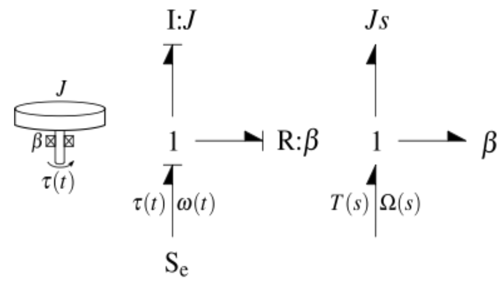
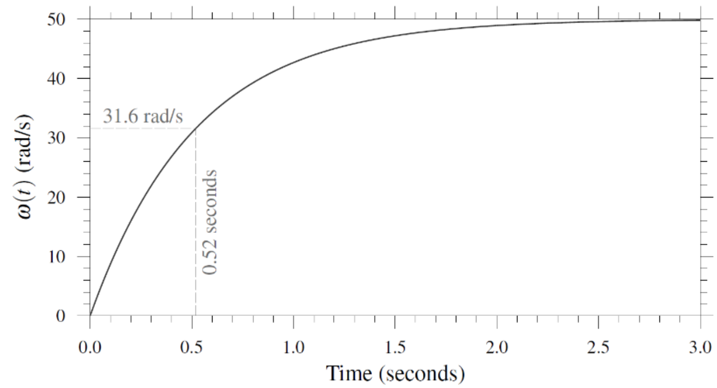
Example 7.1

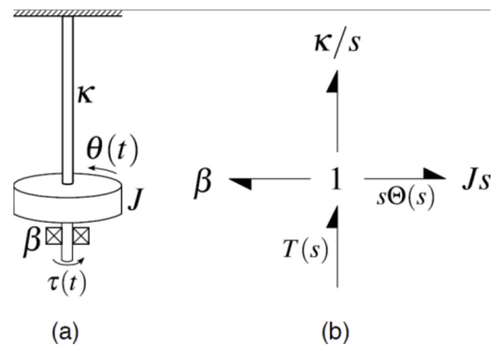


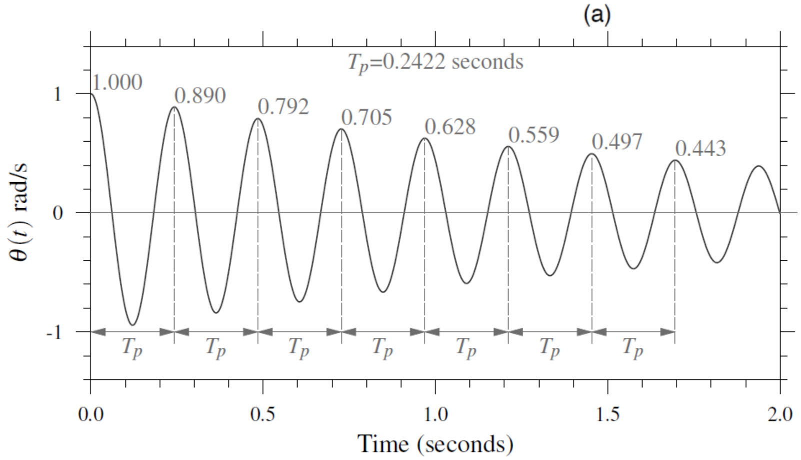
A simple torsion system is depicted. It is a disk mounted on a bearing and is excited by an input torque. The rotational inertia can be readily attained by measuring the mass and diameter of the disk. The bearing damping coefficient, on the other hand, is not something that is commonly advertised or supplied. However, this can be readily determined using experimental data and a model of the system. Given the measured step response plotted in the following figure, what are the rotational inertia, J, and damping coefficient, β?



Example 7.2

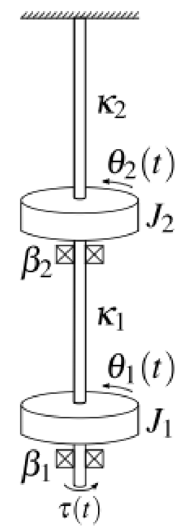
Given the natural response, how could you determine the damping coefficient, β, and the shaft rigidity, κ? The disk is the same as from Example 1.





Example 7.3

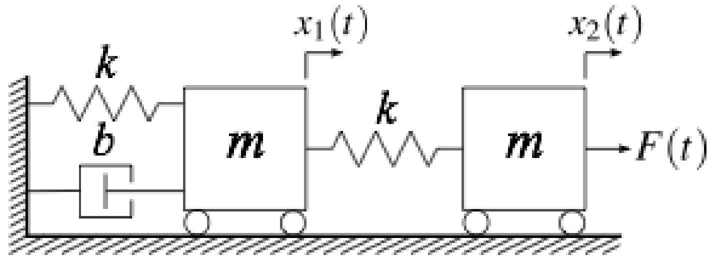
A two-disk system is depicted, and the system parameters are provided in Table 7.1 in your textbook. Determine the lower-order components that contribute to the overall responses $\Theta_1(t)$ and $\Theta_2(t)$. Plot and compare the individual contributions to the overall responses.



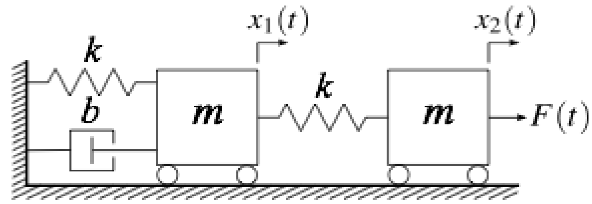
(a)

Example 7.4

Determine the dominant pole of the system.



Example 7.5

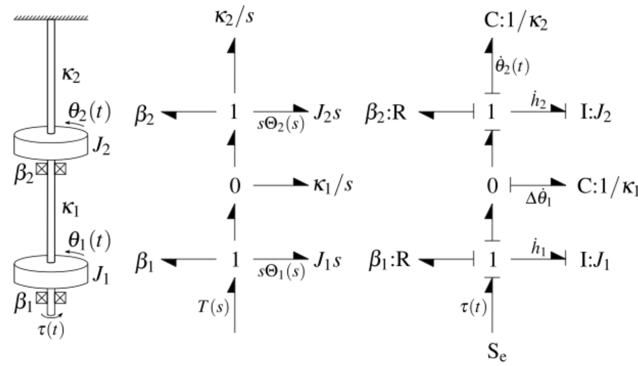


Recall that the state-space model of the mass-spring-damper system in Example 7.4. For this problem, we only require the second displacement, $x_2(t)$. The following matrices compose the state-space model.

$$A = \begin{bmatrix} 0 & 1/m & 0 & 0 \\ -k & -b/m & k & 0 \\ 0 & -1/m & 0 & 1/m \\ 0 & 0 & -k & 0 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}, \quad C = [1 \quad 0 \quad 1 \quad 0], \quad \text{and } D = 0$$

Example 7.6

Given the two-disk torsion system from Example 7.3, find the angular displacements at steady-state for a constant input torque.



$$\begin{bmatrix} \dot{h}_1 \\ \Delta\dot{\theta}_1 \\ \dot{h}_2 \\ \dot{\theta}_2 \end{bmatrix} = \begin{bmatrix} -\beta_1/J_1 & -\kappa_1 & 0 & 0 \\ 1/J_1 & 0 & -1/J_2 & 0 \\ 0 & \kappa_1 & -\beta_2/J_2 & -\kappa_2 \\ 0 & 0 & 1/J_2 & 0 \end{bmatrix} \begin{bmatrix} h_1 \\ \Delta\theta_1 \\ h_2 \\ \theta_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tau(t) \quad \text{and} \quad \begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} h_1 \\ \Delta\theta_1 \\ h_2 \\ \theta_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix} \tau(t)$$