

# Module 7 - Damping Elements

ME3050 - Dynamics Modeling and Controls

Mechanical Engineering

Tennessee Technological University

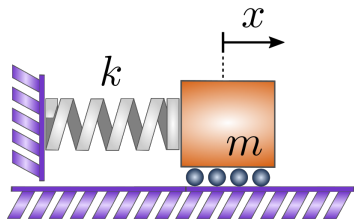
## Topic 1 - System Response

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- Solve Equation of Motion
- Free Response
- Response Equation
- Natural Frequency

# Solve Equation of Motion

We have previously derived the accepted equation of motion for this simple but fundamental system.



$$m\ddot{x} + kx = 0$$

# Solve Equation of Motion

## Dynamic Simulation

A simulation is an approximate imitation of the operation of a process or system;[1] that represents its operation over time. definition Wikipedia

## System Analysis in the Time Domain

**We study the motion and forces in the system as they change over time in response to various initial conditions and external forces.**

This idea is known as the **time response** and we will discuss the derivations and resulting **response equations** for a generalized system model as we proceed (System Dynamics, Ch. 8).

# Free Response

Imagine you displaced the mass, and then released it from rest.

Equation of Motion:

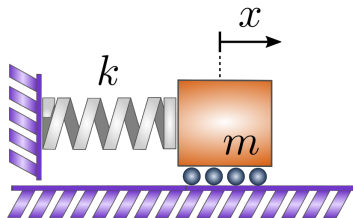
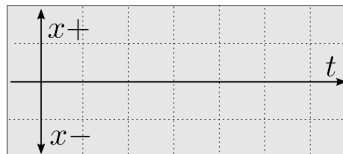
$$m\ddot{x} + kx = 0$$

Initial Position:

$$x(t = 0) = x(0) = x_0$$

Initial Velocity:

$$\dot{x}(t = 0) = v(0) = v_0$$



# Free Response

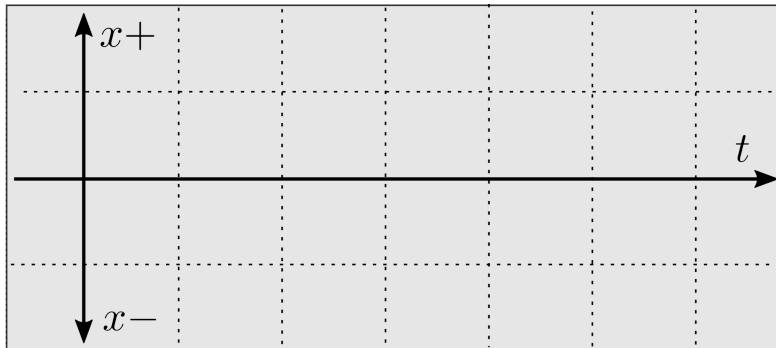
The **free response** is found as the *solution the differential equation* subject to known initial conditions with zero external forced applied.

$$m\ddot{x} + kx = 0 \quad , \quad x(0) = x_0 \quad , \quad \dot{x}(0) = v_0$$

# Free Response

# Response Equation

$$x(t) =$$





# Natural Frequency

Look at the system response subject to various initial conditions.  
What determines the amplitude and frequency of oscillation?