

Module 7 - Damping Elements

ME3050 - Dynamics Modeling and Controls

Mechanical Engineering

Tennessee Technological University

Topic 3 - Mass Spring Damper Model

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- Standard Model Form
- Engineering Applications
- Example: Automobile Suspension

Standard Model Form

The EOMs we have derived can be represented in the following standard form.

$$a_n \frac{d^n}{dt^n} x(t) + a_{n-1} \frac{d^{n-1}}{dt^{n-1}} x(t) + \dots + a_2 \frac{d^2}{dt^2} x(t) + a_1 \frac{d}{dt} x(t) + a_0 x(t) = f(t)$$

- The dependent variable x and its derivatives depend on t .
- The coefficients a_n through a_0 are functions of the physical parameters in the system.
- The function $f(t)$ is called the _____
- The system is linear if ...

Standard Model Form

In solid mechanics and dynamics the standard form of the model becomes the generalized mass spring damper model.

$$a_n x^{(n)} + a_{n-1} x^{(n-1)} + \dots + a_2 x'' + a_1 x' + a_0 x = f(t)$$

$$\rightarrow m\ddot{x} + c\dot{x} + kx = f(t) \rightarrow \mathbf{M}\ddot{\mathbf{x}} + \mathbf{C}\dot{\mathbf{x}} + \mathbf{K}\mathbf{x} = \mathbf{f}(t)$$

This is a fundamental equation that we will investigate throughout the rest of the semester.

The mass spring damper model can be applied to most mechanics problems.

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Example: Automobile Suspension



Newton's Second Law Approach

- 1 Draw a **Free Body Diagram**
- 2 Make an **assumption of motion**
- 3 Determine all **forces** acting on the system and their **directions**.
- 4 Write **Newton's second law** for the appropriate DOF.
- 5 Re-write the ODE in the **standard form** of a system equation.

Example: Automobile Suspension - Steps 1,2 and 3



Example: Automobile Suspension - Steps 4,5

