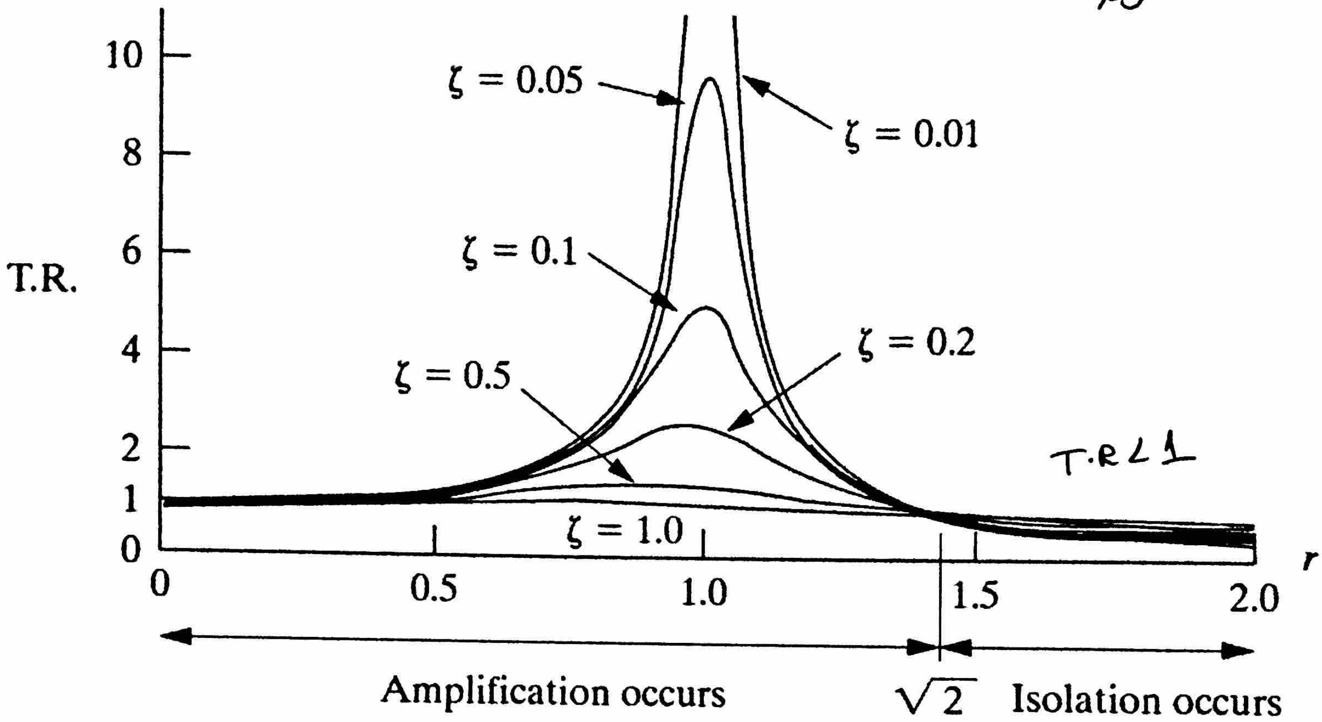
$$F_T = X\sqrt{k^2 + c^2\omega^2}$$

$$x_p(t) = \underset{\text{Amplitude}}{X} \cos(\omega t - \underbrace{\phi}_{\text{phase}})$$

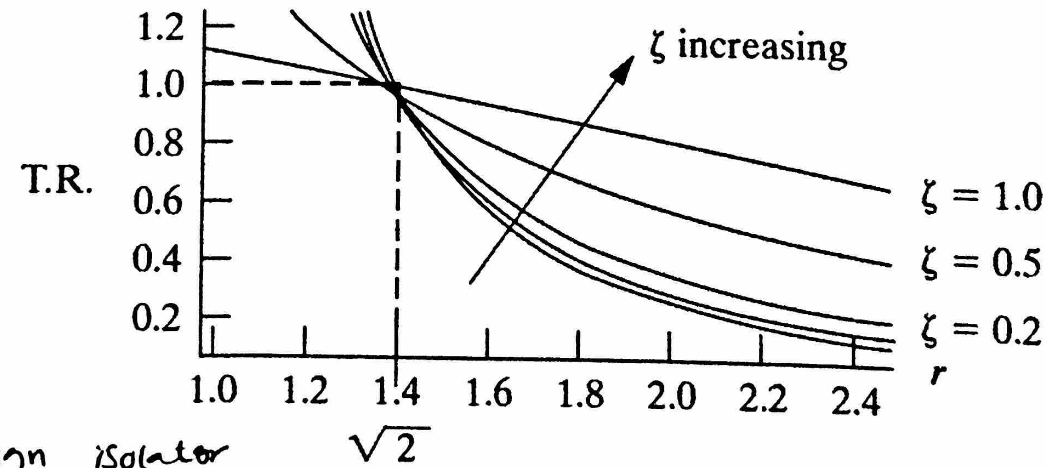
$r = \frac{w}{w_n}$, Frequency ratio

$TR = \frac{X}{Y}$ or $\frac{F_T}{F_0}$

or $\frac{F_T}{kY}$



Magnification of the isolation area



To design isolator
we know m and T.R

① Pick ζ

② Find (r) , $\rightarrow$ get w_n $\left(r = \frac{w}{w_n}\right)$ Known

③ $w_n = \sqrt{\frac{k}{m}}$ $\rightarrow$ $k = w_n^2 \, m$

④ $c = 2\zeta w_n m$ $\qquad \ddot{x} + 2\zeta w_n \dot{x} + w_n^2 x = 0$ $\qquad \frac{c}{m} = 2\zeta w_n$

$m\ddot{x} + c\dot{x} + kx = 0$ $\qquad c = 2\zeta w_n m$

Example: For a system with mass $m = 3kg$ and under base excitation system $y(t) = (0.01)\sin(35t)$ m.

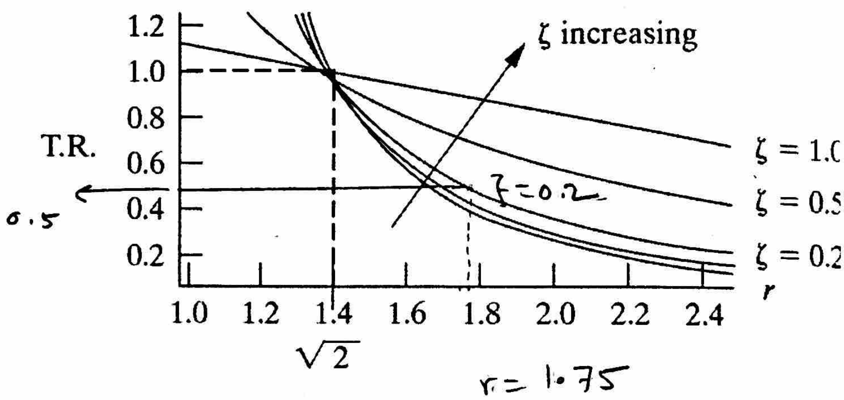
Design vibration isolator (Find K and C), to keep displacement of this mass is less than 5mm.

Solution

$X = 0.005$ m

$Y = 0.01$ m

$$\frac{X}{Y} = T.R = \frac{0.005}{0.01} = 0.5$$



let's pick $\zeta = 0.2$

$r = 1.75$, $\omega = 35$ rad/s

$$\frac{\omega}{\omega_n} = r \Rightarrow \frac{35}{\omega_n} = 1.75$$

$$\omega_n = \frac{35}{1.75} = 20 \text{ rad/s}$$

$$\Rightarrow \omega_n = \sqrt{\frac{K}{m}} \Rightarrow K = \omega_n^2 m$$

$$K = (20)^2(3) = 1200 \text{ N/m}$$

$$C = 2\zeta\omega_n m = (2)(0.2)(20)(3)$$

$$C = 2.4 \text{ kg/s}$$

$$K = 1200 \text{ N/m}$$

$$C = 2.4 \text{ kg/s}$$