LECTURE # 8

In this lecture you will learn about:

- Vibration Isolation.
- Vibration Isolators.
- Transmission of Harmonic Forces to Base.
- Base Excitations.

Course Name:

"Introduction To Earthquake Engineering"

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VIBRATION ISOLATION

- High vibration levels can cause machinery failure, as well as objectionable noise levels.
- A common source of objectionable noise in buildings is the vibration of machines that are mounted on floors or walls. A typical problem is a rotating machine (such as a pump, AC compressor, blower, engine, etc.) mounted on a roof, or on a floor above the ground floor.
- The problem is usually most apparent in the immediate vicinity of the vibration source. However, mechanical vibrations can transmit for long distances, and by very circuitous routes through the structure of a building, sometimes resurfacing hundreds of feet from the source.

VIBRATION ISOLATION

- A related problem is the isolation of vibration-sensitive machines from the normally occurring disturbances in a building (car or bus traffic, slamming doors, foot traffic, elevators…). Examples of sensitive machines include surgical microscopes, electronic equipment, lasers, and computer disk drives.
- A common example of a vibration source is shown in figure, a large reciprocating air conditioning compressor weighing 20,000 pounds, mounted on a roof. Annoying noise levels at multiples of the compressor rotational frequency, predominantly 60 and 120 Hz, were measured in the rooms directly below the compressor.
- Also, this type of compressor (reciprocating) is notorious for high vibration levels. Centrifugal or scroll type compressors are much quieter, but more expensive.

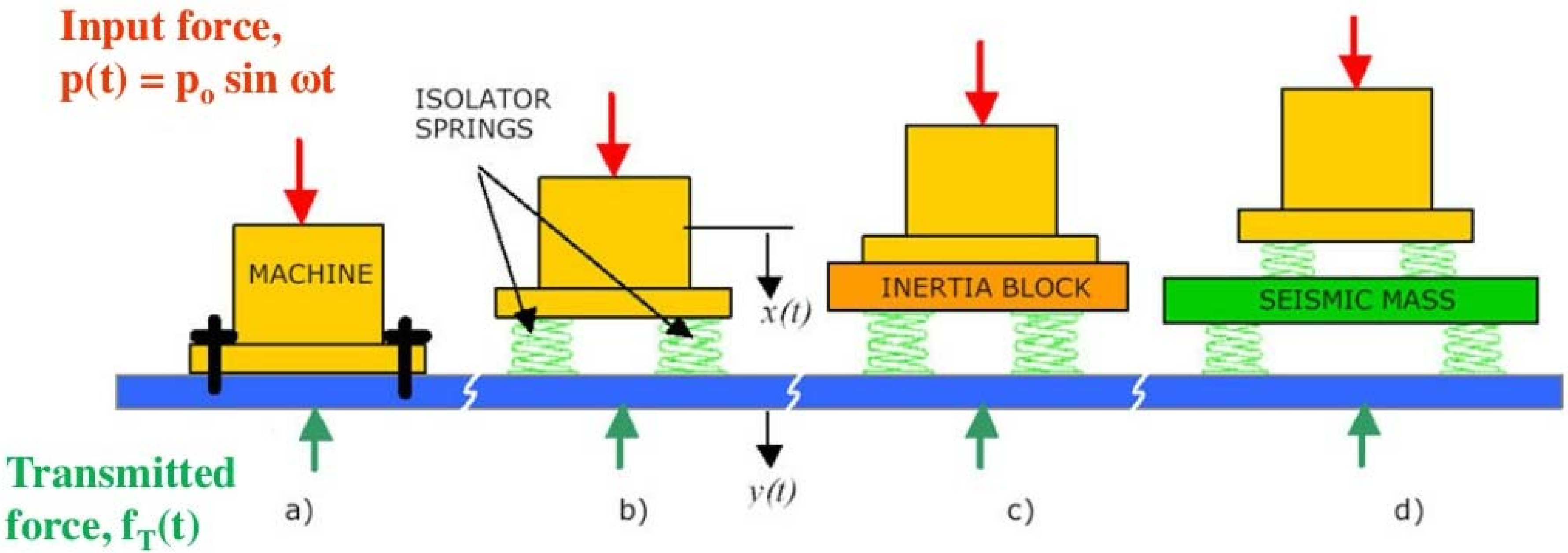
VIBRATION ISOLATION

A reciprocating air conditioning compressor and chiller mounted on a flexible roof, Note the straight conduit on the left of which bypasses the isolators and directly transmit vibration into the roof

VIBRATION ISOLATORS

- A Consider a vibrating machine, bolted to a rigid floor (see figure a on next slide). The force transmitted to the floor is equal to the force generated in the machine.
- The transmitted force can be decreased by adding a suspension and damping elements (often called vibration isolators) Figure b , or by adding what is called an inertia block, a large mass (usually a block of cast concrete), directly attached to the machine (Figure c). Another option is to add an additional level of mass (sometimes called a seismic mass, again a block of cast concrete) and suspension (Figure d).

VIBRATION ISOLATORS



Vibration isolation systems: a) Machine bolted to a rigid foundation b) Supported on isolation springs, rigid foundation c) machine attached to an inertial block d) Supported on isolation springs, non-rigid foundation (such as a floor); or machine on isolation springs, seismic mass and second level of isolator springs

VIBRATION ISOLATORS

- Typically vibration isolators employ a helical spring to provide stiffness, and an elastomeric layer (such as neoprene) to provide some damping.
- Other types use a solid elastomeric element for both the stiffness and the damping.

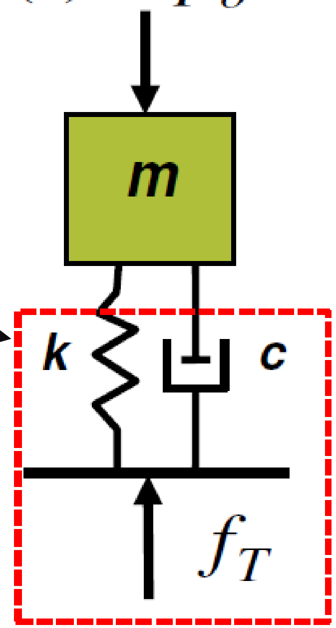
Application of elastic sleeper pads for vibration isolation, and adjustment of track stiffness

TRANSMISSION OF HARMONIC FORCES TO BASE

Consider the mass-spring-damper system subjected to a harmonic force. The force transmitted to the base, f_T, is:

$$p(t) = p_o Sin\omega t$$

$$f_T = f_S + f_D = ku + c\dot{u}$$



By substituting, solving and rearranging we get:

$$TR = \frac{(f_T)_o}{p_o} = \sqrt{\frac{1 + (2\zeta r_\omega)^2}{[1 - r_\omega^{\ 2}]^2 + [2\zeta r_\omega]^2}}$$

Where TR is used to represent *Transmissibility*

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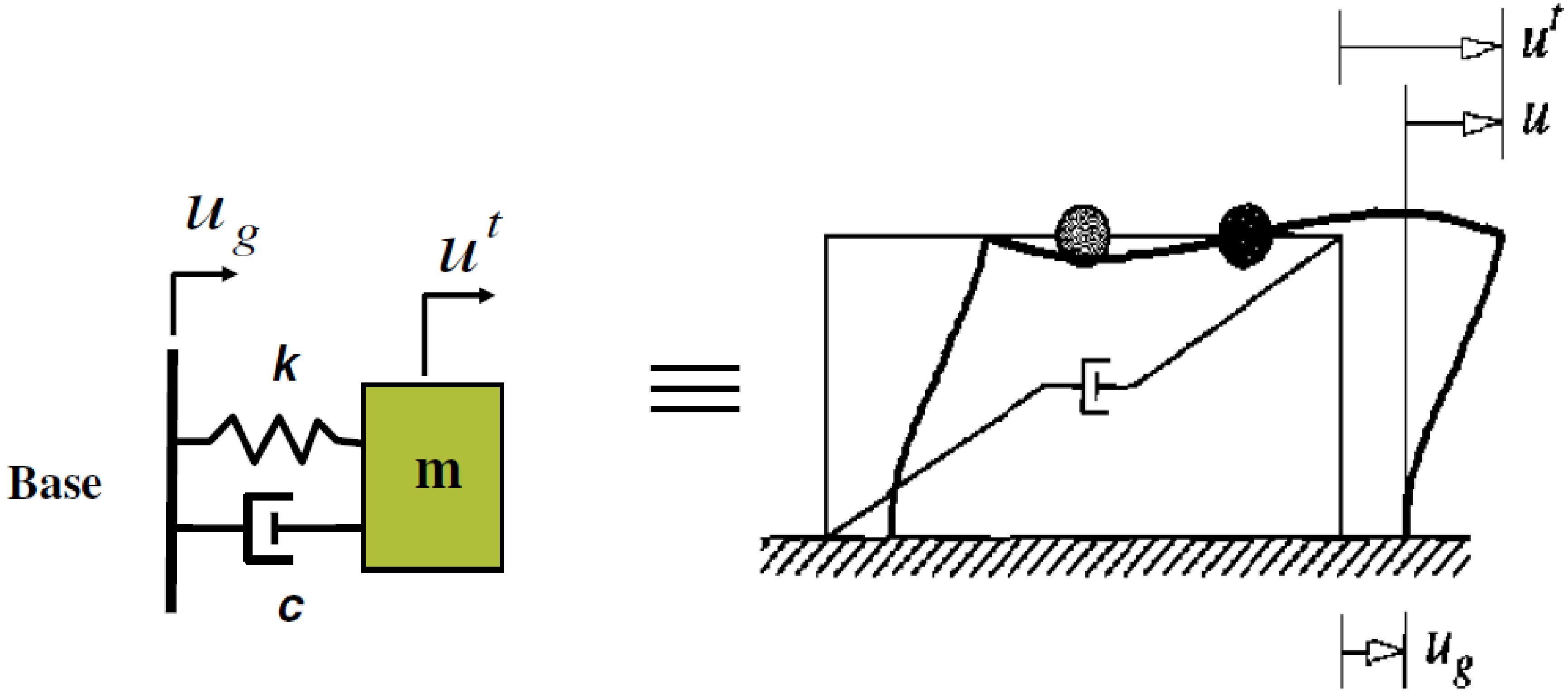
BASE EXCITATIONS
(Transmission of harmonic displacements from base)



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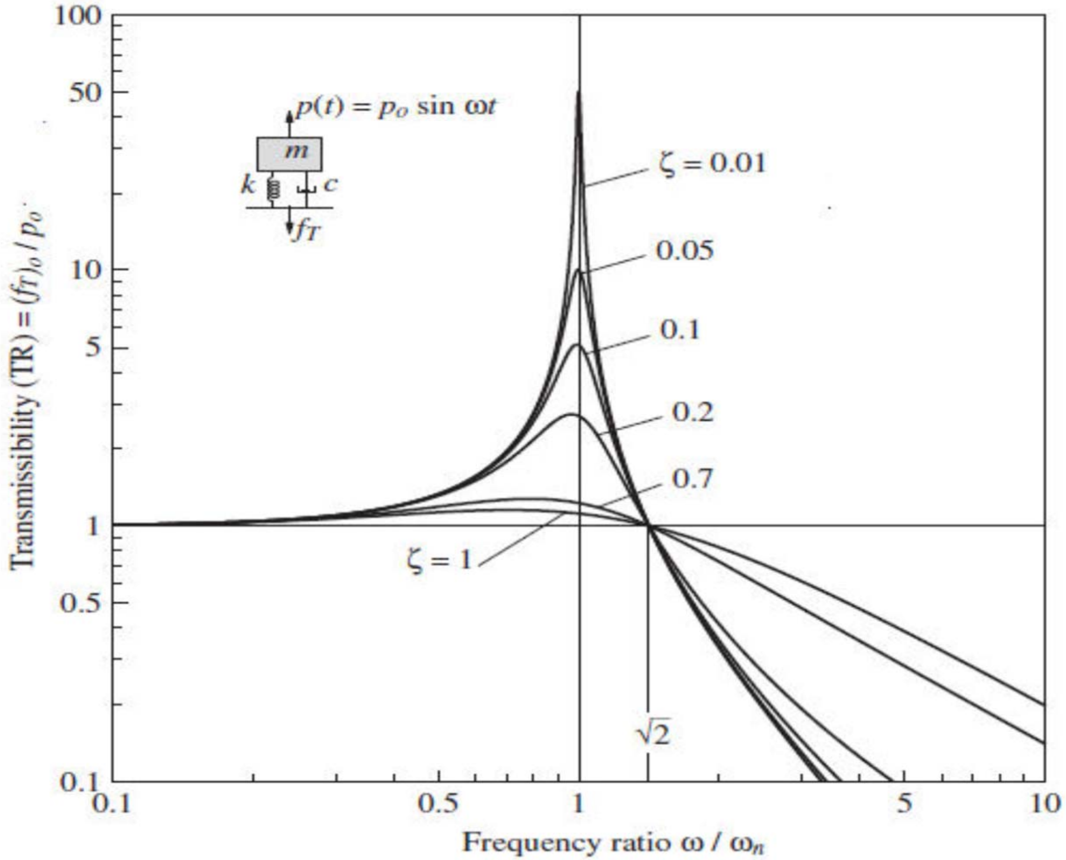
BASE EXCITATIONS
(Transmission of harmonic displacements from base)

If the ground motion is defined as $u_g^t = u_{go} \sin(\omega t)$, it can be shown that the amplitude of u_o^t the total displacement $u^t(t)$ of the mass can be calculated from the same formula that is used for transmission of force from a system to its foundation. i.e.

$$TR = \frac{u^t_o}{u_{go}} = \sqrt{\frac{1+(2\zeta r_\omega)^2}{\left[1-r_\omega{}^2\right]^2+\left[2\zeta r_\omega\right]^2}}$$

TRANSMISSION OF HARMONIC FORCES TO BASE



TRANSMISSION OF HARMONIC FORCES TO BASE

- The magnitude of transmitted force reduces with increase in r_ω beyond $\sqrt{2}$. The force transmitted to base can be decreased by decreasing the value of ω_n in such a way so that $r_\omega > \sqrt{2}$

- The force transmitted to the base can also be reduced by decreasing damping ratio. Although damping reduces the amplitude of mass for all frequencies, it reduces maximum force transmitted to the foundation only if $r_\omega > \sqrt{2}$. Below that value, the addition of damping increases the transmitted force

PROBLEM

A rotating machine with a 600 kg mass operating at a constant speed produces harmonic force in vertical direction. The harmonic force is expressed as p(t)= 5000 Sin 150t, where p(t) is in N. If the damping ratio of isolators at the foundation of machine is 7.5%, determine the stiffness of isolators so that the Transmissibility at the operating speed does not exceed 0.15. Also determine the amplitude of force transmitted to the foundation

Thank You