Lecture Module - 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.

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

- 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.

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

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

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

Engineering Applications

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