Mechanical Vibrations

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<td>No Motion</td>
<td><strong>Who Cares?</strong></td>
<td><strong>Statics</strong></td>
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<td>Motion</td>
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Vibrations in our life

Our heart beat, our lungs oscillate, we hear because our ear drum vibrates…

Vibration even makes us snore!!

The light waves which permit us to see & sound waves through which we hear entail vibration

We move by oscillating our legs

We cannot even say “Vibration” without vibration of larynges, vocal cord

We limit out discussion to “MECHANICAL VIBRATION”…i.e. Vibration of Dynamic Systems

What is a Dynamic System???

Any System that contain Mass and Elasticity.

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Vibration definition

Vibration: Any motion that repeats itself after an interval of time is called vibration or oscillation.

The swinging of a pendulum and the motion of a plucked string are typical examples of vibration. The study of vibration deals with the study of oscillatory motions of bodies and the forces associated with them.
Why study vibration?

- Vibrations can lead to excessive deflections and failure on the machines and structures.
- To reduce vibration through proper design of machines and their mountings.
- To utilize profitably in several consumer and industrial applications (quartz oscillator for computers).
- To improve the efficiency of certain machining, casting, forging & welding processes.
- To stimulate earthquakes for geological research and conduct studies in design of nuclear reactors.

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Simple vibration systems

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basic Concepts of Vibration

Vibration = any motion that repeats itself after an interval of time

Vibratory System consists of:
1) spring or elasticity
2) mass or inertia
3) damper

Involves transfer of potential energy to kinetic energy and vice versa

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Degree of Freedom (D.o.f.)

minimum number of independent coordinates required to determine completely the positions of all parts of a system at any instant of time

Examples of single degree-of-freedom systems:

(a) Slider-crank-spring mechanism

(b) Spring-mass system

(c) Torsional system
Examples of two degree-of-freedom systems:
Examples of three degree-of-freedom systems:
Example of **Infinite**-number-of-degrees-of-freedom system:

1. **Infinite** number of degrees of freedom system are termed *continuous* or *distributed* systems
2. **Finite** number of degrees of freedom are termed *discrete* or *lumped* parameter systems
3. More accurate results obtained by increasing number of degrees of freedom
Classification of Vibration

1. Free Vibration:
A system is left to vibrate on its own after an initial disturbance and no external force acts on the system. E.g. simple pendulum

2. Forced Vibration:
A system that is subjected to a repeating external force. E.g. oscillation arises from diesel engines

**Resonance** occurs when the frequency of the external force coincides with one of the natural frequencies of the system

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Classification of Vibration

1. Undamped Vibration:
   When no energy is lost or dissipated in friction or other resistance during oscillations

2. Damped Vibration:
   When any energy is lost or dissipated in friction or other resistance during oscillations

3. Linear Vibration:
   When all basic components of a vibratory system, i.e. the spring, the mass and the damper behave linearly

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Classification of Vibration

1. Nonlinear Vibration:
   If *any* of the components behave nonlinearly

2. Deterministic Vibration:
   If the value or magnitude of the excitation (force or motion) acting on a vibratory system is known at any given time

3. Nondeterministic or random Vibration:
   When the value of the excitation at a given time cannot be predicted

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Vibration Analysis Procedure

Step 1: Mathematical Modeling
Step 2: Derivation of Governing Equations
Step 3: Solution of the Governing Equations
Step 4: Interpretation of the Results
Example of the modeling of a forging hammer

Anvil: heavy block of iron or steel with a smooth, flat top on which metals are shaped by hammering

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Figure 1.17(a) shows a motorcycle with a rider. Develop a sequence of three mathematical models of the system for investigating vibration in the vertical direction. Consider the elasticity of the tires, elasticity and damping of the struts (in the vertical direction), masses of the wheels, and elasticity, damping, and mass of the rider.
Subscripts
\( t \): tire  \( v \): vehicle  
\( w \): wheel  \( r \): rider  
\( s \): strut  \( eq \): equivalent