Karlsruher Institut für Technologie

Modeling and Simulation, Winter Term 2020/21

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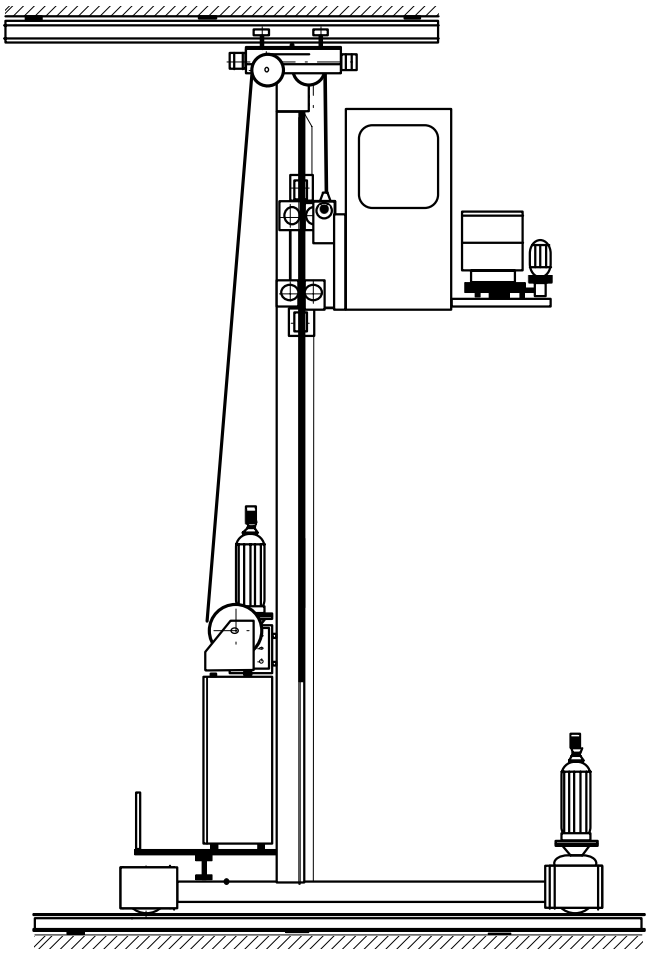
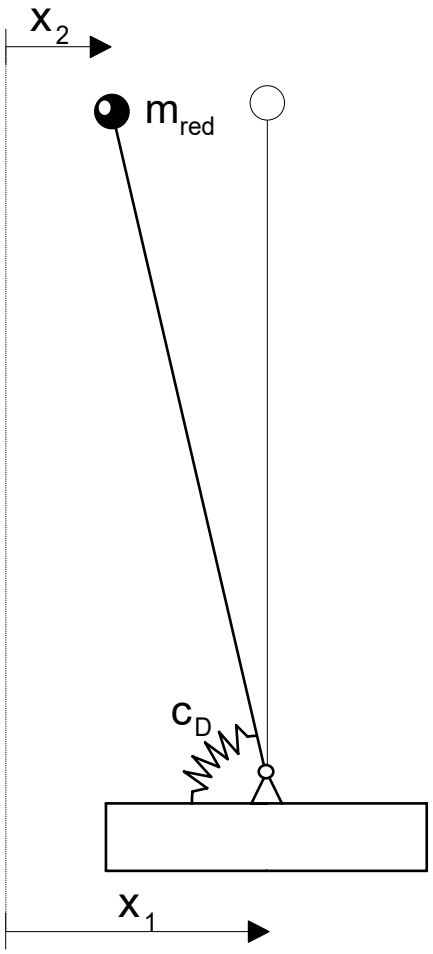
Exercise Number 13

Topic: **Verification and Validation of a Single-mass Oscillator Model of a Stacker Crane**

In the development of a new stacker crane, a lightweight construction was considered, which resulted in different parameters for the modeling.



Stacker crane [1]



Mechanical Model

Mass of lifting carriage:	m_{Hw}	$= 450\,kg$
Pay load mass:	m_L	$= 560\,kg$
Mast height:	l_M	$= 23\,m$
Equivalent spring stiffness:	c	$= 22000\,\frac{N}{m}$
Reduced mast mass:	$m_{M,red}$	$= 750\,kg$
Maximum acceleration:	a	$= 1.5\,\frac{m}{s^2}$

The stacker crane has been modeled as an undamped single-mass oscillator. It is assumed that the lift carriage can move over the entire length of the mast.

[1] Image source: Bopp W.: Untersuchung der statischen und dynamischen Positionsgenauigkeit von Einmast-Regalbediengeräten; Wissenschaftliche Berichte des Instituts für Fördertechnik, Heft 40, Karlsruhe, Juli 1993

1. Verify the model by checking the reduced mass and the respective natural angular frequency for the following extreme values (recalculate).
   a) Lifting carriage lowest position, no load
   b) Lifting carriage lowest position, maximum load
   c) Lifting carriage highest position, no load
   d) Lifting carriage highest position, maximum load

   Reduced mass:

$$m_{red,HL} = \left(\frac{x_2(y)}{x_2(l)}\right)^2 m_{HL} = \frac{1}{4}\left[3\left(\frac{y}{l}\right)^2 - (\frac{y}{l})^3\right]^2 m_{HL}$$

   with

   y = Position of the lifting carriage;

   l = Overall length of the mast;

   m_{HL} = Mass of the lifting carriage + Mass of the load

$$m_{red} = m_{red,M} + m_{red,HL}$$

   Natural angular frequency:

$$\omega = \sqrt{\frac{c}{m_{red}}}$$

   Consider whether the selected extreme values are sufficient for the verification of this model.

2. The function block `excitation` lets you select three different excitation profiles in the model.
   a) Rectangular acceleration and deceleration in fixed predetermined acceleration duration.
   b) Rectangular acceleration with optimal oscillating acceleration duration.
   c) Sine-squared shaped acceleration with optimal oscillating acceleration duration.

   You have received real measurement data of a stacker crane (Excel file). Validate your model using the given measurement data. To do so, adjust the input variables accordingly. Check the amplitudes of the oscillations during excitation and the maximum deflections, as well as the frequencies of the oscillations.

   Then write your simulation data in a separate Excel file to compare them with the real data.

   For this, use the command `writematrix` from Matlab. The measurement data will be provided by the model in the variable `w` in the workspace of Matlab.