
Vibration Engineering Notes

Textbook: Engineering Vibration, 4th Edition, Daniel J. Inman

Author
Philip LIGTHART

June 14, 2024

Contents

1	Chapter 1 - Introduction to vibration and free response	1
1.1	The spring-mass model	1
2	Chapter 2 - Response to harmonic excitation	3

Chapter 1

Chapter 1 - Introduction to vibration and free response

Definition 1

Degree of freedom The degree of freedom of a system is the minimum number of displacement coordinates needed to represent the position of the systems mass at any instant of time.

Definition 2

Free response Free response refers to analysing the vibration of a system resulting from a non-zero initial displacement and/or velocity of the system with no external force or moment applied.

1.1 The spring-mass model

The fundamental kinematic quantities used to describe the motion of a particle are displacement, velocity, and acceleration vectors.

Definition 3

Kinematic Kinematic quantities are those that describe the motion of a particle without regard to the forces that cause the motion.

From physics, we know that: The motion of a mass with changing velocity is determined by the net force acting on the mass.

In fig. 1.1, the forces acting on the mass consist of the force of gravity pulling down (mg) and the *elastic-restoring* force of the spring pulling it back up (f_k)...

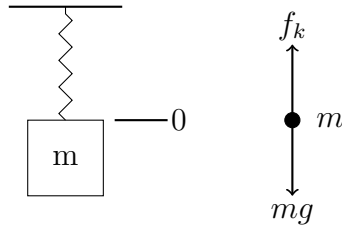


Figure 1.1. Single degree of freedom mass-spring system

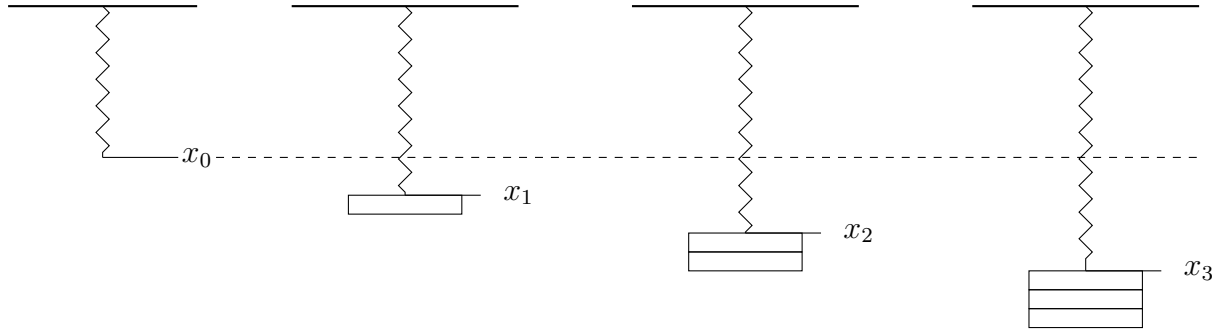


Figure 1.2. A schematic of a massless spring with no mass attached showing its static equilibrium position, followed by increments of increasing added mass illustrating the corresponding deflections.

Definition 4

Constant of proportionality The slope of the straight line in the graph of force versus displacement of a spring.

The constant of proportionality can be easily determined for a spring using a simple experiment. Hanging a known mass on a spring and measuring the resulting displacement. This can be repeated for successively heavier masses and a force displacement graph can be plotted.

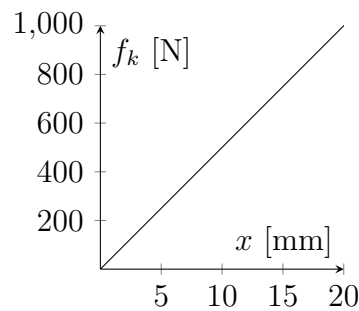


Figure 1.3. The static deflection curve for the spring in fig. 1.2

Chapter 2

Chapter 2 - Response to harmonic excitation

Definition 5

Harmonic excitation Harmonic excitation refers to a sinusoidal external force of a single frequency applied to the system.

Definition 6

Resonance Resonance is the tendency of a system to absorb more energy when the driving frequency matches the systems natural frequency of vibration.

Harmonic excitations are a common source of external force applied to machines and structures. Rotating machines such as fans, electric motors, and reciprocating engines transmit a sinusoidally varying force to adjacent component's. In addition, the Fourier theorem indicates that many other forcing functions can be expressed as an infinite series of harmonic terms.