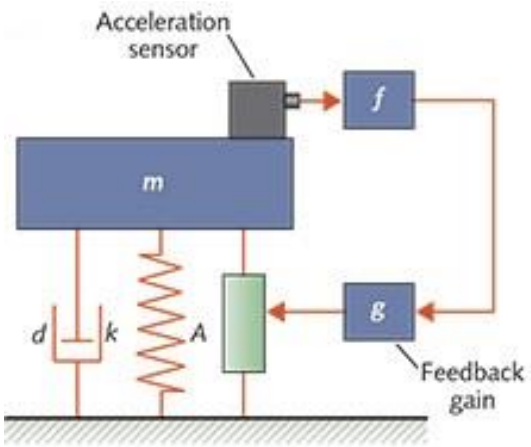
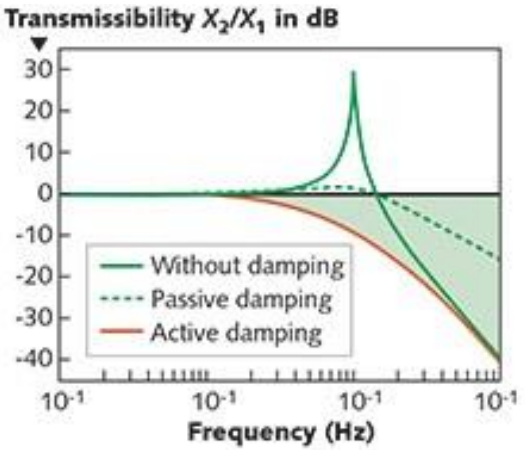
ME756A

Principles of Vibration Control





Instructor : ***Prof. Bishakh Bhattacharya***
Department of Mechanical Engineering
IIT Kanpur
E-mail: *bishakh@iitk.ac.in*

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Smart Materials Structures and Systems Laboratory
IIT Kanpur

Course References

Textbook

Principles of Vibration Control, *A. K. Mallik*, *Affiliated East-West Press, India.*

Major Reference Books

I. ***Vibration with Control*** by Daniel J Inman, John Wiley Publication
II. **Vibration Damping, Control and Design** by C. W. de Silva (Ed.), Publisher CRC Press.
III. **Dynamics and Control of Structures** by L. Meirovitch, John Wiley Publication
IV. **Passive Vibration Control**, Denys J. Mead, John Wiley Publication.
V. **Vibration Control of Active Structures**, A Premount, Springer Publication.
VI. **Piezoelectric Translators for Vibration Control and Damping** by Moheimani and Fleming, Springer Publication.

Course evaluation

I. Mid term exam……. (30%)
II. End term exam……. (40%)
III. Two Quizzes…… (10%) **@5% each**
IV. Two assignments……. (10%)
V. Term paper…….…. (10%)
VI. Bonus*

*Based on attendance (min. 90%).

Will help the students on border marks during grading.

Introduction
to
Vibration Control

Smart Materials Structures and Systems
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IIT Kanpur

Lecture Contents

- ✓ Adverse effects of vibration
- ✓ Quantitative description of vibration
- ✓ Parameters of vibration system
- ✓ Control of Vibration
- ✓ Various Active and Passive Control Strategies

VIBRATION signifies To and Fro motion about some equilibrium configuration

This is undesirable in most engineering systems. The ill effects of vibration includes:

- Loss of accuracy of Work-piece due to vibration of machine tools.
- Fatigue failure of structures like aircraft fuselage and machine components like crankshaft.
- Malfunctioning of Sensitive Instruments/ systems like payloads from vibration of launching rockets.
- Severe damages due to resonance e.g. Collapsing of bridges, transmission lines and offshore structures.

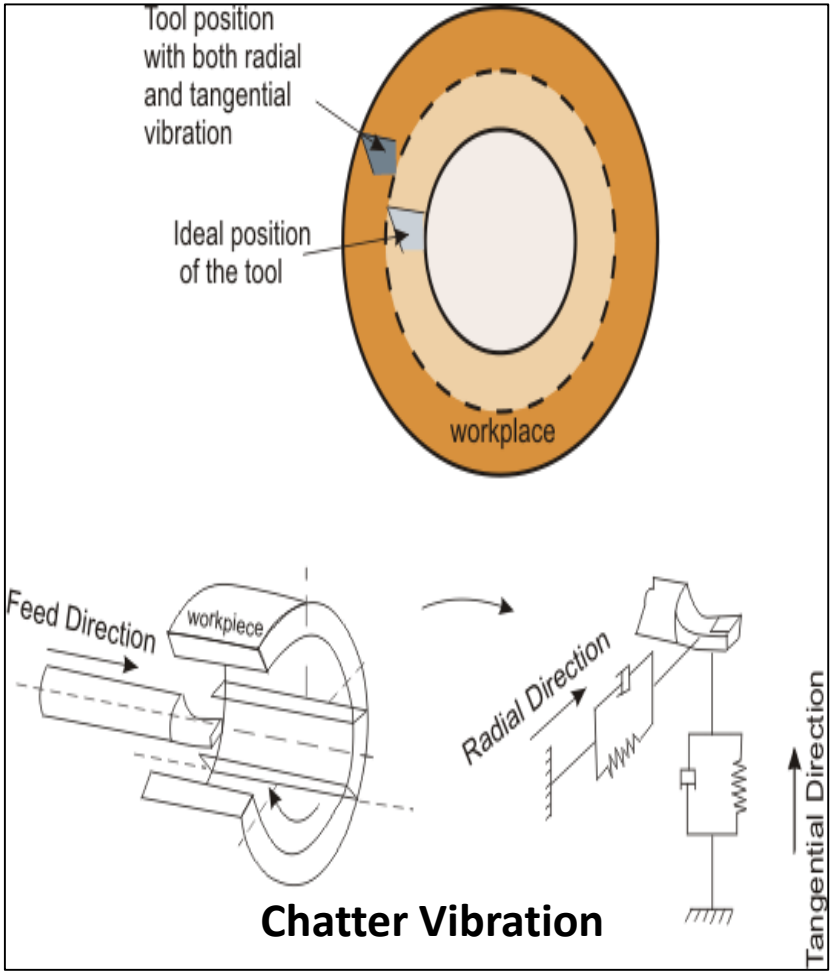
Chatter Vibration

Loss of Accuracy of Work piece: Shifting of Tool Position due to Vibration of cutting tool

There are two types of chatter:

Forced chatter : Force chatter **originates** in the **driving system** (for e.g., from a motor) and gets **transmitted** to the cutting zone.

Self excited chatter : Self excited chatter is generated due to **uneven surface** of the work piece, fractures of metal chips etc.



Chatter Vibration

Typical Fatigue Failure in a Shaft due to Torsional Oscillation

Camshaft Assembly of a 6.5 MW Diesel Engine

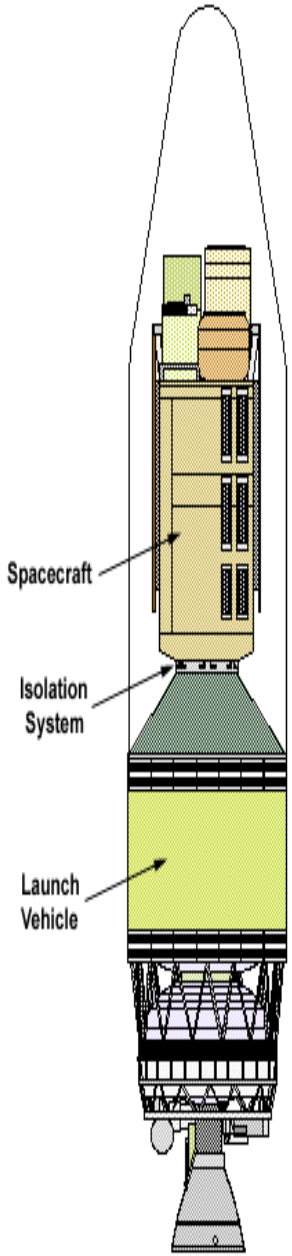
Broken camshaft: Due to malfunctioning of Torsional Damper

Such torsional oscillations are caused either due to

- ❑ **Periodic acceleration** of the piston, connecting rod and crank, or
- ❑ **Periodic variation** in gas pressure inside the engine cylinder.

Source: cr4.globalspec.com/thread/37470/Camshaft-Failure

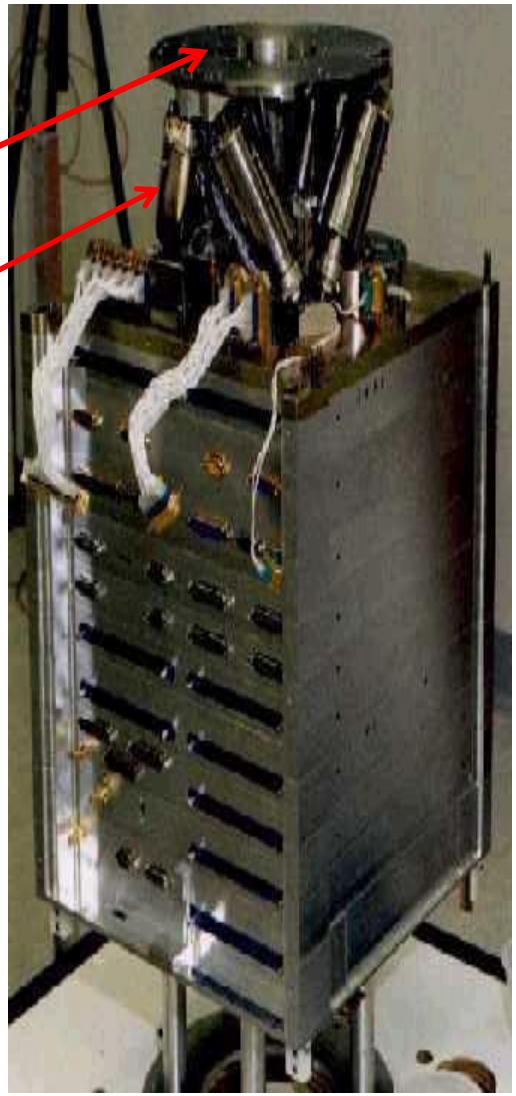
Satellite Ultra-quiet Isolation Technology Experiment (SUITE)



Vibration Isolation of Spacecraft from the Launch Vehicle

Observe the Isolation System consisting of six variable length struts

The challenge is to isolate the payload such that at three different sinusoidal excitations of frequencies 5Hz, 25Hz and 100 Hz, the vibration amplitude is to be reduced. The isolation is achieved by the hexapod assembly by using stiff piezoelectric actuators that extend and contract in response to the vibration originating at the base. This hexapod assembly is commonly known as Active Stewart Platform.



PICOSat – a micro satellite of US Air Force

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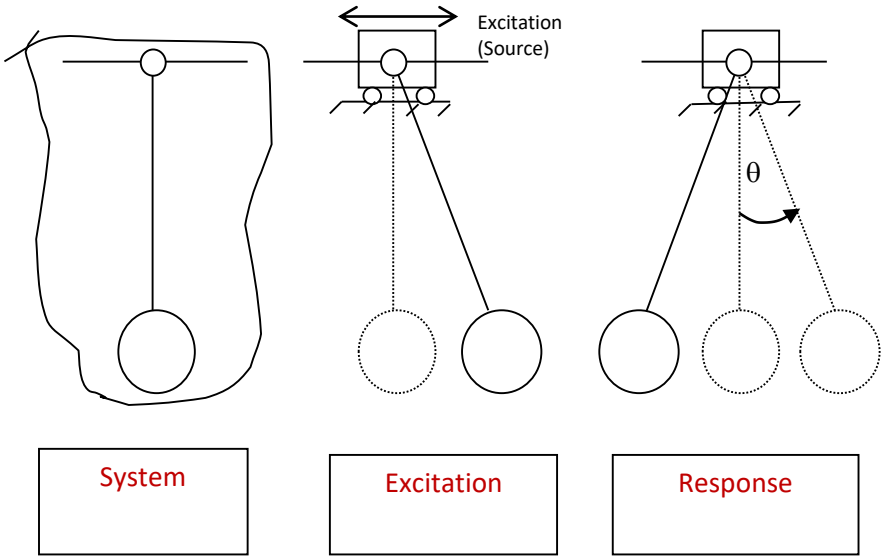
Quantitative Description of Vibration

Vibration is defined as the Response of an Elastic System subjected to Dynamic Disturbance.

Complete description of a vibration problem involves three items - **Vibrating System**, **Excitation** and **Response**.



Every Vibrating System, in general, comprises three parameters

- ✓ **Inertia** is linked with the **Kinetic Energy** of the system.
- ✓ **Stiffness** is linked with the **Potential Energy** stored in the system.
- ✓ **Damping** indicates the **energy** that gets **dissipated** from the system in each cycle.

Inertia and **Stiffness** are generally modelled as simple elements like:

	Rectilinear	Angular
Inertia	**Mass**	**Moment of inertia**
Stiffness	**Linear spring**	**Torsional spring**

Damping is the most difficult parameter among the three. Some of the simple damping models are :-

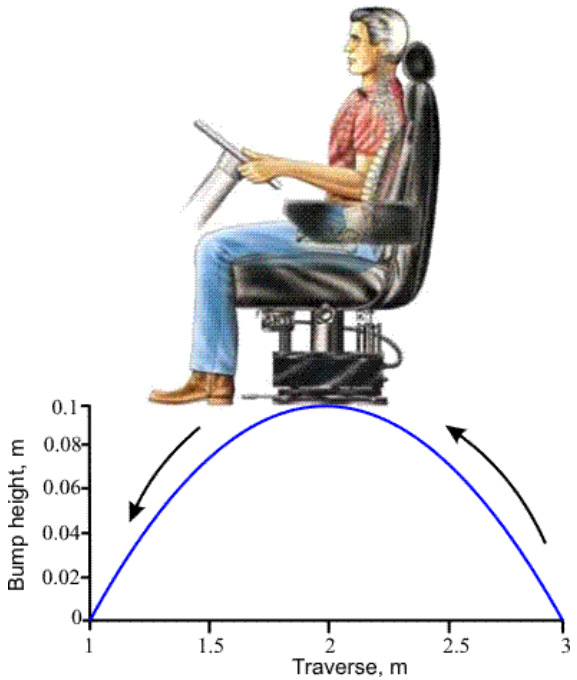
- ✓ Viscous damping
- ✓ Coulomb damping
- ✓ Material/ Hysteric/Structural damping

These models will be discussed in detail in upcoming lectures

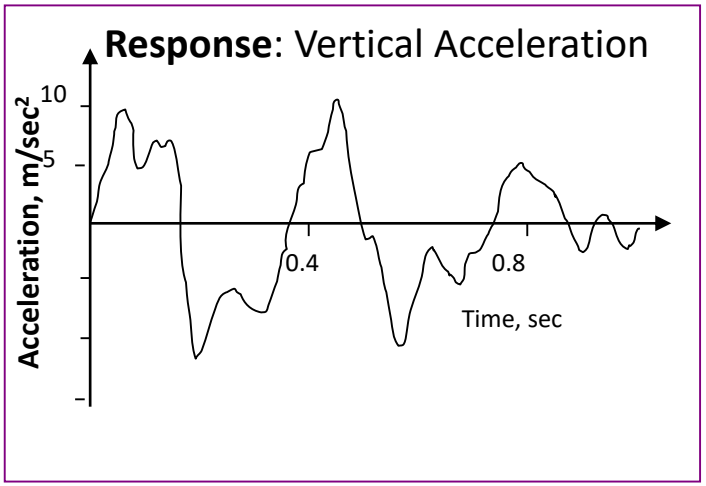
- The excitation and response of a system are often characterized by the physical variables like – Displacement, Velocity, Acceleration, Stress and Noise etc.

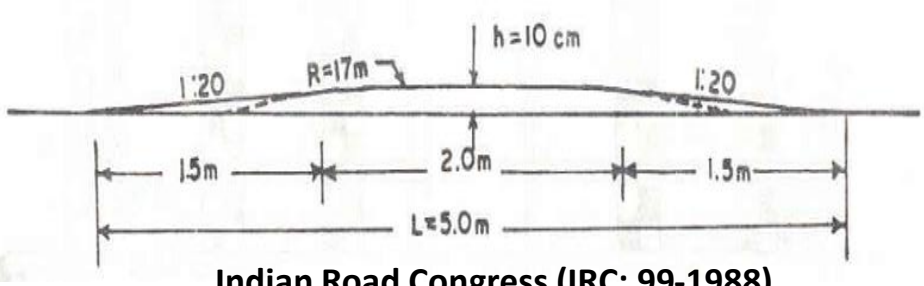
- The selection of these variables, depends on various factors, such as the nature of the problem and the objective of the analysis.

Example - To analyze Ride-Comfort



Excitation: Displacement of the Axle

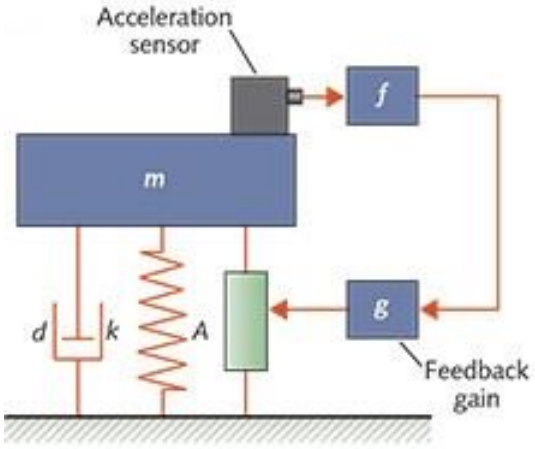


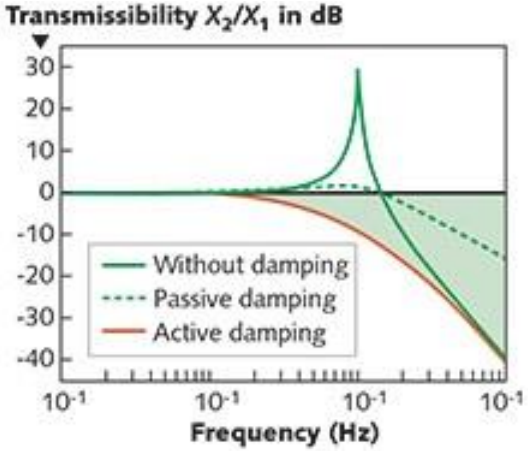


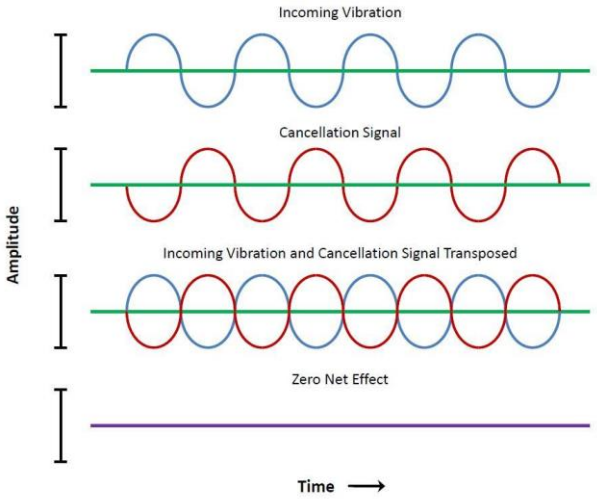
Indian Road Congress (IRC: 99-1988)

Methods for Vibration Suppression

- **Passive action** is independent of the resulting Vibration – ***Open Loop System***.
- **Active action** is dependent on the resulting Vibration – ***Closed Loop System***.







Vibration Control Strategies