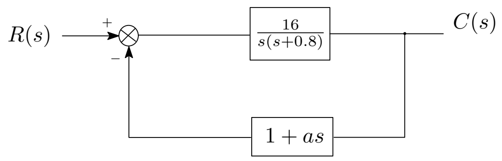
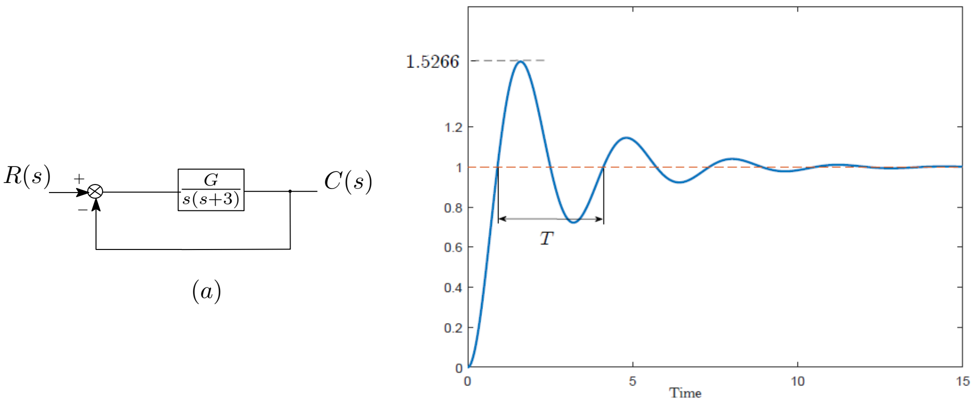
Tutorial & Homework #4 Due: 6 September 2018

1. Consider the system shown in figure below. Determine the value of a such that the damping ratio is 0.5. Also obtain the rise time T_r and the maximum overshoot M_p in its step response.



2. The block diagram of a feedback system is shown in figure (a). Find the transfer function of the system. Find the value of G so that the closed loop response for a step input is shown in figure (b). Find the value of T.

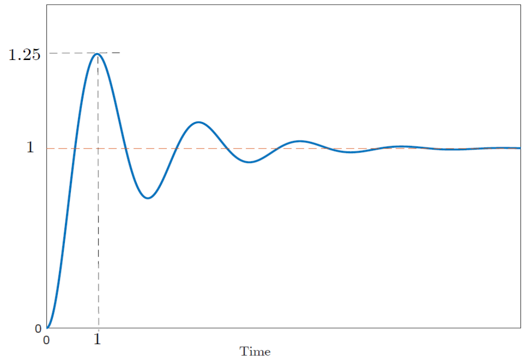


(a)

(b)

3. The design specification for the output response to step input for a second order system are as follows. The output response is critically damped with a 3.3579 second rise time. Find the transfer function of the system and compute the settling time.

4. The unit step response to a closed loop system (with feedback gain equal to -1) is shown in the figure below. Find ξ, ω_n, T_r, T_p, T_s %OS. Find the open loop and closed loop transfer functions. Find the time at which second peak occurs. Find the time at which the undershoot of the first valley point occurs.



5. Consider the translational mechanical system (Mass(M)-Spring(K)-Damper(f_v)). A 1 pound force $f(t)$ is applied at $t = 0$. If $f_v = 1$, find K and M such that the response is characterized by an 8 second settling time and a 2 second peak time. Also, what is the resulting percent overshoot?

6. The transfer function of a system is given by $G(s) = \frac{a}{s+a}$. We are interested in analyzing the effect of adding a zero on the real axis, i.e., $\tilde{G}(s) = \frac{s+b}{s+a}$. Analyze the step response for $\tilde{G}(s)$ for the situations where $0 < \frac{b}{a} < 1$, $\frac{b}{a} \gg 1$ and $\frac{b}{a} \ll -1$.

7. Verify if the transfer functions given below can be approximated to a second order system. If not, justify?

   (a) $G(s) = \frac{14.145}{(s^2+0.902s+3.2)(s+5)}$

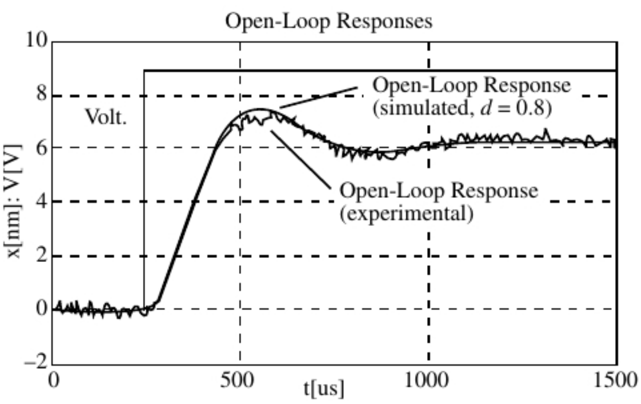
   (b) $G(s) = \frac{s+3}{(s+2)(s^2+3s+10)}$

   (c) $G(s) = \frac{s+2.01}{(s+2)(s^2+5s+20)}$

8. (a) Calculate the step response of the transfer function $G(s) = \frac{30s+36}{(s+3)(s^2+8s+12)}e^{-3s}$.
   (b) Calculate the response of the transfer function $G(s)$ to a pulse signal of 2 second duration.

9. The transfer function of a system is given by $G(s) = \frac{a}{s+a}$. Find the output response for the test signals (a) Ramp (b) Step, and (c) Impulse. Show that the response for (b) can be obtained by differentiating the response from (a), and response for (c) can be obtained by differentiating the response from (b). Explain this observation.

10. An optimal MEMS (Micro Electromechanical System) with an optical fiber channel that takes light generated from a laser diode. It also has a photo-detector that measures light intensity variations and outputs voltage variations proportional to small mechanical device deflections. Additionally, a voltage input is capable of deflecting the device The apparatus can be used as an optimal switch or as a variable optical attenuator. Figure below shows input-output signal pairs used to identify the parameters of the system. Assume a second order transfer function and find the system's transfer function.



11. Anestheisa induces muscle relaxation (paralysis) and 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 drug is a mixture of isoflurane and atracurium. An approximate model relating muscle relaxation to the percent isoflurane in the mixture is $\frac{P(s)}{U(s)} = \frac{7.63\times10^{-2}}{s^2+1.15s+0.28}$, where $P(s)$ is the muscle relaxation measured as a fraction of total paralysis (normalized to unity) and $U(s)$ is the percent mixture of isoflurane.

    a) Find the damping ratio and natural frequency of the paralysis transient response

    b) Find the maximum possible percent paralysis if a 2% mixture of isoflurane is used.

    c) What percent of isoflurane would have to be used for 100% paralysis?