Consider the block diagram in Figure CP2.6.
(a) Use an m-file to reduce the block diagram in Figure CP2.6, and compute the closed-loop transfer function.
(b) Generate a pole-zero map of the closed-loop transfer function in graphical form using the pzmap function.
(c) Determine explicitly the poles and zeros of the closed-loop transfer function using the pole and zero function.

A system has a transfer function
\[ X(s) = \frac{15s + 2}{s^2 + 2s + 15} \]
\[ R(s) = \frac{1}{s^2} \]
Plot the response of the system when \( R(s) \) is a unit step for the parameter \( \tau = 3, 6, \text{ and } 12 \).

**FIGURE CP2.6** A multiple-loop feedback control system block diagram.

Consider the feedback control system in Figure CP2.9, where
\[ G(s) = \frac{s + 1}{s + 2} \quad \text{and} \quad H(s) = \frac{1}{s + 1}. \]
(a) Using an m-file, determine the closed-loop transfer function.
(b) Obtain the pole-zero map using the pzmap function. Where are the closed-loop system poles and zeros?
(c) Are there any pole-zero cancellations? If so, use the minreal function to cancel common poles and zeros in the closed-loop transfer function.
(d) Why is it important to cancel common poles and zeros in the transfer function?

**FIGURE CP2.9** Control system with nonunity feedback.
CP3.4 Consider the system
\[
\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u, \\
y = [1 \ 0 \ 0] x.
\]
(a) Using the \texttt{tf} function, determine the transfer function \(Y(s)/U(s)\).
(b) Plot the response of the system to the initial condition \(x(0) = [0 \ -1 \ 1]^T\) for \(0 \leq t \leq 10\).
(c) Compute the state transition matrix using the \texttt{expm} function, and determine \(x(t)\) at \(t = 10\) for the initial condition given in part (b). Compare the result with the system response obtained in part (b).

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CP3.6 Consider the closed-loop control system in Figure CP3.6.

(a) Determine a state variable representation of the controller.
(b) Repeat part (a) for the process.
(c) With the controller and process in state variable form, use the series and feedback functions to compute a closed-loop system representation in state variable form and plot the closed-loop system impulse response.

![Diagram of closed-loop control system]

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CP3.7 Consider the following system:
\[
\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \end{bmatrix} u, \\
y = [1 \ 0] x
\]  
with
\[
x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}
\]
Using the \texttt{lsim} function obtain and plot the system response (for \(x_1(t)\) and \(x_2(t)\)) when \(u(t) = 0\).