1. Given the following transfer function implementing a third-order low-pass filter

\[ H(s) = \frac{K}{(s + \omega_c)(s^2 + \sqrt{2} \omega_c s + \omega_c^2)} \]

(a) realize the filter using the canonical form (Direct Form II).
(b) choose a value for \( K \), expressed in dB, so that the DC gain of the filter is unity when the cutoff frequency is 240Hz.
(c) is the above value for \( K \) practical?

2. Given the following block diagram,

(a) determine the overall transfer function
(b) convert the block diagram into a signal flow graph

3. Given the following signal flow graph
(a) determine the overall transfer function
(b) convert the signal flow graph to a block diagram

4. Convert the following linear differential equation into a state equation

\[ 2y''' + 4y'' + y' + 10y = x \]
\[ y(0^-) = 4 \]
\[ y'(0^-) = 1 \]
\[ y''(0^-) = 0 \]

(a) determine its state equation description
(b) suppose \( x(t) = u(t) \), determine the total solution to the state equation in the Laplace domain using Matlab

5. Given the following circuit from ps0 assuming zero-state,

\[ x(t) \]
\[ V_C \]
\[ C \]
\[ L \]
\[ i_L \]
\[ R \]
\[ y(t) \]

(a) determine its state equation description (be sure to identify the states in the context of the circuit)
(b) suppose \( x(t) = (1 - e^{-2t})u(t) \), determine the solution to the state equation in the Laplace domain, and in the time domain using Matlab

6. Given the following transfer function,

\[ H(s) = \frac{100s}{s^2 + 4s + 20} \]

(a) realize the filter using the canonical form (Direct Form II).
(b) determine its state equation description
(c) suppose \( x(t) = 2u(t) \), determine the solution to the state equation in the Laplace domain, and in the time domain using Matlab
7. Reconsider the systems in problems 1-6 above, determine if each system is internally stable, or if not possible, if it is BIBO (externally) stable.
   
   (a) Problem 1
   (b) Problem 2
   (c) Problem 3
   (d) Problem 4
   (e) Problem 5
   (f) Problem 6

8. Given the following transfer function,
   
   \[ H(s) = \frac{100}{s^2 + 8s + 41} \]

   (a) convert the transfer function to a frequency response in terms of the magnitude and phase
   (b) sketch the asymptotic approximation of the Bode plot for each component of the frequency response
   (c) for what range of frequencies is the gain below unity?

9. Consider the open-loop Bode plot below (from the specification sheet of a Philips 741 op-amp)
(a) estimate the DC gain
(b) determine a plausible candidate transfer function modeling the op-amp
(c) using Matlab plot the frequency response from part b). How does it compare to the one above?