Reading Assignments:

Shinners: Chapter 2 and Chapter 3 (Background Reading: Chapter 1).

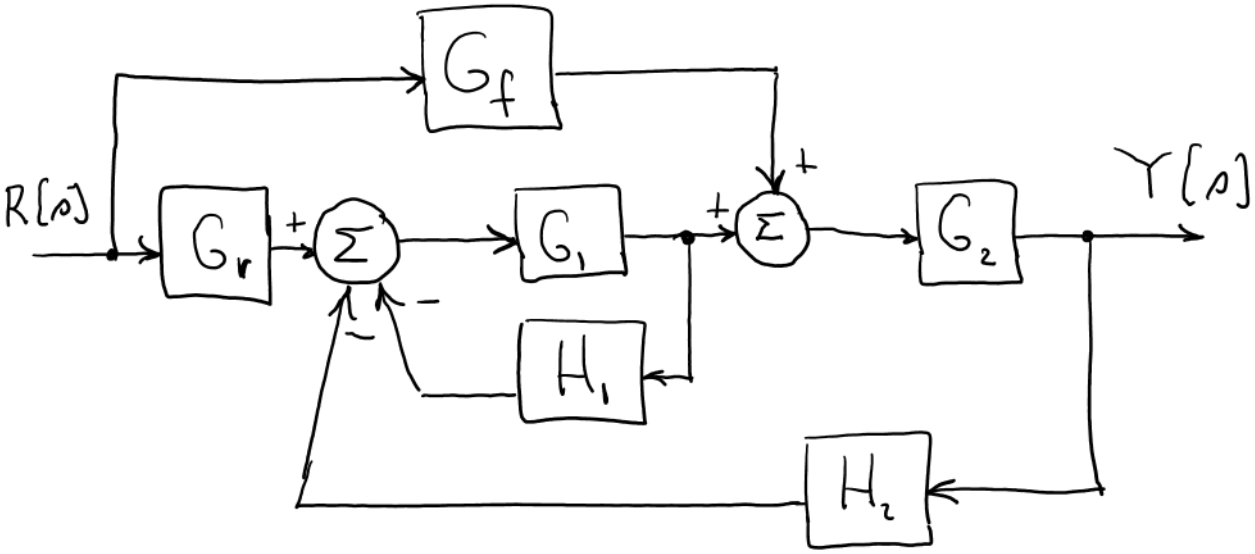
Doyle, Francis, and Tannenbaum: Chapter 1 and Chapter 2.

Please enter your answers using the D2L Quiz for Homework #2.

1. Suppose a system is governed by the following differential equation. Linearize this system about
   a. $\theta = 0$ radians,
   b. $\theta = \frac{\pi}{4}$ radians,
   c. $\theta = \pi$ radians.

$$\dot{\theta}(t) = \sin\big(\theta(t)\big) + u(t)$$

2. Find the transfer function between $R[s]$ and $Y[s]$ in the given block diagram.



3. For the given set of equations,
   a. Draw an all-integrator block diagram for equation (2),
   b. Starting with the all-integrator block diagram from Part (a), incorporate equation (1) into an all-integrator block diagram that consists of two integrators,
   c. Using the block diagram from Part (b), create an all-integrator block diagram that relates $u(t), x_1(t),$ and $x_2(t)$ with $y(t)$, where $y(t)$ obeys the linear relationship in equation (3).

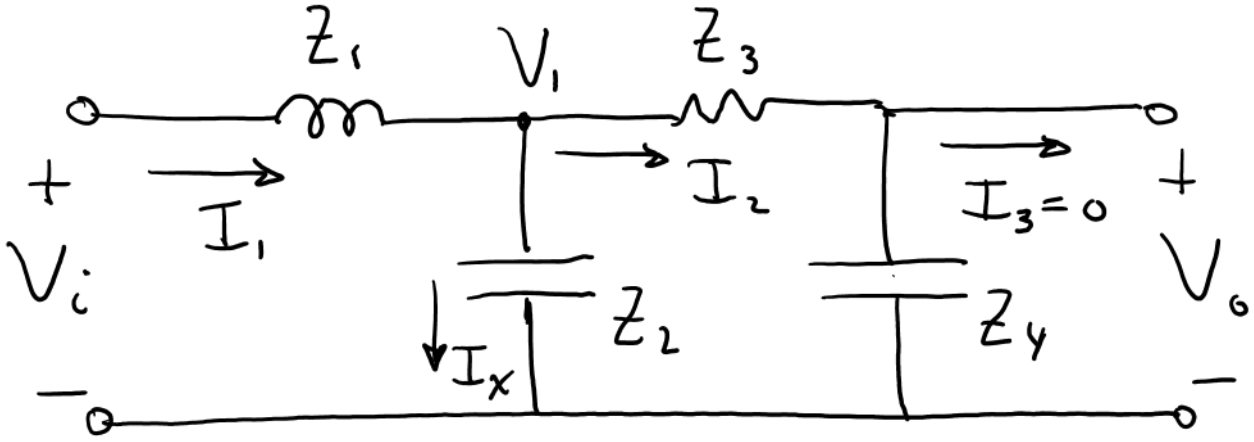
d. Use the block diagram from Part (c) to find the transfer function between $u(t)$ and $y(t)$.

$$x_1'(t) = -x_1(t) + 4x_2(t) + u(t) \quad (1)$$

$$x_2'(t) = -5x_2(t) + 2x_1(t) \quad (2)$$

$$y(t) = 3x_1(t) + 7x_2(t) \quad (3)$$

4. Consider the following RLC ladder network. Refer to Problem I2.23 in the Shinner's textbook for a strategy.
   a. (a) Use Ohm's Law at Z_1, Z_2, Z_3, and Z_4 and Kirchhoff's Current Law (KCL) at node 1 to find equations relating V_i, V_1, V_o, I_1, and I_2.
   b. Draw a block diagram or a signal flow graph to interconnect your equations from Part (a).
   c. Use your block diagram from Part (b) to find the transfer function between V_i and V_o.



5. Consider a DC motor that is to be modelled as a first-order transfer function. Suppose an input voltage of 4V applied to the DC motor at time zero gives rise to a rotational speed of 20 radians/second at one second and a steady-state rotational speed of 100 radians/second. Find the values of K and τ in the following first-order transfer function.

$$\omega[s] = \frac{K}{\tau s + 1} V[s],$$

where

$$G[s] = \frac{K}{\tau s + 1}.$$