BMM3553 Mechanical Vibrations

Chapter 1:Introduction to Vibrations

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Chapter Description

- Expected Outcomes

  Students will be able to:

  - Understand the basic concepts of vibration
  - Identify the different types of motion
  - Identify the different types of vibration
  - Identify the Degree of Freedom.

- References

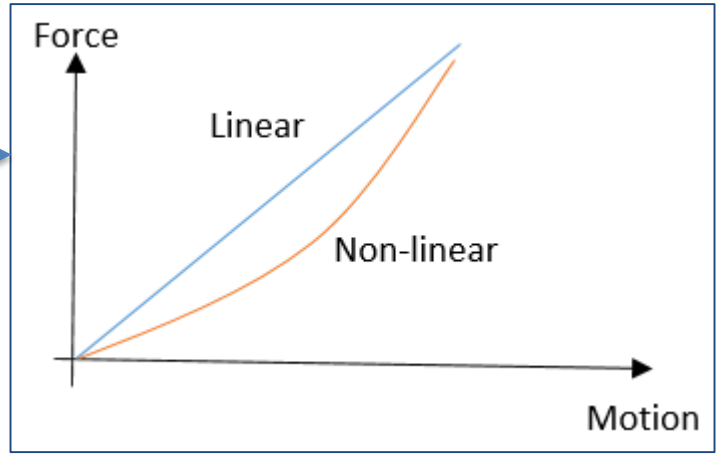
  - Singiresu S. Rao. Mechanical Vibrations. 5th Ed
  - Abdul Ghaffar Abdul Rahman. BMM3553 Mechanical Vibration Note. UMP.
  - Md Mustafizur Rahman. BMM3553 Mechanical Vibration Lecture Note. UMP

Introduction

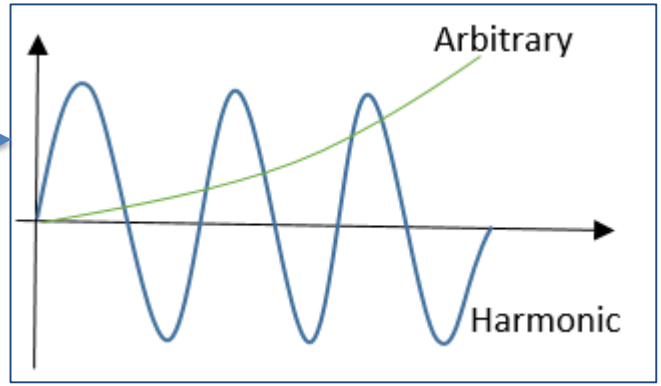
	No Forces	Forces
No Motion	Who Care?	Statics
Motion	Kinematics	Dynamics

Dynamics

Linear
Non-Linear



Arbitrary motion
Harmonic motion



- Mechanical Vibration
- Acoustics

Building on the Past

Dynamics and Kinematics

Strength of Materials

Thermodynamics

Differential Equations

Basic Concepts of Vibration

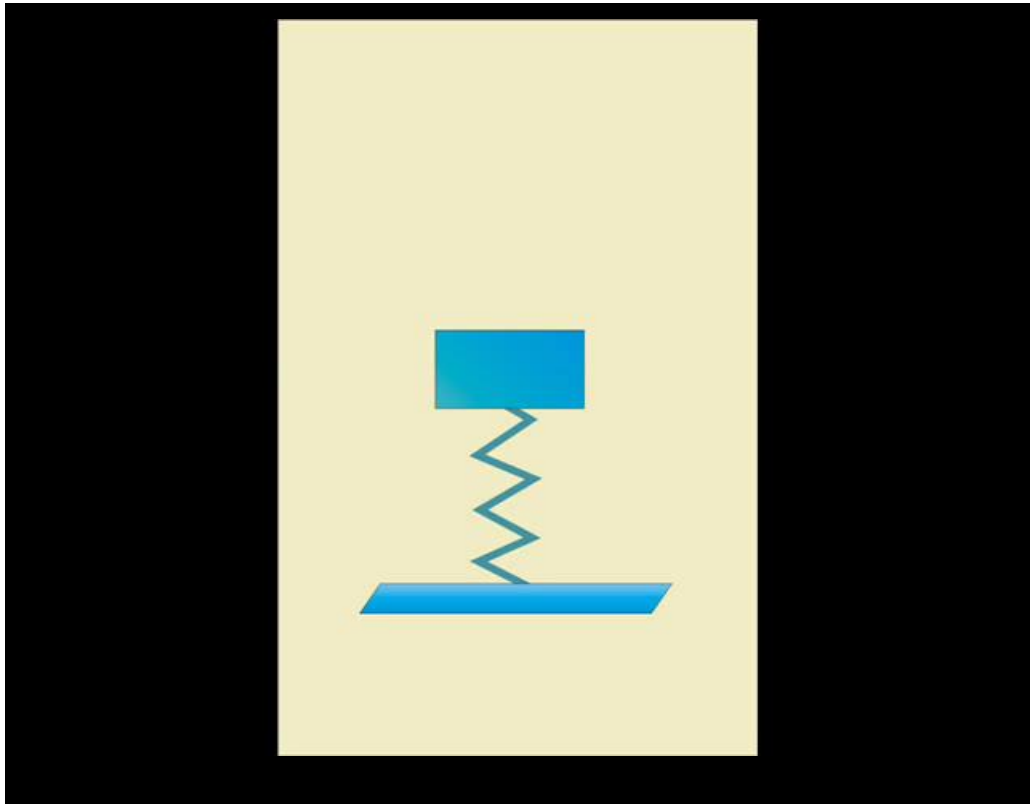
- Inherent in the study of vibration is **oscillation**.
- **Electric circuits** can have **oscillatory voltages** or currents but these are **not called vibratory systems** and their study is not called vibration.
- **Air pressure** oscillation is called sound but the study of sound is called **acoustics not vibration**.
- **Vibration** is usually used to describe the **motion of mechanical objects** that **oscillates** or have the **potential to oscillate**

Basic Concepts of Vibration

- Vibration is repetition of any motion after a period of time
- Vibration System consists of those elements:
  1) mass or inertia
  2) spring or elasticity
  3) damper
- Involves transfer of potential energy to kinetic energy and vice versa

Why is sine function often associated with vibration?

- The decomposed rotating force vector is sinusoidal
- The natural or free motion of an elastic body about equilibrium position is sinusoidal
- Combined they create a sinusoidal motion commonly known as **VIBRATION**



Rotating force vector becomes sinusoidal force in the vertical direction

$$= F \sin \omega t$$

Classification of Vibration

By Motion:

Simple Harmonic Motion

The simplest form of vibration.

Exact position is predictable from the equation of motion.

Mathematical description:

$$x(t) = A\sin(\omega t + \theta)$$

Simple Harmonic Motion

$$x(t) = A\sin(\omega t + \theta)$$

Terms:

$x(t)$ - instantaneous displacement (m)

A - maximum amplitude (m)

ω - angular velocity (Radians/Second)

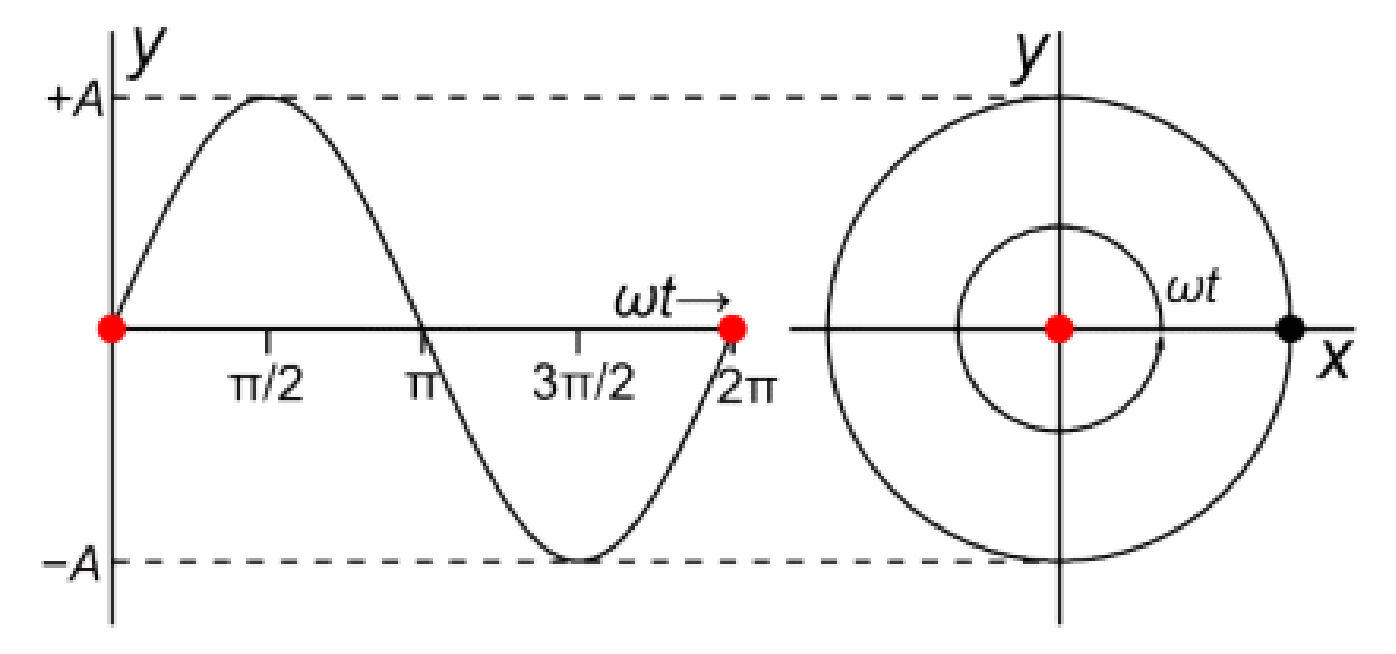
θ - phase angle (Radians)

f = frequency, $\omega = 2\pi f$

T = cycle/period, $T = 1/f$

Natural frequency, characteristic frequency, fundamental frequency, resonance frequency, normal frequency

Simple Harmonic Motion

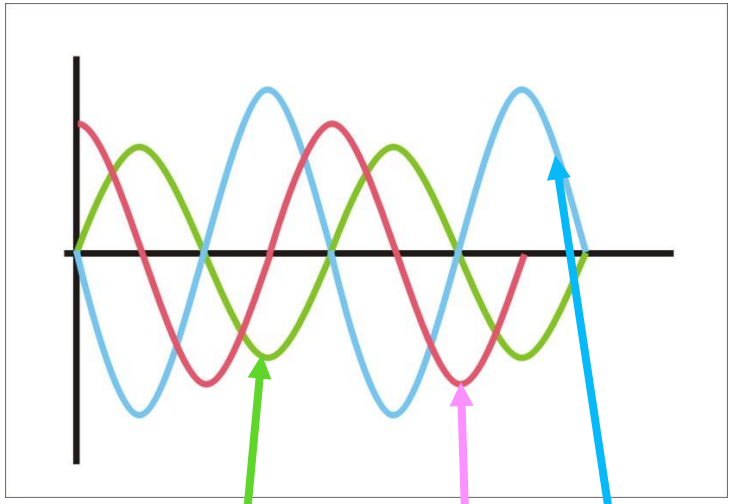


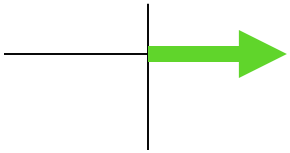
Graphical description of simple harmonic motion

Image source: https://commons.wikimedia.org/wiki/File:Simple_harmonic_motion_animation_1.gif

Simple Harmonic Motion

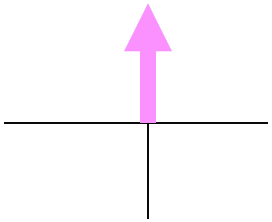
- Vibration Parameters: Displacement, Velocity and Acceleration





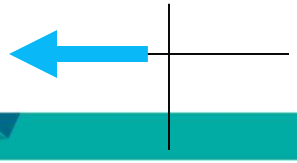
Displacement

$$x = A\sin\omega t$$



Velocity

$$\dot{x} = \omega A\cos\omega t$$



Acceleration

$$\ddot{x} = -\omega^2 A\sin\omega t = -\omega^2 x$$

Periodic Motion

- Motion repeats itself in equal time periods. Includes harmonics motion, pulses, etc.

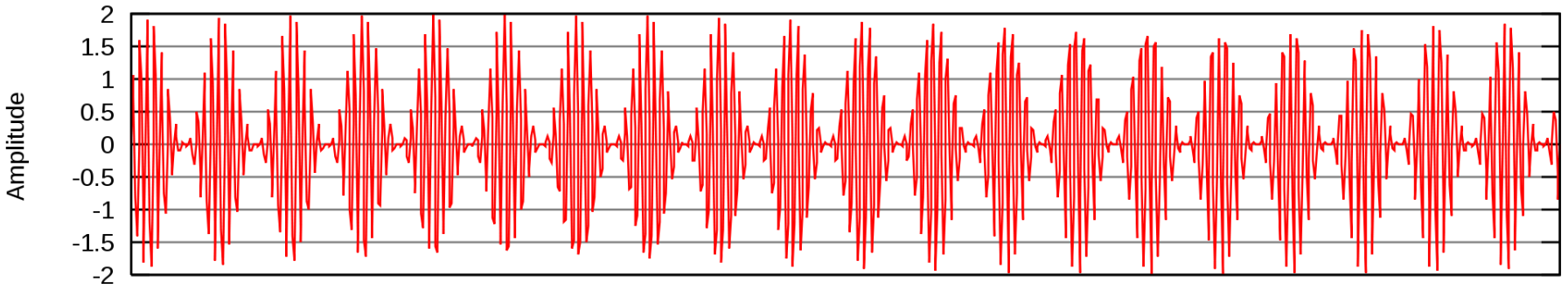
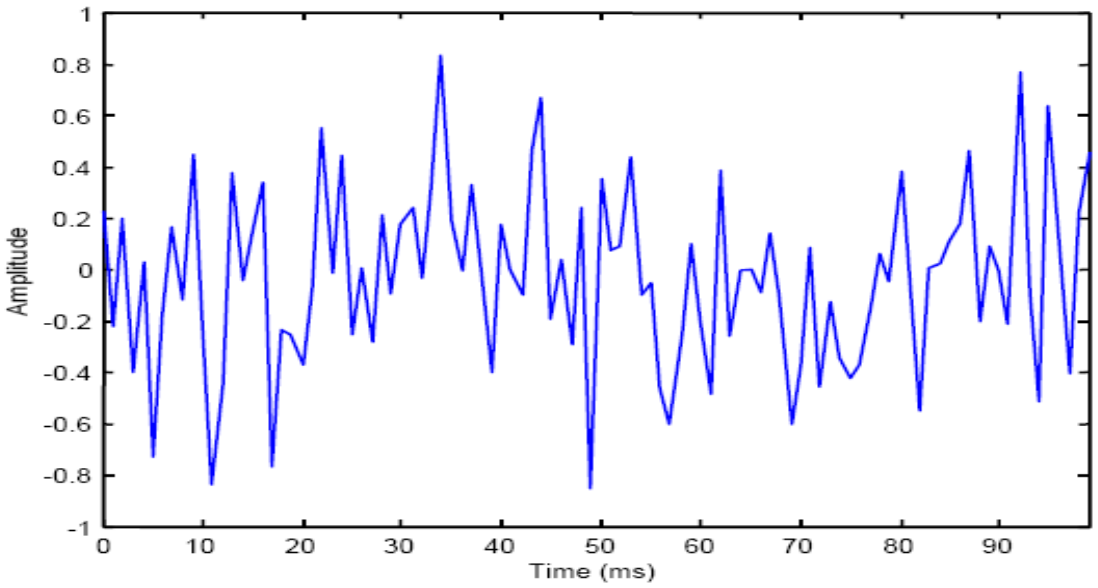


Image source: https://commons.wikimedia.org/wiki/File:AM_signals.svg

Random Motion

- Motion is not deterministic signal with no mathematical expression
- Vibration signal contains broad frequency band.
- Example: vehicle on uneven road surface, machine looseness.



Chaotic Motion

- Combination of random and periodic motion
- Random and repeatable characteristics combined in a non-linear fashion
- Vibration signal contains all frequencies in a given band but not is equal proportions

Transient Motion

- Any motion other than the above mentioned motion is called Transient motion
- Impulsive in nature, but not regularly repeated

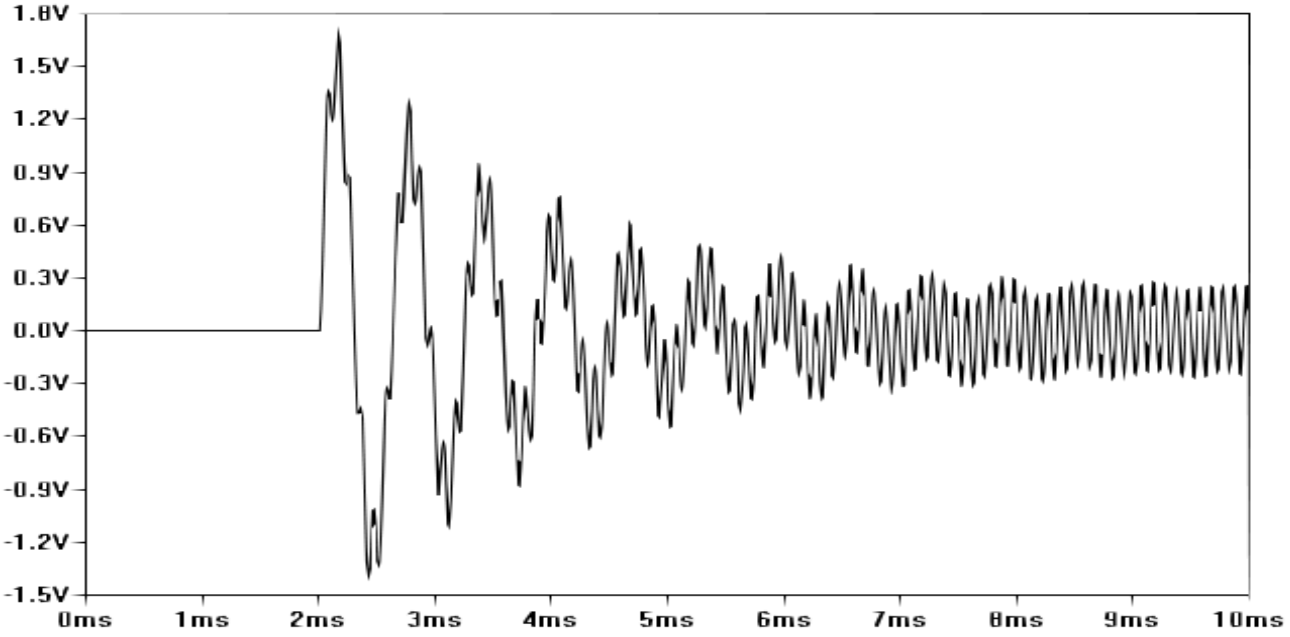


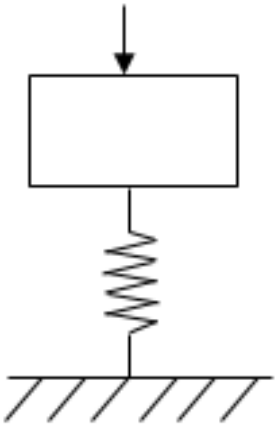
Image source: https://commons.wikimedia.org/wiki/File:Transiten_power_supply.svg

Basic Concepts of Vibration

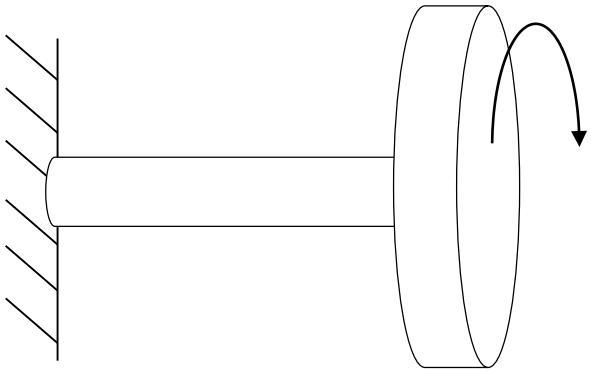
- Degree of freedom (DOF) is the minimum no. of independent coordinate systems required to define the position of the mass at any instant of time
- Depending on the independent coordinate, vibrating system is divided into the following
  - Single Degree of Freedom (SDOF) Systems
  - Multi Degree of Freedom (MDOF) Systems
  - Continuous System (Infinite DOF)systems

Basic Concepts of Vibration

- Single degree of freedom system



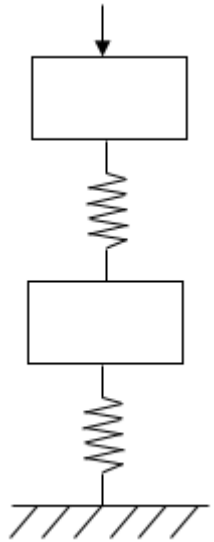
Translation motion



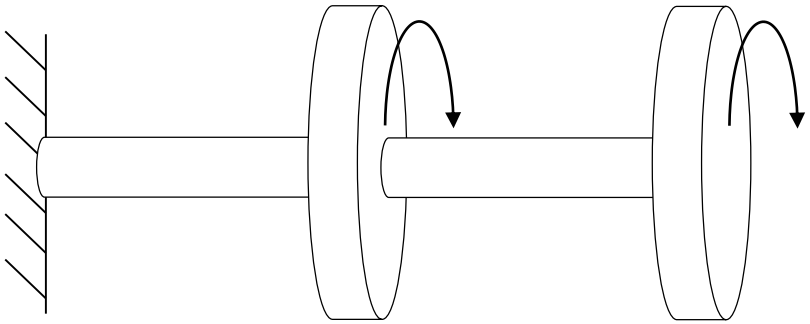
Torsional motion

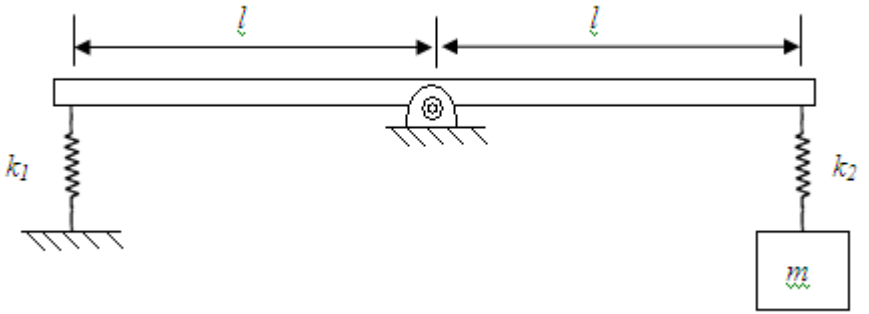
Basic Concepts of Vibration

- Examples of Two degree-of-freedom systems:



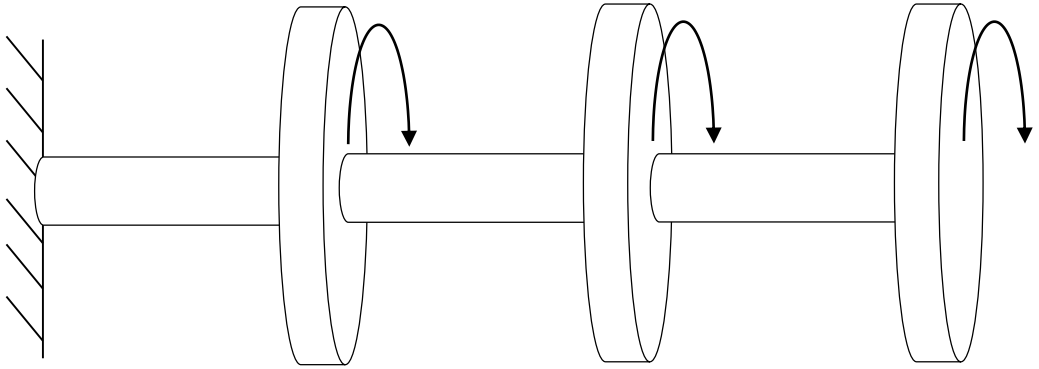
- If more than one independent coordinate is required to define at any instant the position of different points in the system, it is referred to as a MDOF.

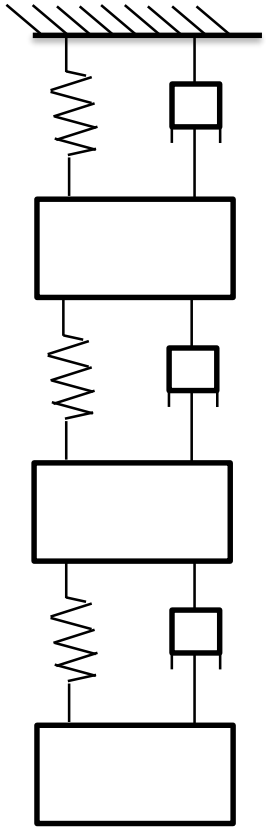




Basic Concepts of Vibration

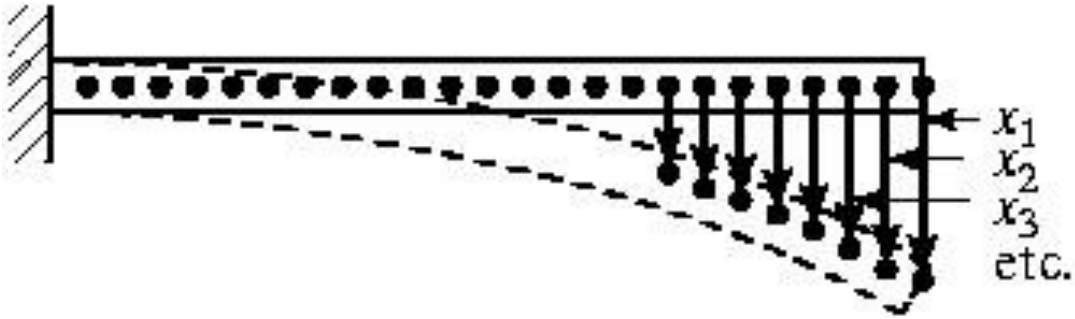
- Examples of Three degree of freedom systems:





Basic Concepts of Vibration

- Example of Continuous (Infinite-number-of-degrees-of-freedom) system:



- Infinite number of degrees of freedom (n-DOF) system are termed continuous or distributed systems
- Finite number of degrees of freedom are termed discrete or lumped parameter systems
- High n-DOF will produce more accurate results

Thank You

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