Read: Sections 9.7.

Problems:

- Derive the closed-loop transfer function, \( \frac{Y(s)}{R(s)} \), for the system given in Fig. 1. If \( P_1(s) = \frac{1}{s} \), \( P_2(s) = \frac{1}{s} \), and \( K(s) = 1 \), use whatever method you like to find the steady-state output to a step input.

![Block diagram](image)

**Problem 2:** Sketch the asymptotes of the Bode plot magnitude and phase for the following transfer functions. After completing the hand sketches, verify using the Matlab commands `tf` and `bode`, or using the GUI for asymptotic bode plots linked on the course website. Turn in your hand sketches and the Matlab results on the same scales.

(a) 
\[
G(s) = \frac{1}{s^2 + 2s + 10}
\]

(b) 
\[
G(s) = \frac{1}{s - 10}
\]

**Problem 3:** Consider the system whose transfer function is
This is a model of a tuned circuit with quality factor $Q$.

(a) Compute the magnitude and phase of the transfer function analytically, and plot them for $Q = 0.5, 1, 2,$ and $5$ as a function of normalized frequency $\omega/\omega_0$; use $A_0 = 1$.

(b) Define the bandwidth as the distance between the frequencies on either side of $\omega_0$ where the magnitude drops to 3 dB below its value at $\omega_0$, and show that the bandwidth is given by

$$BW = \frac{1}{2\pi} \left( \frac{\omega_0}{Q} \right).$$