1. Introduction to Vibrations

MECH 463: Mechanical Vibrations

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Suggested Readings:

1. Topic 1 from notes package.
2. Sections 1.1–1.6 in the course textbook.

Your Notes

1.1 Learning Objectives

Objectives met so far

1. Understand the importance of vibrations in mechanical design and learn about force and energy perspectives.

2. Identify degrees of freedom of a mechanical system.

Now on ...

1. Identify different types of vibrations and vibration analysis procedures.

2. Apply principle of superposition (in this and later topics).

3. Develop lumped parameter models (in this and later topics).

Your Notes

1.6. Classification of Vibration (T 1.5+NP 1.6.) — # 1

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Fill in the class

Your Notes

1.6. Classification of Vibration (T 1.5+NP 1.6.) — # 2

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Your Notes

Principle of Superposition (NP 1.6.5) — # 1

Principle of superposition states that the response of a mechanical system to a set of forces is equal to the sum of the responses of the system subjected to *each force acting on its own*.

Let us see what this principle means using an example of a linear system.

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Principle of Superposition (NP 1.6.5) — # 2

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Your Notes

Principle of Superposition (NP 1.6.5) — # 3

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Your Notes

1.7. Vibration Analysis (NP 1.7)

1. Develop a simple model of the system and gradually improve it. Simple models that we develop comprise spring-mass-damper elements.
2. Formulate equations of motion. Here we need some knowledge in dynamics: kinematics and kinetics. We will use Free-Body-Diagrams (FBDs) and energy methods to formulate equations of motion.
3. Solve the equations of motion. This requires some knowledge in ordinary differential equations, matrix algebra, complex numbers, Fourier methods *etc.* In an advanced course one will employ computers and numerical methods. But here we use simple analytical or hand calculations.
4. Interpretation of results with a view to fix the vibration problem. We will do this throughout the course, especially when we consider vibration isolators and absorbers.

Your Notes

Example 1 — # 1

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Example 2: A reciprocating engine is mounted on foundations as shown in Fig.(1). The unbalanced forces and moments developed in the engine are transmitted to the frame and the foundation. An elastic pad is placed between the engine and the foundation block to reduce the transmission of vibration. Develop two mathematical models of the system using a gradual refinement of the modelling process.

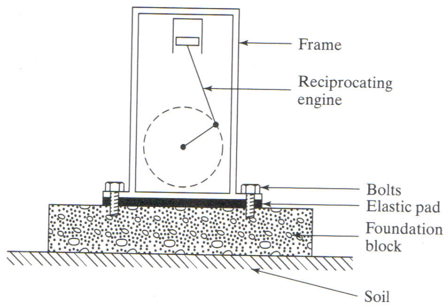

Figure : Figure for example 1.

Your Notes

Example 1 — # 2

Solution:

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Your Notes

Example 1 — # 3

Fill in the class

Your Notes

Example 1 — # 4

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Your Notes

Example 2 — # 1

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Example 2: Consider an automobile on a rough road shown in Fig.(3) exhibits vibration caused by road roughness. Develop three models in the increasing order of complexity by considering (a) weight of the car body, passengers, seats, front wheels, and rear wheels; (b) elasticity of tires/suspension, main spring, and seats; and (c) damping of seats, shock absorbers, and tires.

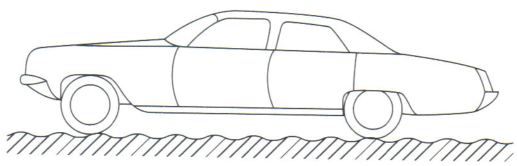

Figure : Figure for example 2.

Solution:

Fill in the class

Your Notes

Example 2 — # 2

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Your Notes

Example 2 — # 3

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Example 2 — # 4

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Your Notes

Vibration Models of a Human Body

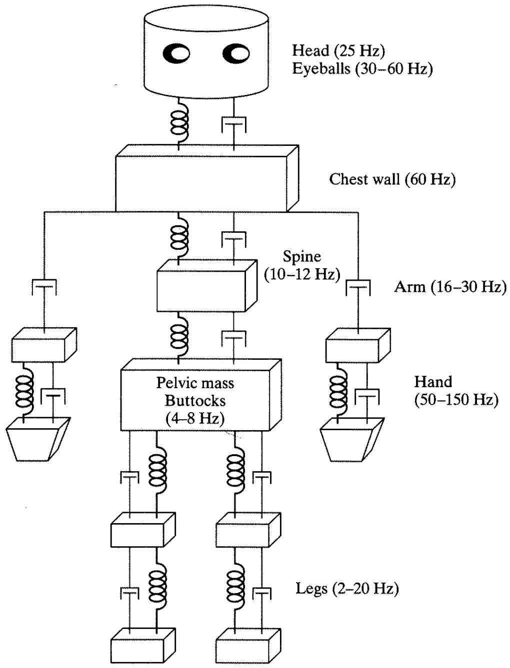

Figure : Mass-Spring-Damper Models for a human.

Your Notes

1.8. Topic Summary (NP 1.8)

1. A study of Vibrations is important to design safe and efficient products.
2. Vibration phenomenon can be viewed as an energy exchange mechanism in which potential energy is continuously transformed into kinetic energy, and vice versa.
3. Vibration is an interplay between inertial and restoring forces. All *realistic* vibrations involve dissipative forces as well.
4. Kinematic constraints play an important role in reducing the number of co-ordinates required to describe motion of mechanical systems.
5. Vibrations can be free or forced; damped or undamped; transient or steady; linear or nonlinear; deteministic or random; or any combination of these.
6. Spring-mass-damper models can be used to effectively describe vibrations of complex real world systems.

Your Notes