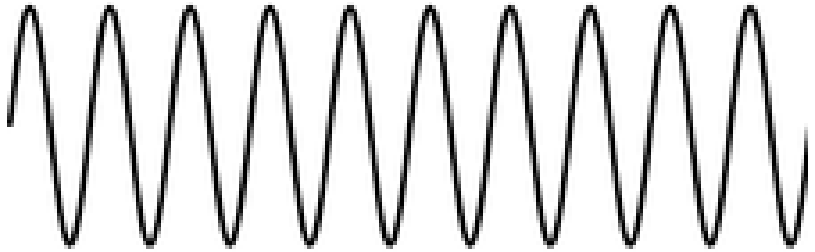
# Introduction to Earthquake Engineering

**Notes Compiled by: Engr. Abdul Rahim Khan**

# List of Content

- **Damping**
- Damping is a phenomenon that makes any vibrating body/structure to decay in amplitude of motion (Fig-19) gradually by means of energy dissipation through various mechanisms. In other words, gradual transformation of energy within the vibrating system is referred as Damping.

- **Damping**
- In other words, gradual transformation of energy within the vibrating system is referred as Damping. Damping ultimately ceases the vibratory motion of structures. It could be compared with gradual application of brakes in a moving vehicle to stop it. Had there been no damping, motion of structures would have continued indefinitely. Thus Damping plays an important role in Structural Dynamics.

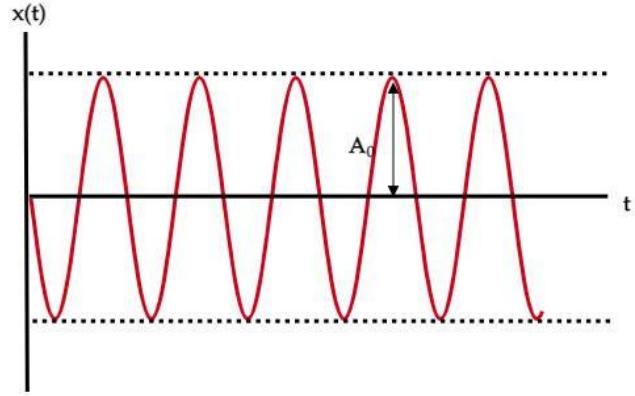


Undamped

Damped

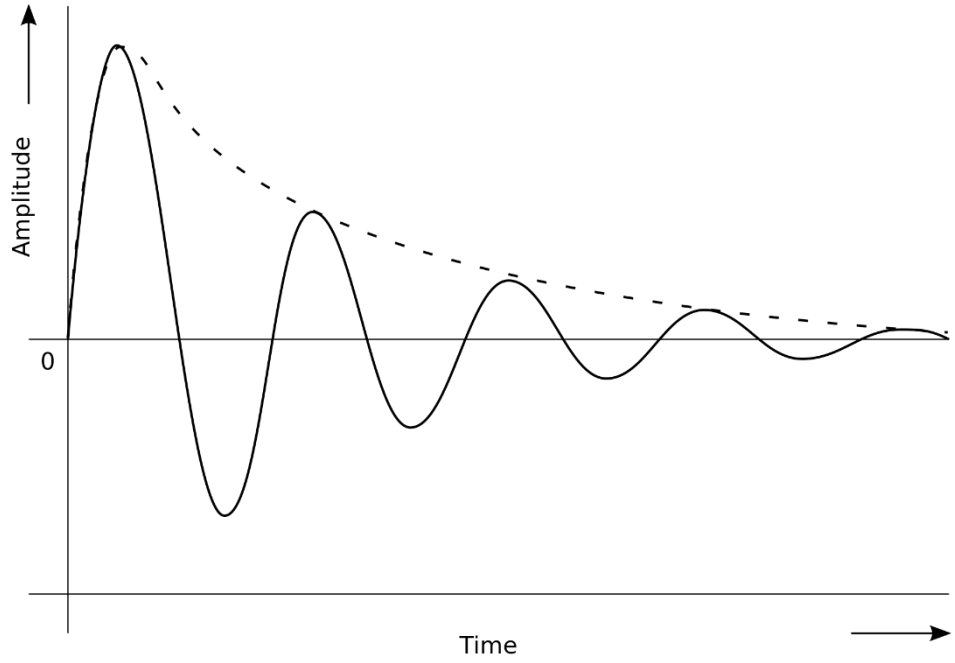
- **Damped Vs Undamped**
- The main difference between damped and undamped vibration is that undamped vibration refer to vibrations where energy of the vibrating object does not get dissipated to surroundings over time.
- Whereas damped vibration refers to vibrations where the vibrating object loses its energy to the surroundings.

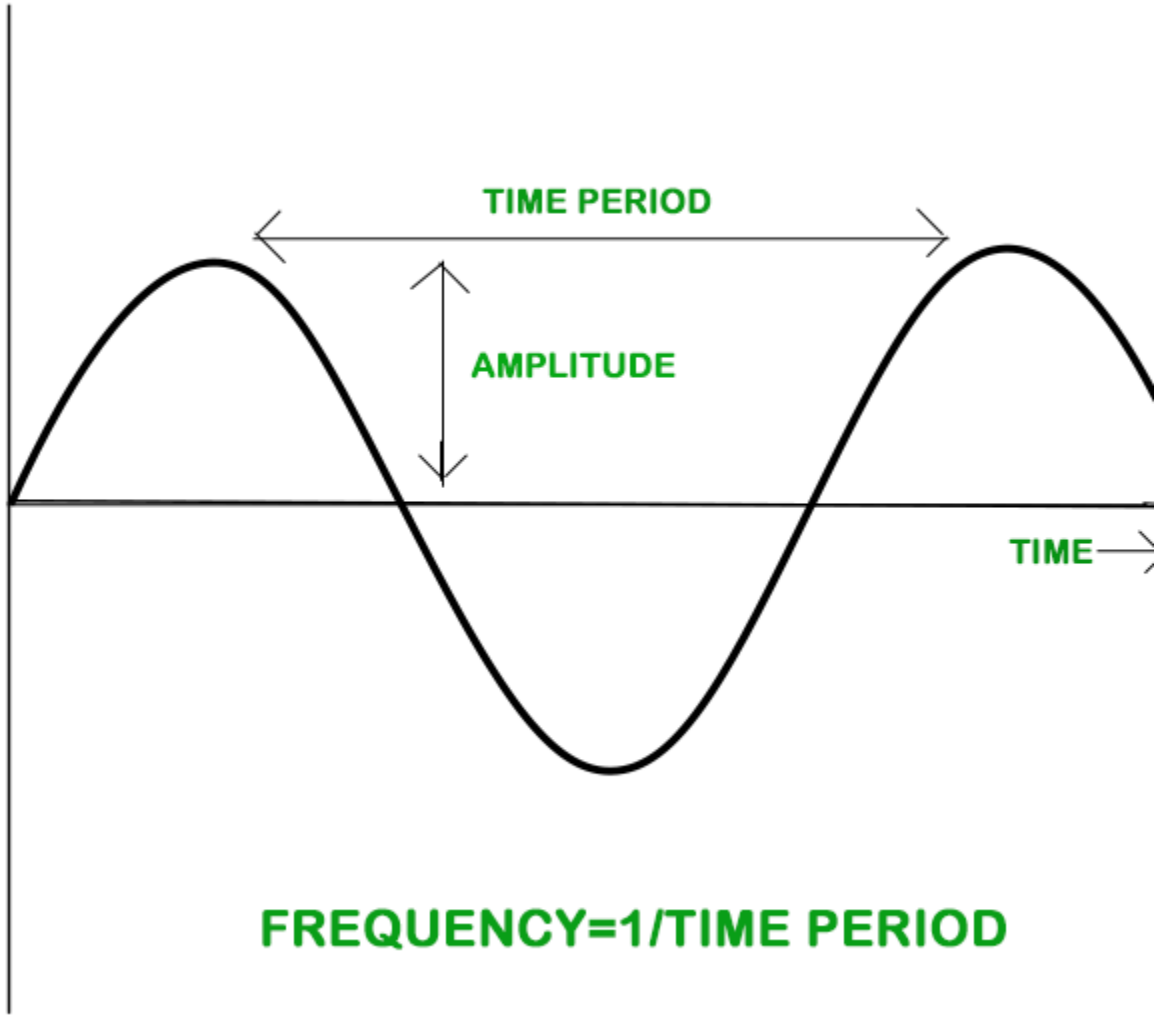
- **Undamped Vibration**
- In undamped vibrations, no resistive force acts on the vibrating object. As the object oscillates, the energy in the object is continuously transformed from kinetic energy to potential energy and back again, and the sum of kinetic and potential energy remains a constant value. In practice, it's extremely difficult to find undamped vibrations. For instance, even an object vibrating in air would lose energy over time due to air resistance.



- **Damped Vibration**
- In damped vibrations, external resistive forces act on the vibrating object. The object loses energy due to resistance and as a result, the amplitude of vibrations decreases exponentially.

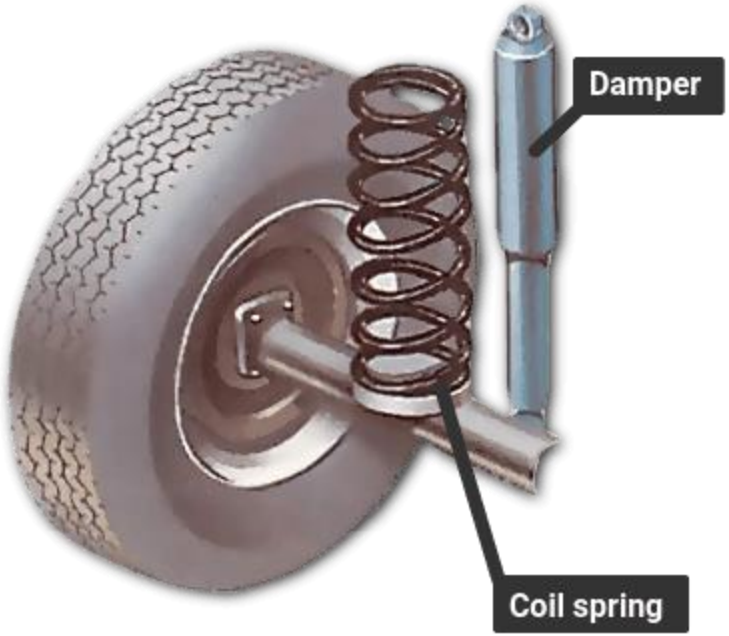
A vibrating object moves to a certain maximum distance on either side of its stationary position. **Amplitude** is the distance from the stationary position to the extreme position on either side and is measured in metres (m). The intensity of vibration depends on amplitude.






**FREQUENCY=1/TIME PERIOD**

- **Use of Damping Action**
- We can make use of damping in situations where we do not want something to vibrate.
- Cars consist of dampers that prevent the car from bobbing up and down repeatedly every time it falls into a pothole.
- Dampers are also found on bridges to prevent them from swaying due to wind.
- Tall buildings also sometimes have dampers to ensure that the building does not sway too much and topple during earthquakes.
- On power lines, “Stockbridge dampers” are used to ensure that the cables do not undergo large vibrations.

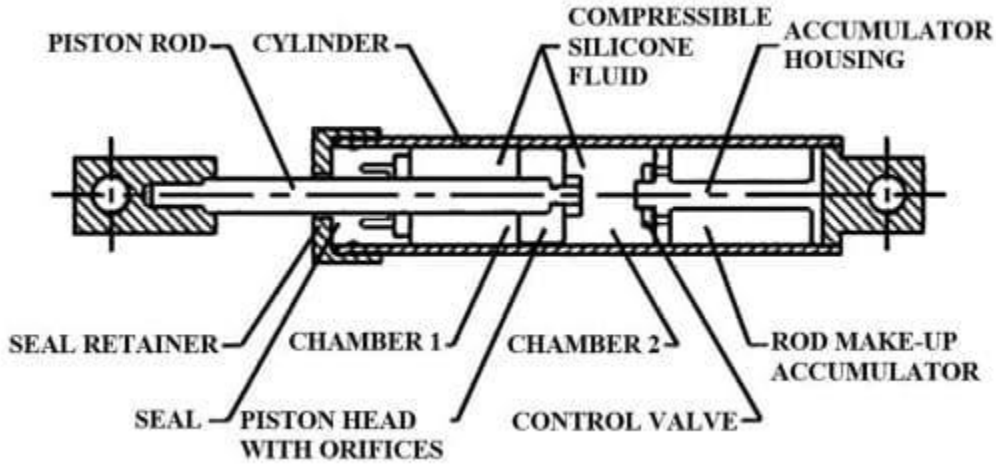

Damper
Coil spring


MAESTRO

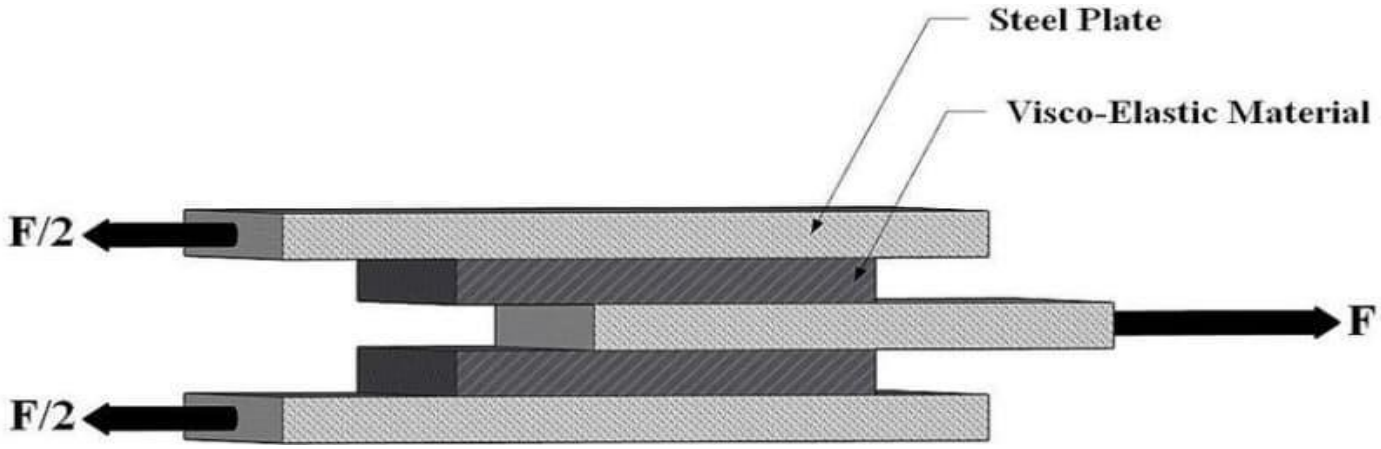
- **Types of Damper**

- **Viscous Dampers**
- **Viscoelastic Dampers**
- **Friction Dampers**
- **Tuned Mass Damper (TMD)**
- **Yielding Dampers**
- **Magnetic Damper**

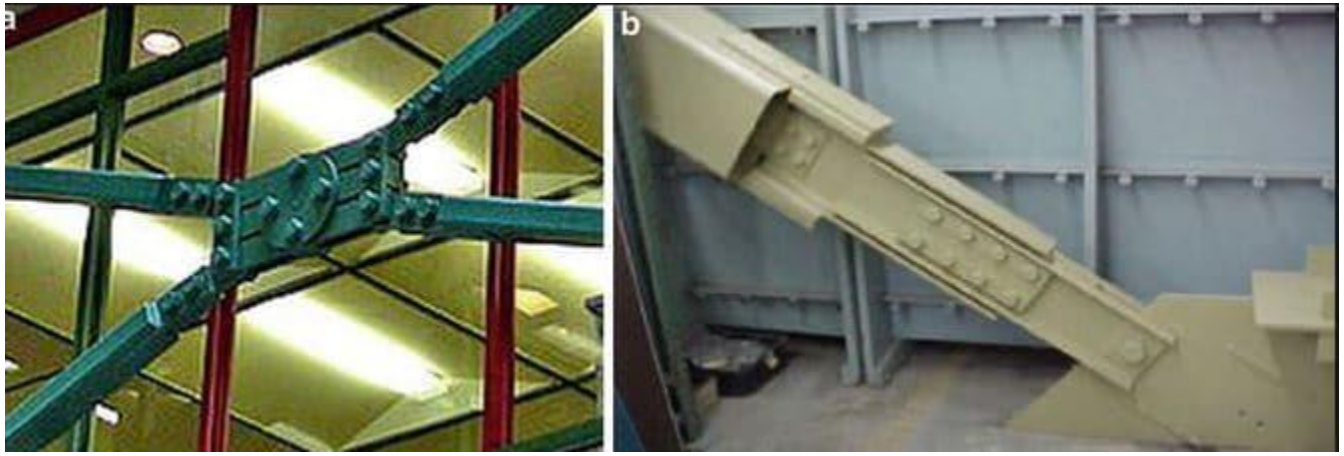
- **Viscous Dampers**
- In viscous dampers, seismic energy is absorbed by silicone-based fluid passing between piston-cylinder arrangement. Viscous dampers are used in high-rise buildings in seismic areas. It can operate over an ambient temperature ranging from 40°C to 70°C. Viscous damper reduces the vibrations induced by both strong wind and earthquake.



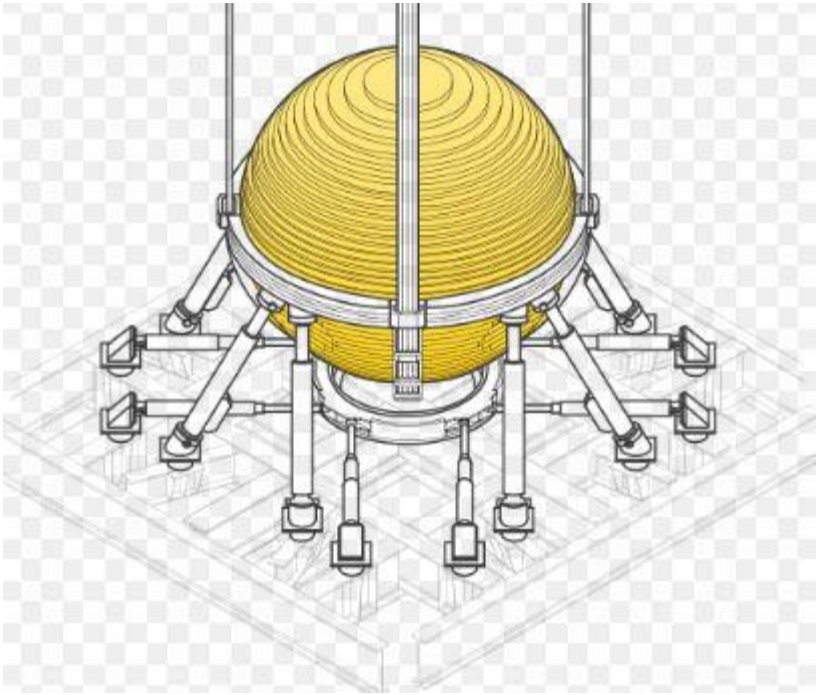
- **Viscoelastic Dampers**
- Another type of damper is viscoelastic dampers that stretch an elastomer in combination with metal parts. This type of damper dissipates the building's mechanical energy by converting it into heat. Several factors such as ambient temperature and the loading frequency affect the performance and consequently the effectiveness of the damper system.



- **Friction Dampers**
- Generally, a friction damper device consists of several steel plates sliding against each other in opposite directions. The steel plates are separated by shims of friction pad material.
- The damper dissipates energy by means of friction between the surfaces which are rubbing against each other. It is also possible to manufacture surfaces from materials other than steel.

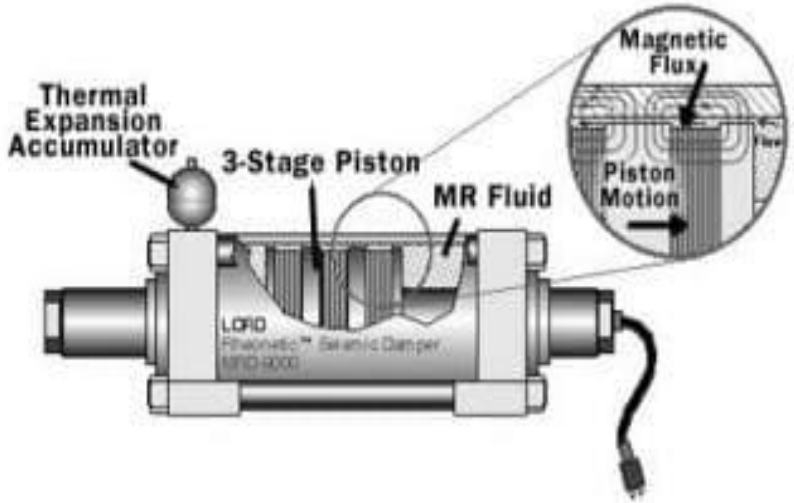


- **Tuned Mass Damper (TMD)**
- Tuned Mass Damper (TMD), also known as vibration absorbers or vibration dampers, is a passive control device mounted to a specific location in a structure so as to reduce the amplitude of vibration to an acceptable level whenever a strong lateral force such as an earthquake or high winds hit.



- **Yielding Dampers**
- Yielding damper or metallic yielding energy dissipation device or passive energy dissipation device is manufactured from easily yielded metal or alloy material.
- It dissipates energy through its plastic deformation (yielding of the metallic device) which converts vibratory energy and consequently declines the damage to the primary structural elements. yielding dampers are economical, effective, and proved to be a good energy dissipator.

- **Magnetic Dampers**
- Magnetic Damper consists of two racks, two pinions, a copper disk and rare-earth magnets. This type of damper is neither expensive nor dependent on temperature. Magnetic damping is not strength that is why it is effective in dynamic vibration absorbers which require less damping.



# THANK YOU!