ME301: Dynamics and Vibration of Machinery
Lecture 1
Fundamentals

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Vibration/Oscillation:

Vibration/Oscillation is the to and fro motion of a material particle or rigid body about its mean position. A particle or rigid body can have response falling in the following categories if it is vibrating.

a. Harmonic

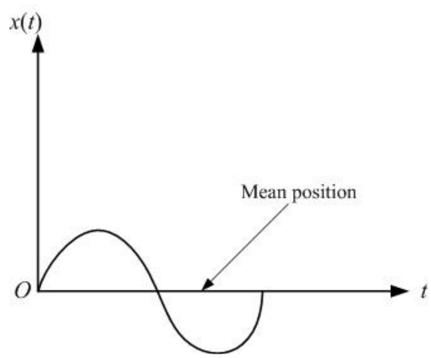


Fig. 1 Harmonic function

b. Periodic

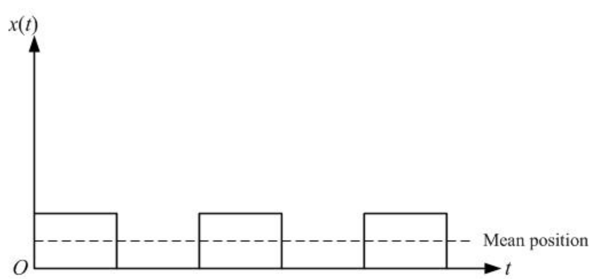


Fig. 2 Periodic function

c. Random

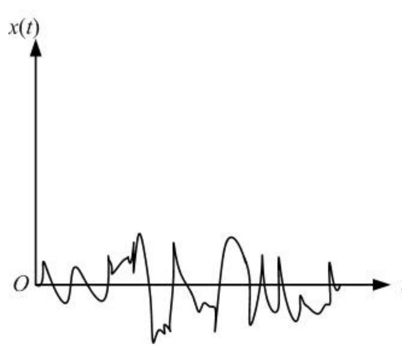


Fig. 3 random function

Mathematical modelling in vibration:

There are two kinds of persons in this world. One who does experiments and the other one who make mathematical modelling for understanding any physical phenomenon. Here, in this course of dynamics and vibration of machinery, mainly we will be dealing with the mathematical modelling of vibratory systems. So, when we say mathematical modelling, that means we want to capture physical phenomenon in terms of equations. In the area of vibration, we use the following for developing mathematical models:

- Linear momentum balance
- Angular momentum balance
- Constitutive law

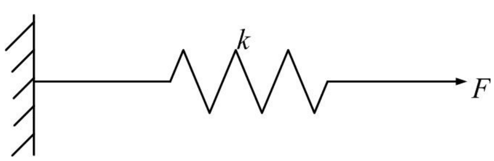
Linear momentum balance: $\sum F_{\text{ext}} = m_{\text{tot}} a,$ Newton's second law (1)

Angular momentum balance: $\sum T_{\text{ext}} = I\alpha,$ for planar problem (2)

where I is the mass moment of inertia and α is the angular acceleration.

Constitutive law:

For linear spring



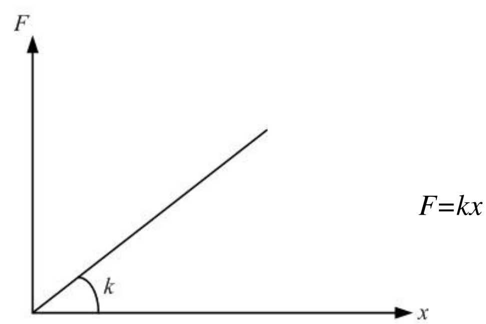


Fig. 4 Constitutive law for a linear spring

For linear viscous damper

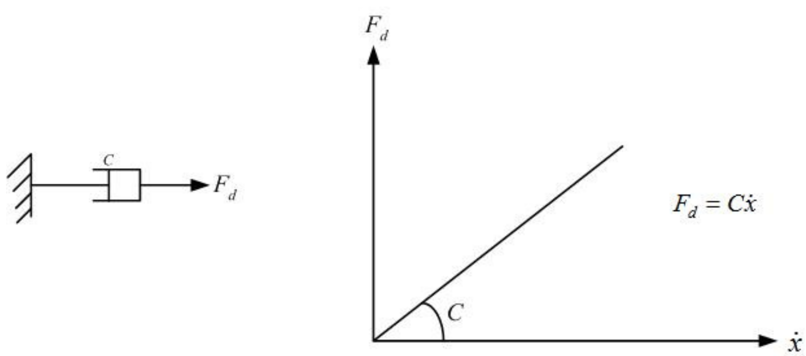


Fig. 5 Constitutive law for a linear viscous damper

The Newton's second law of motion (Eq. 1) can also be thought of as a constitutive law as in the following:

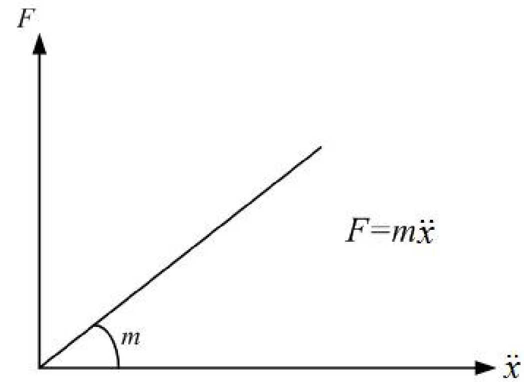


Fig. 6 Representation of Newton's second law as constitutive law

Degrees of freedom:

It is the number of independent coordinates needed to describe the system dynamics/configuration completely. In a three dimensional space, a particle has three degrees of freedom (translations along x, y and z coordinates) and a rigid body has six degrees of freedom (translations along x, y and z coordinates and three rotations about x, y and z-axes).

Single degree of freedom vibratory system

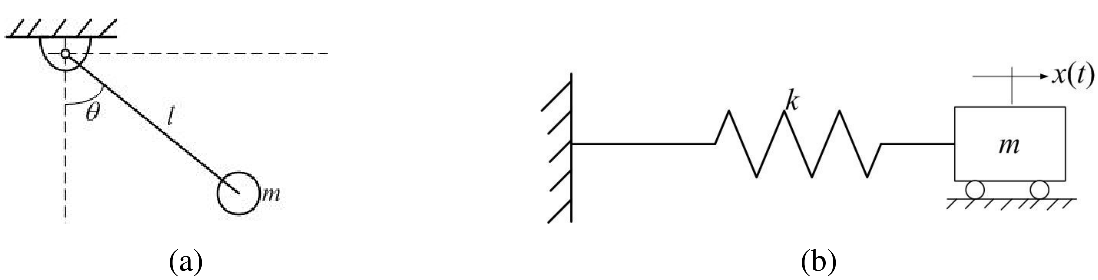
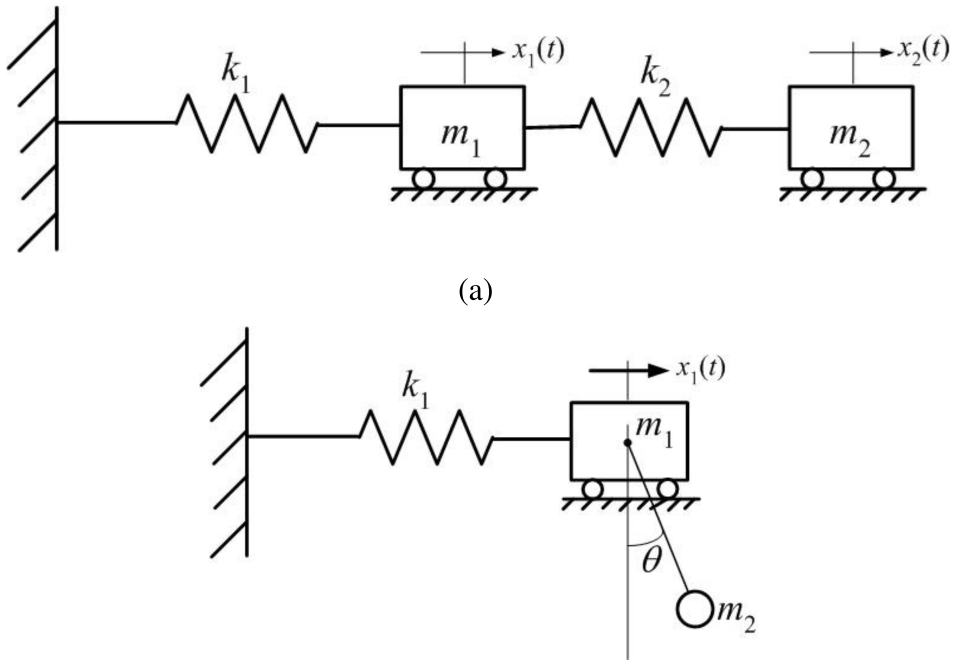


Fig. 7 Single degree of freedom systems

Two degrees of freedom vibratory system



(b)

Fig. 8 Two degrees of freedom system

This way if you connect three masses by three flexible springs in series or three simple pendulums in series masses a, you will get three degrees of freedom vibratory system. If there are *n* masses connected by *n* springs in series or *n* masses connected by *n* rigid massless rods you will get *n* degrees of freedom system. The system may be combination of spring, mass, simple pendulum or viscous damper.

The figures, which have drawn here, are the **discrete systems**. These are called discrete systems because you see the spring and mass separately. The suspension system in a bike is a discrete system. There is another system called **distributed parameter system**, where you cannot see the spring and mass separately, rather they are inbuilt and distributed within the system. The cutting tool in lathe machine, which is vibrating during machining, is an example of distributed parameter system. The distributed parameter system has infinite degrees of freedom.

The analyses of single degree of freedom vibratory systems have already been covered. We will concentrate on the analysis of two degrees of freedom/multi degrees of freedom systems in the subsequent lectures.