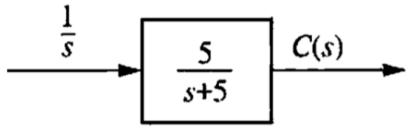
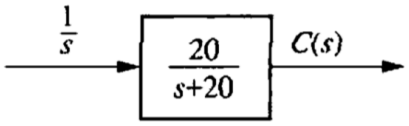
**BME 444**
**HW 4 - Due Mar 2, 2024 Midnight**

1. For each of the systems shown below, find (1) $c(t)$, (2) the time constant, (3) rise time, and (4) settling time.




(a)




(b)

2. For each of the transfer functions shown below, do the following:
   A. Plot the poles and zeroes on the s-plane (complex plane)
   B. Write an expression for the *general* form of the step response
   C. State the type of each response (overdamped, underdamped, etc.)

**a.** $T(s) = \dfrac{2}{s+2}$

**b.** $T(s) = \dfrac{5}{(s+3)(s+6)}$

**c.** $T(s) = \dfrac{10(s+7)}{(s+10)(s+20)}$

**d.** $T(s) = \dfrac{20}{s^2+6s+144}$

**e.** $T(s) = \dfrac{s+2}{s^2+9}$

**f.** $T(s) = \dfrac{(s+5)}{(s+10)^2}$

3. Find the poles of the transfer function

$$G(s) = \frac{s^2+2s+2}{s^4+6s^3+4s^2+7s+2}$$

4. For each transfer function shown below find $\zeta$, $\omega_n$, $T_s$, $T_p$, $T_r$, and $\%OS$.

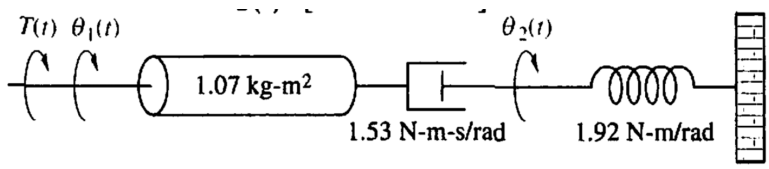
$$\textbf{a.}\quad T(s) = \frac{16}{s^2 + 3s + 16}$$

$$\textbf{b.}\quad T(s) = \frac{0.04}{s^2 + 0.02s + 0.04}$$

$$\textbf{c.}\quad T(s) = \frac{1.05 \times 10^7}{s^2 + 1.6 \times 10^3 s + 1.05 \times 10^7}$$

5. Find the transfer function of a second-order system that yields a 12.3% overshoot and a settling time of 1 second.

6. For the system shown below, a step torque is applied at $\theta_1(t)$. Find
   A. The transfer function $G(s) = \theta_2(s)/T(s)$.
   B. The percent overshoot, settling time, and peak time for $\theta_2(t)$.




7. Anesthesia induces muscle relaxation (paralysis) an unconsciousness in the patient. Muscle relaxation can be monitored using electromyogram signals from nerves in the hand; unconsciousness can be monitored using the cardiovascular system's mean arterial pressure. The anesthetic drugs is a mixture of isoflurane and atracurium. An approximate model relating muscle relaxation to the percent isoflurane in the mixture is

$$\frac{P(s)}{U(s)} = \frac{7.63 \times 10^{-2}}{s^2 + 1.15s + 0.28}$$

where $P(s)$ is muscle relaxation measured as a fraction of total paralysis (i.e., it has a value between 0 and 1) and $U(s)$ is the percent mixture of isoflurane.
   A. Find the damping ratio and the natural frequency of the paralysis transient response.
   B. Find the maximum possible percent paralysis if a 2% mixture of isoflurane is used.
   C. Plot the step response of paralysis if a 1% mixture of isoflurane is used.
   D. What percent isoflurane would have to be used for 100% paralysis.

8. Find $J$ and $K$ in the rotational system shown below to yield a 30% overshoot and a settling time of 3 seconds for a step input in torque.