Mass-Spring-Damper Systems
Curriculum Module

Created with R2020b. Compatible with R2020b and later releases.

Description

This curriculum module contains interactive *live scripts* and *Simulink models* that explore mass-spring-damper systems. Students learn to create and work with mass-spring-damper models in guided activities. These techniques are motivated by two applications: tuning the damping of a vehicle's suspension and analyzing a building's response to an earthquake. Throughout the module, students apply Simulink models to study the dynamics of the physical systems. In the final lesson, students identify the resonant frequencies of a mass-spring-damper building model by computing the power spectrum of a displacement signal. These lessons can be used as part of a lecture, as activities in an instructional setting, or as interactive assignments to be completed outside of class.

Learning Goals:

- Construct free body diagrams and derive the equations of motion for mass-spring-damper systems
- Relate the mass, spring, and damper to their corresponding components in a physical system
- Create models that solve ordinary differential equations in Simulink
- Use the Symbolic Math Toolbox to help create Simulink models
- Complete Simulink mass-spring-damper models with 1, 2, and *n* degrees of freedom
- Relate parameter values to the dynamics of mass-spring-damper systems
- Tune the damping of a vehicle suspension model to meet requirements
- Identify the resonant modes of a mass-spring-damper building model

Suggested Prework

MATLAB Onramp – a free two-hour introductory tutorial that teaches the essentials of MATLAB.
Simulink Onramp – a free three-hour introductory tutorial that teaches the essentials of Simulink.

Details

`massSpringDamper.mlx`

Products: MATLAB, Symbolic Math Toolbox, Simulink
Contents: An interactive lesson that teaches how to model a single mass-spring-damper in Simulink. Students apply their knowledge to tune the damping of a vehicle's suspension system.

`doubleMassSpringDamper.mlx`

Products: MATLAB, Symbolic Math Toolbox, Simulink
Contents: An interactive lesson that teaches how to model a double mass-spring-damper in Simulink. Students apply their knowledge to identify the resonant frequencies present in a two-story building model.

`multipleMassSpringDamper.mlx`

Products: MATLAB, Symbolic Math Toolbox, Simulink
Contents: Students practice more advanced skills in this lesson, such as vectorizing a Simulink model and using the Spectrum Analyzer block to compute the power spectrum.

`massSpringDamperSoln.mlx, doubleMassSpringDamperSoln.mlx, multipleMassSpringDamperSoln.mlx`

Products: MATLAB, Symbolic Math Toolbox, Simulink
Contents: Solutions for the live script lessons.

`models/`

Products: MATLAB, Simulink
Contents: Simulink models used during the guided activities. Starter models and their completed solutions are included.