Challenge Deliverable 3
Answer form

4DB00 Dynamics and Control of mechanical systems
2019-2020

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Be aware of the TU/e Code of Scientific conduct. See: https://www.tue.nl/en/our-university/about-the-university/organization/integrity/scientific-integrity/.

Question a):

Consider the undamped response of the system (i.e. you may assume that $\underline{D} = 0$) in order to determine the eigenfrequencies ω_1 and ω_2, with $\omega_1 \leq \omega_2$, of the system.

$\omega_1 = 0$ [rad/s]

$\omega_2 = 1.4007$ [rad/s]

Question b):

Excite the "virtual test setup" with the input signal $F_A(t) = 1500\sin(\omega_2 t)$, by utilizing the "Sim_Setup" request within the DOMS toolbox. Use the simulation conditions as described in the deliverable and add the requested plots here.

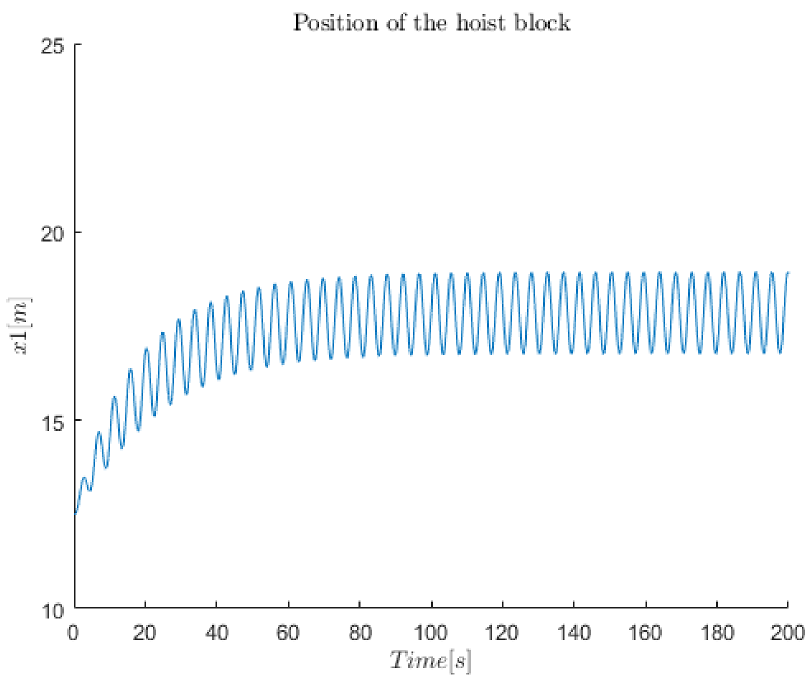

Figure 1: Time response of the position of the hoist block with an input signal $F_A(t) = 1500\, sin(\omega_2 t)$

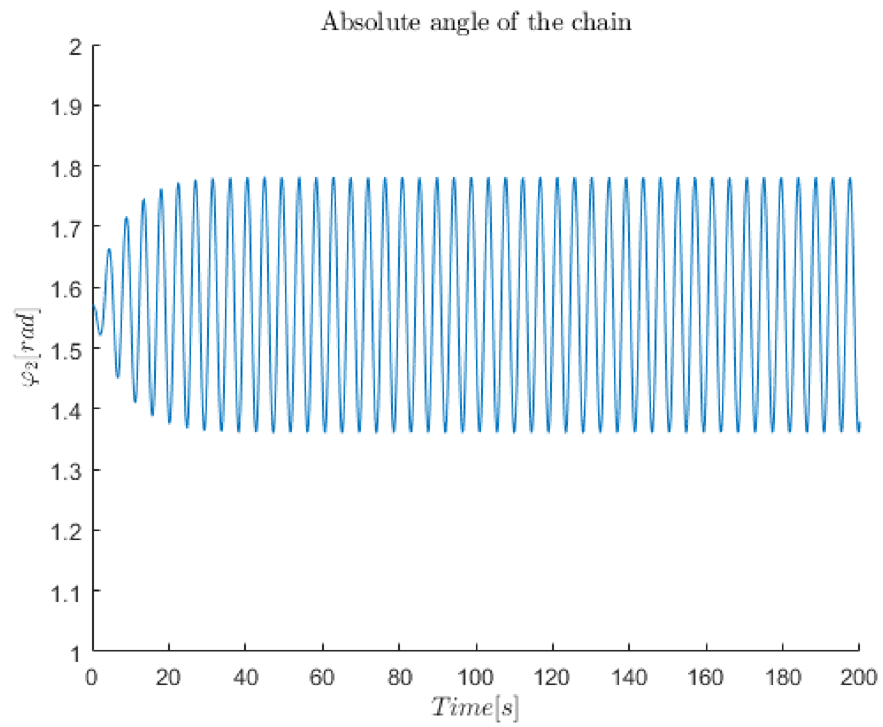

Figure 2: Time response of the angle of the chain with an input signal $F_A(t) = 1500\, sin(\omega_2 t)$

Question c):

Repeat this simulation experiment with the input signal $F_A(t) = 1500\sin(0.7 \cdot \omega_2 t)$ and the input signal $F_A(t) = 1500\sin(1.3 \cdot \omega_2 t)$. After the initialization of the experiment (i.e. for $t \geq 100$ s), do you observe a difference between the amplification of these sinusoidal input signals and the input signal considered in question b? If so, can you explain this difference?

$F_A(t) = 1500\sin(0.7 \cdot \omega_2 t)$

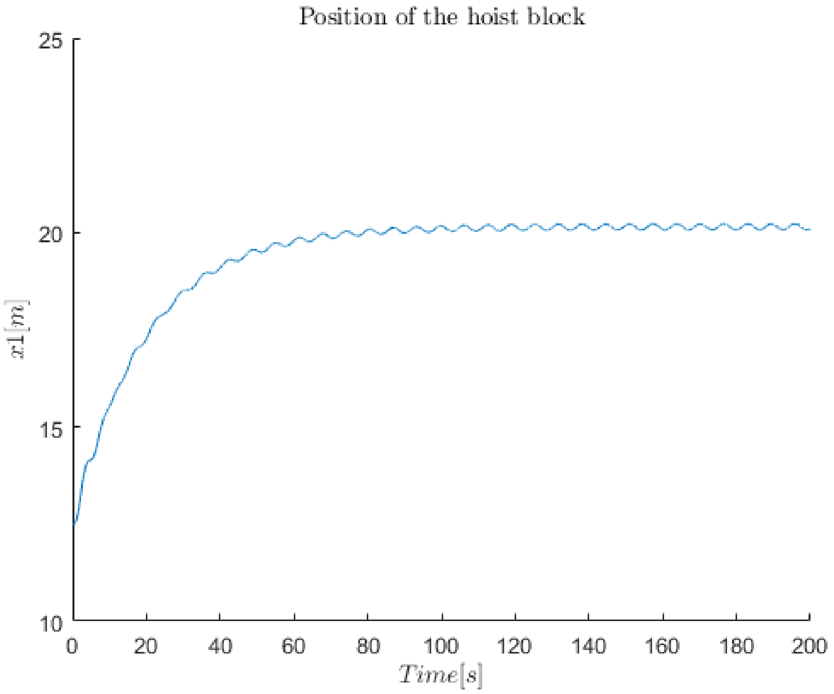

Figure 3: Time response of the position of the hoist block with an input signal $F_A(t) = 1500\,sin(0.7\omega_2 t)$

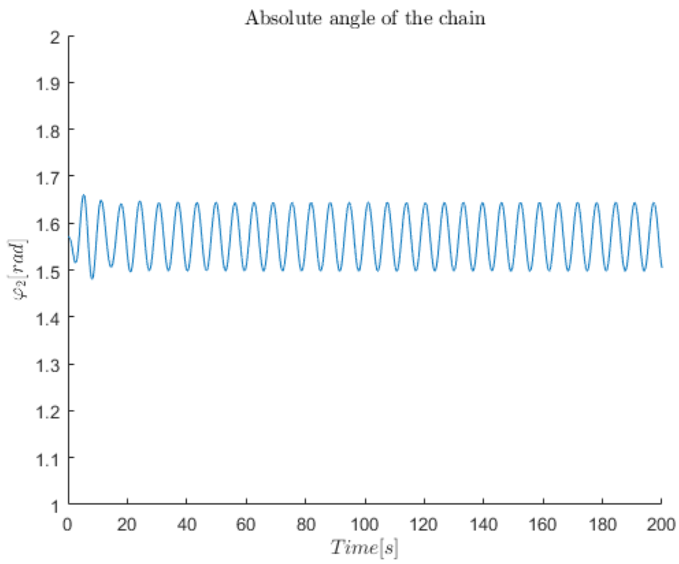

Figure 4: Time response of the angle of the chain with an input signal $F_A(t) = 1500\,sin(0.7\omega_2 t)$

$F_A(t) = 1500\sin(1.3\cdot\omega_2 t)$

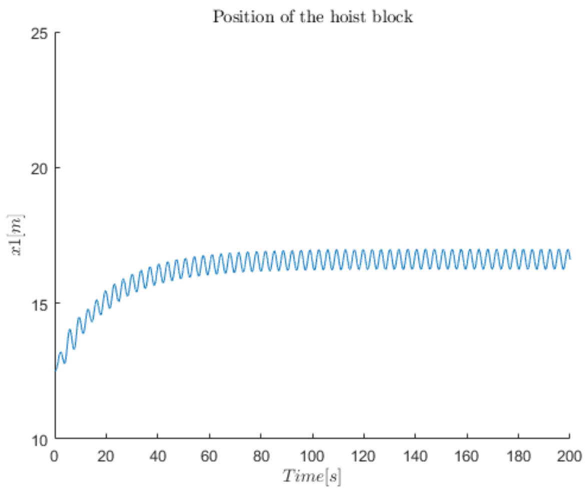

Figure 5: Time response of the position of the hoist block with an input signal $F_A(t) = 1500\,sin(1.3\omega_2 t)$

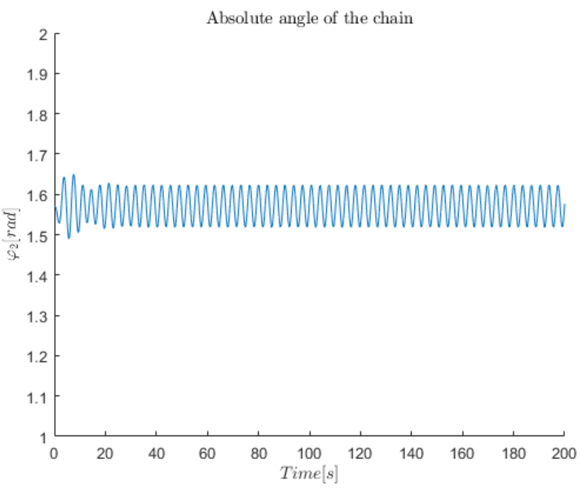

Figure 6: Time response of the angle of the chain with an input signal $F_A(t) = 1500\,sin(1.3\omega_2 t)$

Explanation

There is indeed a difference in amplitude visible between both frequencies plotted in this question compared to the plots in the previous question. This can be easilly explained by the fact that ω_2 is the eigenfrequency, thus the system resonates when exitated at a frequency that equals (one of) the eigenfrequencies. One can see this resonance effect clearly when plotting trajectories of an exitation that is not at a eigenfrequency (e.g. $0.7\omega_2$ and $1.3\omega_2$, as done in this question). For T>100, when the system “settled”, the amplitudes are indeed far lower at these frequencies compared to ω_2.

Question d):

Compute the transfer functions $G_1(s)$ and $G_2(s)$, by utilizing the "Make_tf" request and by providing the linear equations of motion to the DOMS toolbox. Add the bode diagrams of these transfer functions here.

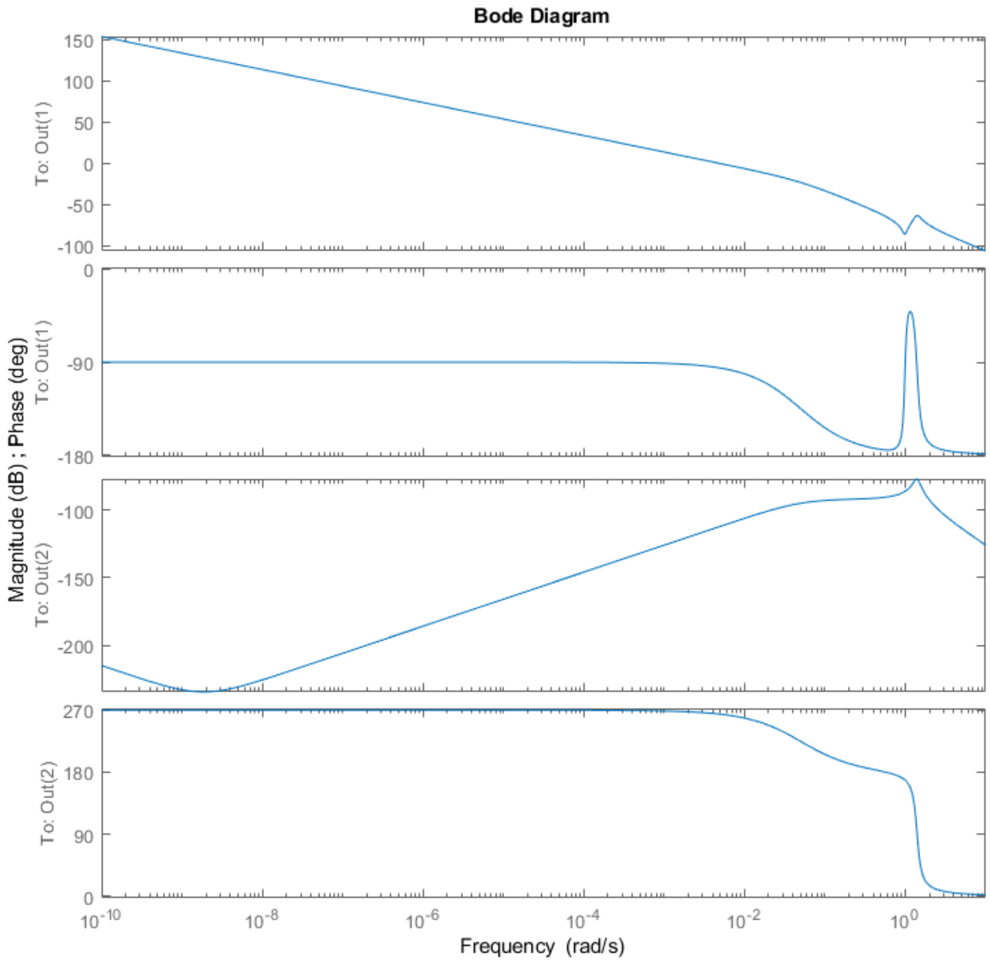

Figure 7: Bode plots of $G_1(s)$ and $G_2(s)$ at the top two and bottom two respectively

Question e):

Determine the gains $|G_1(j\omega_2)|$ and $|G_2(j\omega_2)|$. Are these values similar to the amplification that you observed in question b? **(Do not forget to include units)**

$|G_1(j\omega_2)| = 0.7209 \times 10^{-3}$ (**not** in dB)

$|G_2(j\omega_2)| = 0.1427 \times 10^{-3}$ (**not** in dB)

Comparison

$|G_1(j\omega_2)| \times 1500\ [N] = 1.08135$ (**not** in dB)

$|G_2(j\omega_2)| \times 1500\ [N] = 0.21405$ (**not** in dB)

These values are similar to the amplifications found in the plots of question b). The plot in figure 1 has indeed an amplitude of about 1.1 (see $|G_1(j\omega_2)| \times 1500\ [N]$) and the plot in figure 2 has indeed an amplitude of about 0.2 (see $|G_2(j\omega_2)| \times 1500\ [N]$).

Question f):

Express $G_l(s)$ in terms of the variables $G_1(s)$, $G_2(s)$ and the system parameters.

$G_l(s) = G_1(s) + L_2 G_2(s)$

Question g):

Add the bode diagram for $G_l(s)$ here.

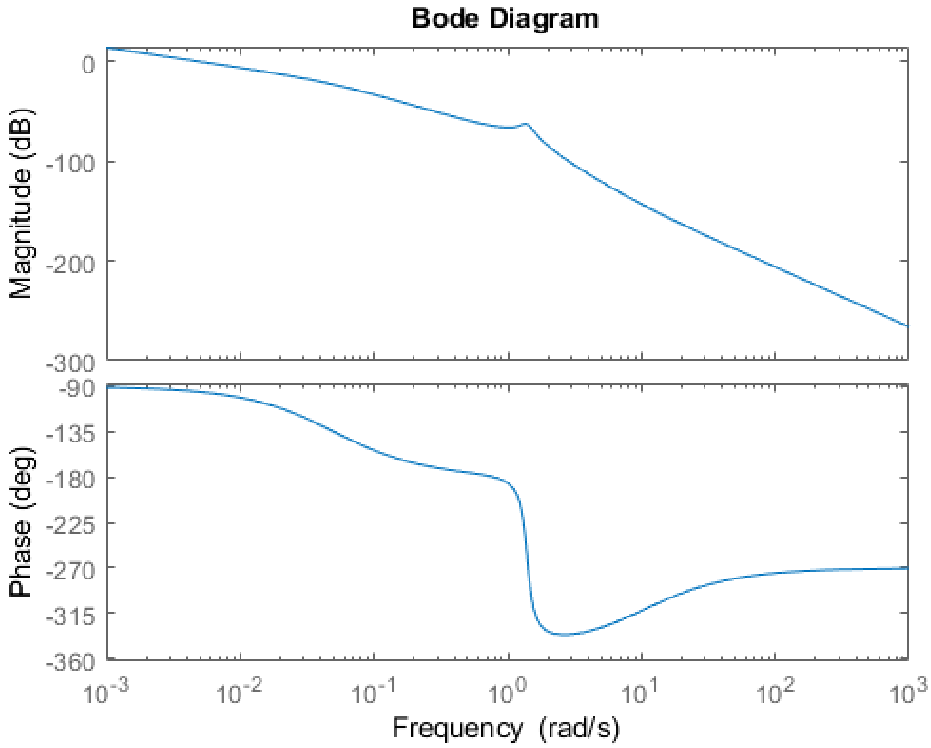

Figure 8: Bode plot of $G_l(s)$.