

Chapter 2

Single Degree of Freedom Forced Vibration System

ABSTRACT

This chapter concerns the study of forced vibration of a single degree of freedom system, treating undamped and damped system under harmonic, periodic, and arbitrary loading with different cases and examples. Passing by all components of the general solution of an undamped forced system, which are a transient solution, depends only on initial conditions, transient solution due to the load at the end the stationary solution. In this chapter, a study of the dynamic influence factor depends on the ration between load frequency and structure one is presented.

INTRODUCTION

Time-dependent physical phenomena are generated initially by differential equations. In the simplest case, there is a single quantity, which varies and speaks of a system with one degree of freedom, most of the time governed by a second order differential equation. Natural phenomena are usually non-linear, but in many cases, the small motion hypothesis provides an excellent approximation provided by a linear differential equation with constant coefficients of second order. The forced oscillator evolves according to a transient regime then a permanent regime. This chapter aims to give a physical interpretation of some interesting case of a forced one degree of freedom system. A large part of this chapter is devoted to one type of loading, which is the harmonic load; the end of the chapter will be devoted to another type of loading and to the construction of an analytical as well as mathematical model of a forced vibration system linear oscillator

HARMONIC LOADING

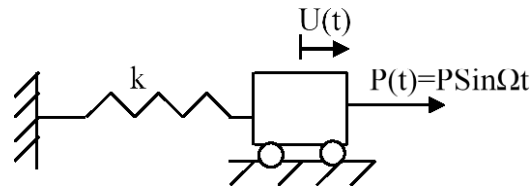
Among the existing external forces, we have the harmonic forces. Other types exist, and will be studied later at the end of this chapter.

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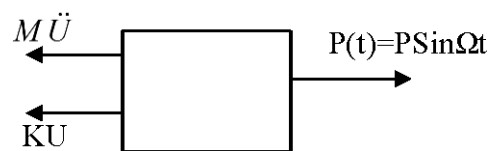
Undamped System (c = 0)

We will assume a system with a single degree of freedom represented in the following figure.

Figure 1. Undamped single degree of freedom model system



In order to write the motion of equation we use Dalambert principle so we isolate the mass as follows:



The dynamic equilibrium equation of forced undamped system is:

$$M\ddot{U}(t) + K U(t) = P_0 \sin \Omega t$$

$$\ddot{U}(t) + \omega^2 U(t) = \frac{P_0}{M} \sin \Omega t \quad (1)$$

With $\omega^2 = K / M$

Equation (1) is a second-degree differential equation with second member.

The general solution = the particular solution + the homogeneous solution

The dynamic equilibrium of a forced, undamped system is:

$$U(t) = U_p(t) + U_h(t)$$

The homogeneous solution is as shown by the following equation:

$$U_h(t) = A \sin \omega t + B \cos \omega t \quad (2)$$

On the other hand, for the particular solution we can assume that $U_p(t)$ has of the same form of the harmonic excitation force

$$U_p(t) = C \sin \Omega t, \quad \dot{U}_p(t) = \Omega(C_3 \cos \Omega t - C_4 \sin \Omega t), \quad \ddot{U}_p(t) = -\Omega^2 C \sin \Omega t = (-\Omega^2)U_p(t)$$

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