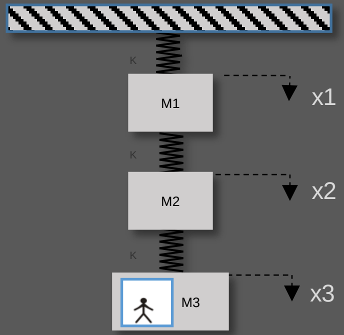
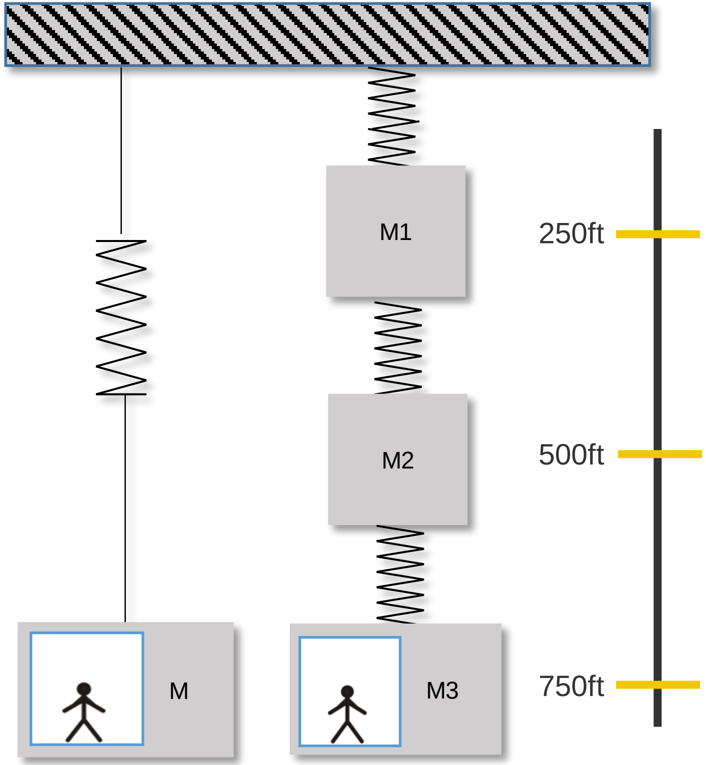
Modeling and Simulation of a highrise roped elevator hoistway using solidThinking Activate



Highrise roped elevator hoistway

Comparison of a single mass vs. a multi-mass lumped parameter model to model the dynamics of the highrised roped elevator hoistway.

A large signal command is used to illustrate the low frequency behavior and a small signal command is used to illustrate the high frequency behavior.



Objectives

- Learn how to…
  - … develop and simulate a lumped parameter model
  - … create individual signal generator commands

Creation and Simulation of an elevator hoistway

Theoretical background and how to implement it using *Activate*

Step 1: Construction of equations

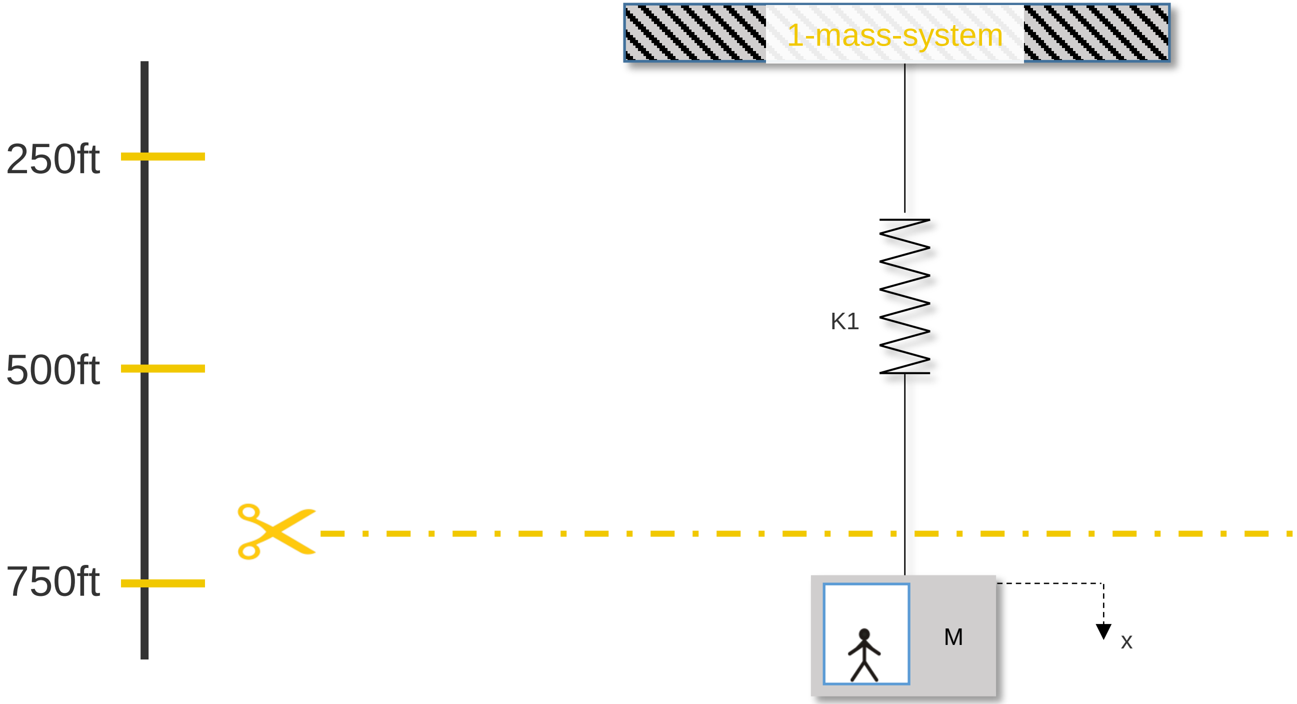
- Step 1.1: Creating subsystems
- Step 1.2: Cut-forces and application of analogies

Step 2: Implementation using *Activate*

Step 3: Validation of the results

Step 1: Construction of equations *(1-mass-system)*

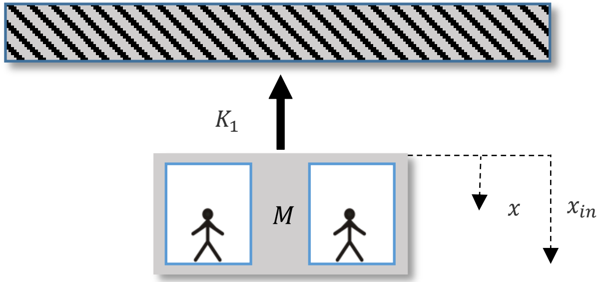
- Step 1.1: Creating subsystems *(no subsystem needed)*



Step 1 *(1-mass-system)*:

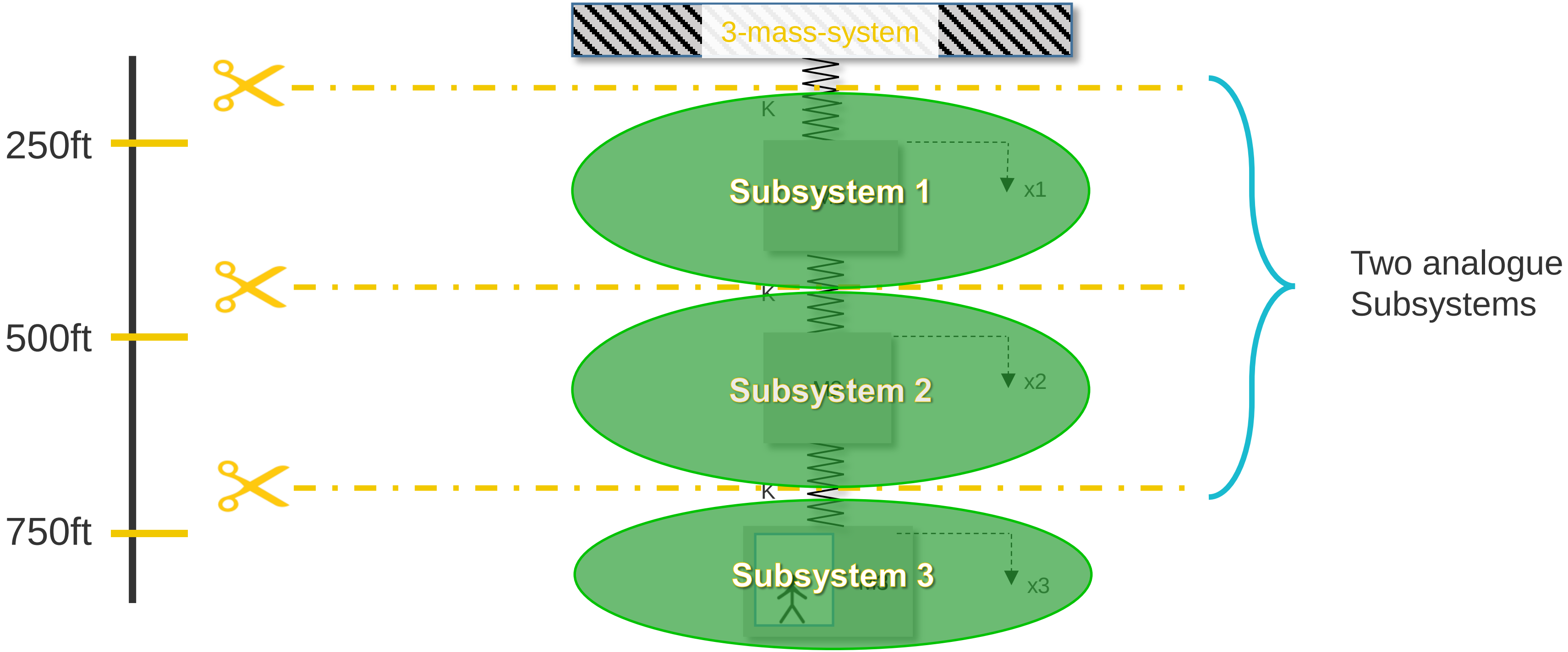
- Step 1.2: Cut-forces

- Equations:
- $M\ddot{x} = K_1(x_{in} - x)$



Step 1: Construction of equations *(3-mass-system)*

- Step 1.1: Creating subsystems

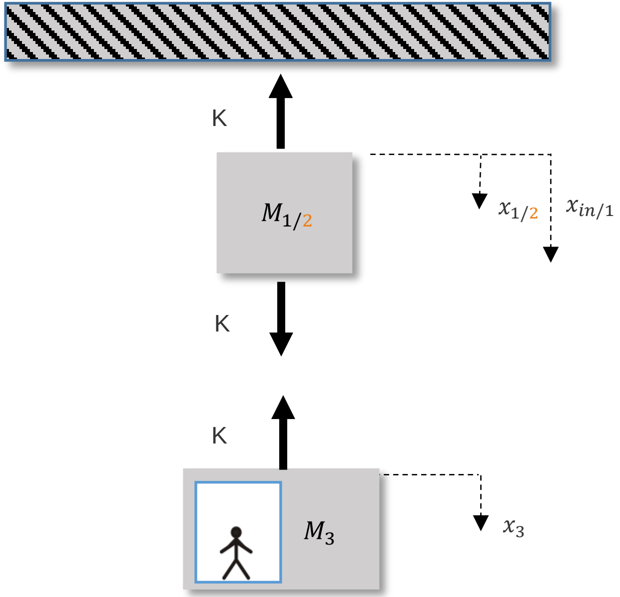


Step 1 *(3-mass-system)*:

- Step 1.2: Cut-forces and application of analogies

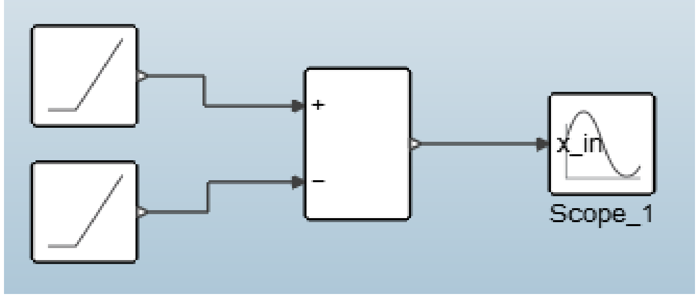
- Equations:
- Subsystem 1: $M_1\ddot{x}_1 = -Kx_2 + K(x_{in} - x_1)$
- Subsystem 2 *(Analogue 1)*: $\rightarrow M_2\,\ddot{x}_2 = -Kx_3 + K(x_1 - x_2)$

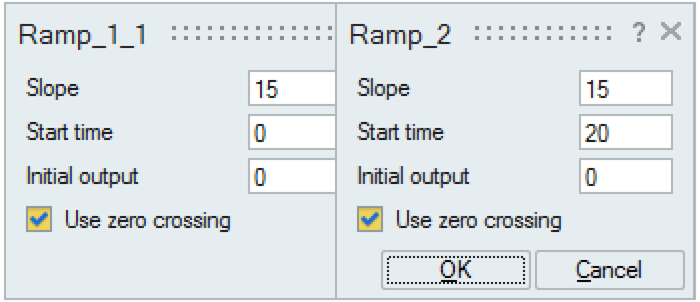
- Subsystem 3: $M_3\ddot{x}_3 = K(x_2 - x_3)$

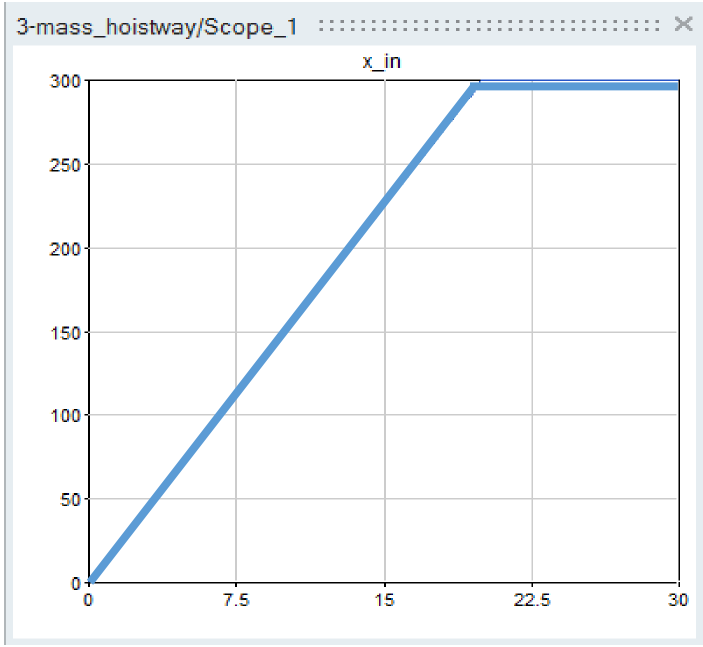


Step 2: Implementation using *Activate*

- Creating the large signal vertical position command x_{in}

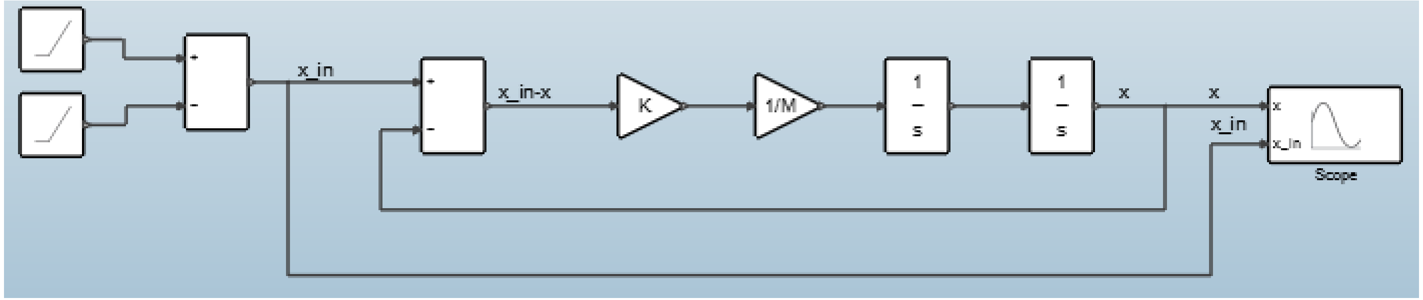






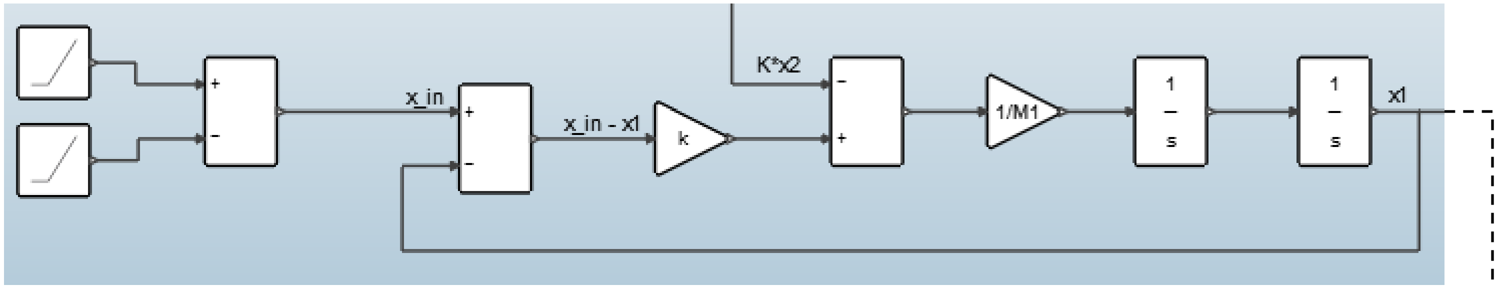
Step 2: Implementation using *Activate* *(1-mass-system)*

- $M\ddot{x} = K(x_{in} - x)$

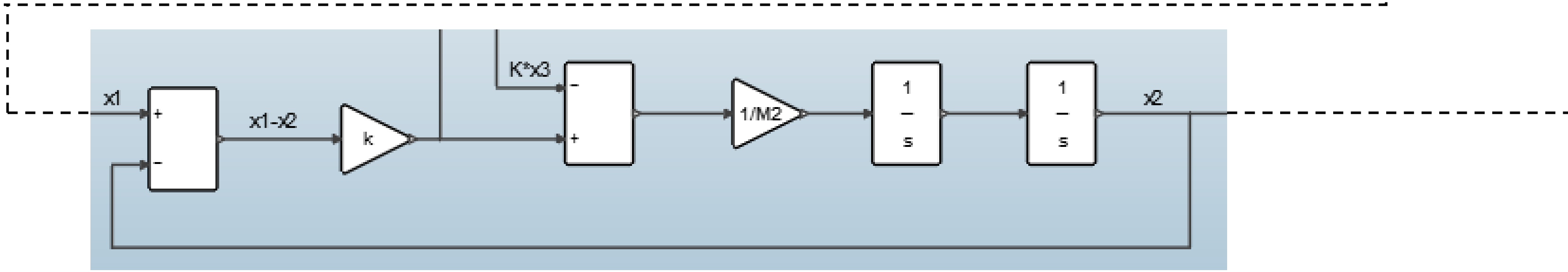


Step 2: Implementation using *Activate* (3-mass-system)

- Start with *Subsystem 1:* $M_1\ddot{x}_1 = -Kx_2 + K(x_{in} - x_1)$

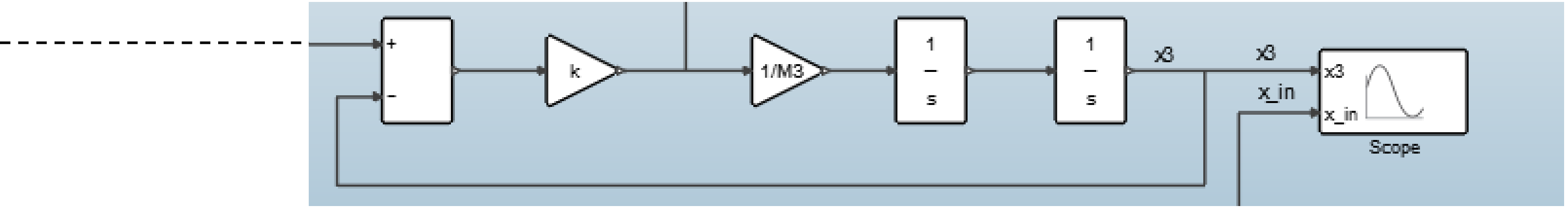


- *Add Subsystem 2:* $M_2\ddot{x}_2 = -Kx_3 + K(x_1 - x_2)$

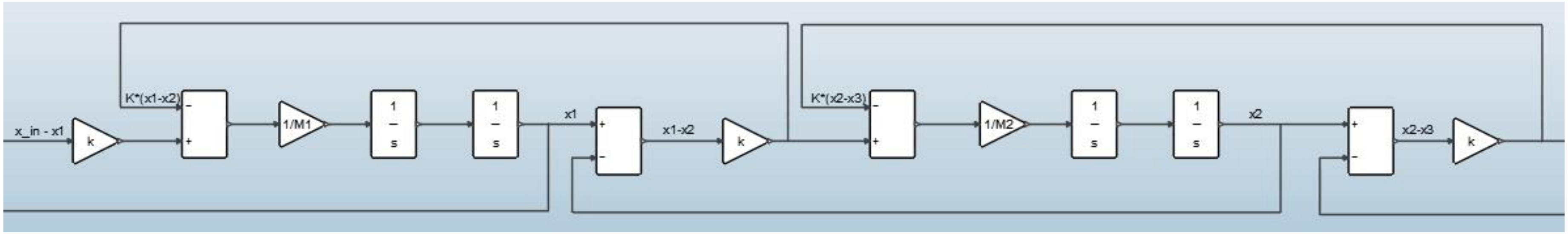


Step 2: Implementation using *Activate* (3-mass-system)

- Add *Subsystem 3*: $M_3\ddot{x}_3 = K(x_2 - x_3)$



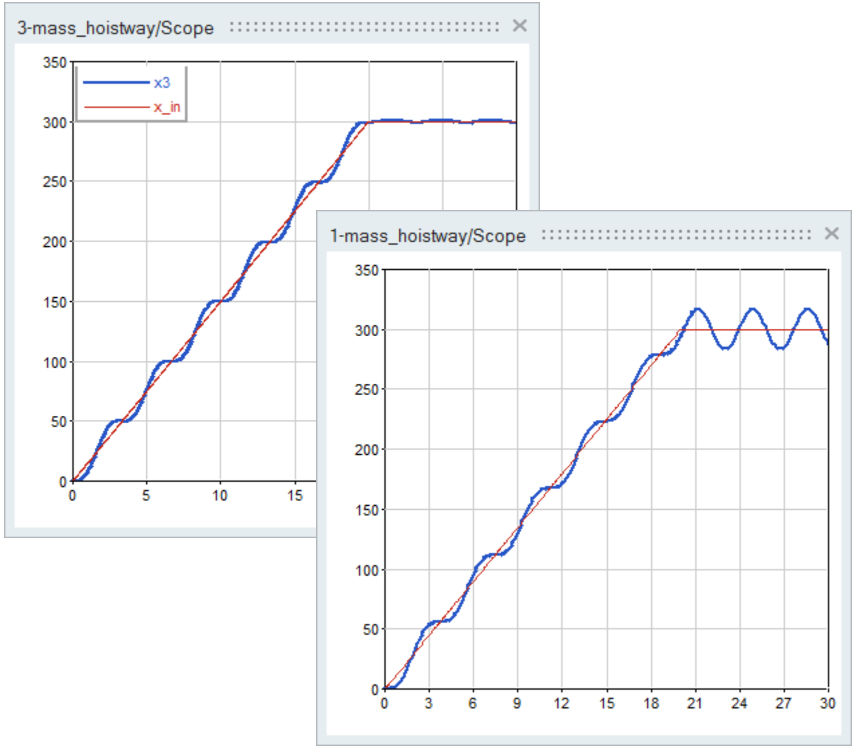
- Feedback the forces F_{K,x_2} and F_{K,x_3}: $F_{K,x_2} = -Kx_2; F_{K,x_3} = -Kx_3$



Step 3: Validation of the results

- Comparison of large signal response for both systems

- Before the ramp reaches the maximum point of 300, both systems do not differ very much in their behavior.
  - Both systems are oscillating around the input signal
  - Both systems exhibit similar low frequency behavior



Step 3: Validation of the results

- Comparison of small signal response for both systems using a step-unit input
  - When changing the input signal to a step unit, one can see the fine differences of the frequencies
  - The 1-mass-hoistway (red) is a perfect sine wave which displays the fundamental frequency of the hoistway.
  - The 3-mass-hoistway (blue) is a distorted sine wave consisting of both the fundamental frequency and higher frequencies due to the additional masses.