Introduction to RIS
Spring term 2022
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Course CH-220-A
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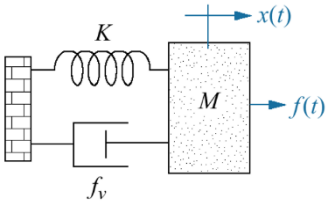
Practice Problems II - 03

Practice problems are supposed to help you digest the content of the lecture. It is important that you manage to solve them on your own. Before you write your solutions, you may of course ask questions, and discuss things. In order to prepare for the exam, already now, try to explicitly write down your solutions – clearly and easy to read. Apply definitions properly, and give explanations for what you are doing. That will help you to understand them later when you prepare for the final exam.

I. Transfer Functions



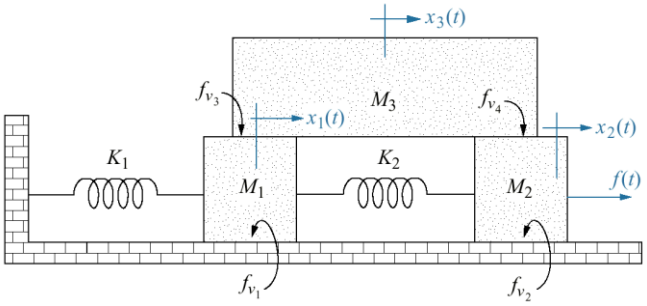
a) Write the transfer function $H(s)$ of the system shown on the left.

b) For parameter values $M = 1$ kg, $f_v = 5\frac{Ns}{m}$, and $K = 100\frac{N}{m}$ find the magnitude of $|H(j\omega)|$

c) Is there a ``resonance´´ peak? If so, find its position… where?

d) What happens for $f_v \to 0$?

II. Modeling in Frequency Domain



a) Write the frequency domain model for the system to the right. Avoid the detour through the time domain – write it directly in frequency domain and in terms of the 3 × 3 force-displacement impedance matrix **Z**(s), the displacement vector $\boldsymbol{X}(s)$, and the force vector $\boldsymbol{F}(s)$:

$$\boldsymbol{Z} \cdot \begin{pmatrix} X_1(s) \\ X_2(s) \\ X_3(s) \end{pmatrix} = \begin{pmatrix} F_1(s) \\ F_2(s) \\ F_3(s) \end{pmatrix}$$

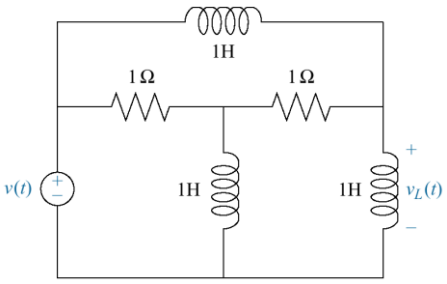
Do not get confused, here: $F_1(s)$ and $F_3(s)$ are zero in our case.

b) You can use Matlab's symbolic toolbox in order to invert the equation from above:

$$\begin{pmatrix} X_1(s) \\ X_2(s) \\ X_3(s) \end{pmatrix} = \boldsymbol{Z}^{-1} \begin{pmatrix} F_1(s) \\ F_2(s) \\ F_3(s) \end{pmatrix} = \boldsymbol{T} \begin{pmatrix} F_1(s) \\ F_2(s) \\ F_3(s) \end{pmatrix}$$

In our case, we have $F_1(s) = 0$, and $F_3(s) = 0$. Hence, $X_1(s) = T_{12}(s)F_2(s)$, and $X_2(s) = T_{22}(s)F_2(s)$. Find these factors $T_{12}(s)$, and $T_{22}(s)$ from the matrix $\boldsymbol{T}$, above.

III. Modeling in Frequency Domain



Write the frequency domain model for the system to the right. Avoid the detour through the time domain – write it directly in frequency domain and in terms of the 3 × 3 voltage-current impedance matrix $\boldsymbol{Z}(s)$, the displacement vector $\boldsymbol{I}(s)$, and the voltage-source vector $\boldsymbol{V}(s)$:

$$\boldsymbol{Z} \cdot \begin{pmatrix} \mathrm{I}_1(\boldsymbol{s}) \\ I_2(\boldsymbol{s}) \\ I_3(\boldsymbol{s}) \end{pmatrix} = \begin{pmatrix} V_1(\boldsymbol{s}) \\ V_2(\boldsymbol{s}) \\ V_3(\boldsymbol{s}) \end{pmatrix}$$

Mind: Before you write anything, think about the meshes you want to consider, and draw their orientation … you don't want to get confused later on.