EEG307: Intro to Feedback Control

Fall 2020

Homework Assignment #6

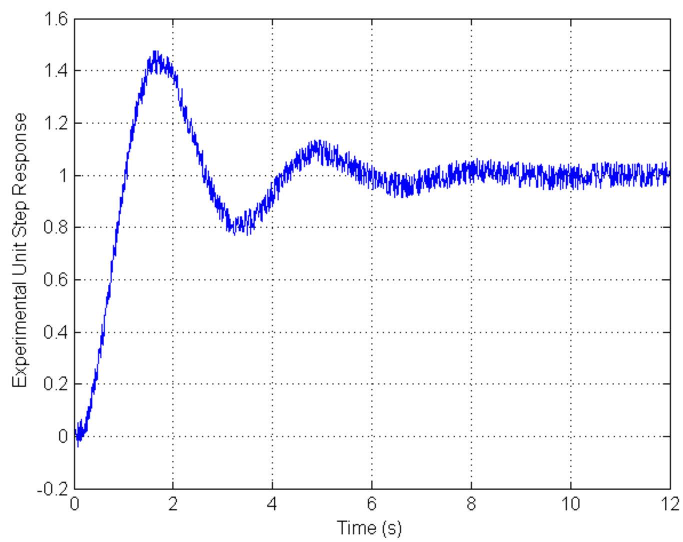
Due: Monday, Oct 12th, 11:59pm

1. A control systems engineer has calculated that an experimental system can be represented by the transfer function

$$\frac{Y(s)}{R(s)} = \frac{s+80}{(s+10)(s^2+s+4)}$$

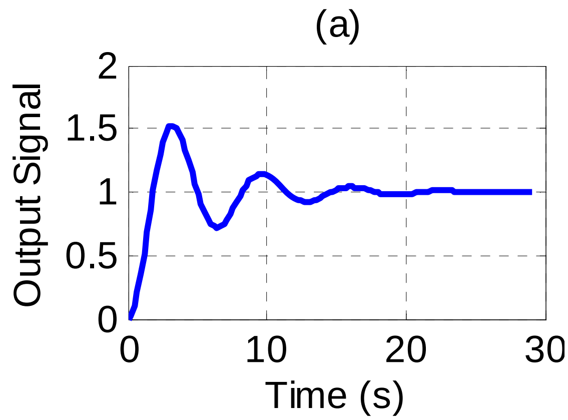
(a)) Predict the rise time, percent overshoot, and final value of the signal $y(t)$ in response to a unit step input $r(t)$.

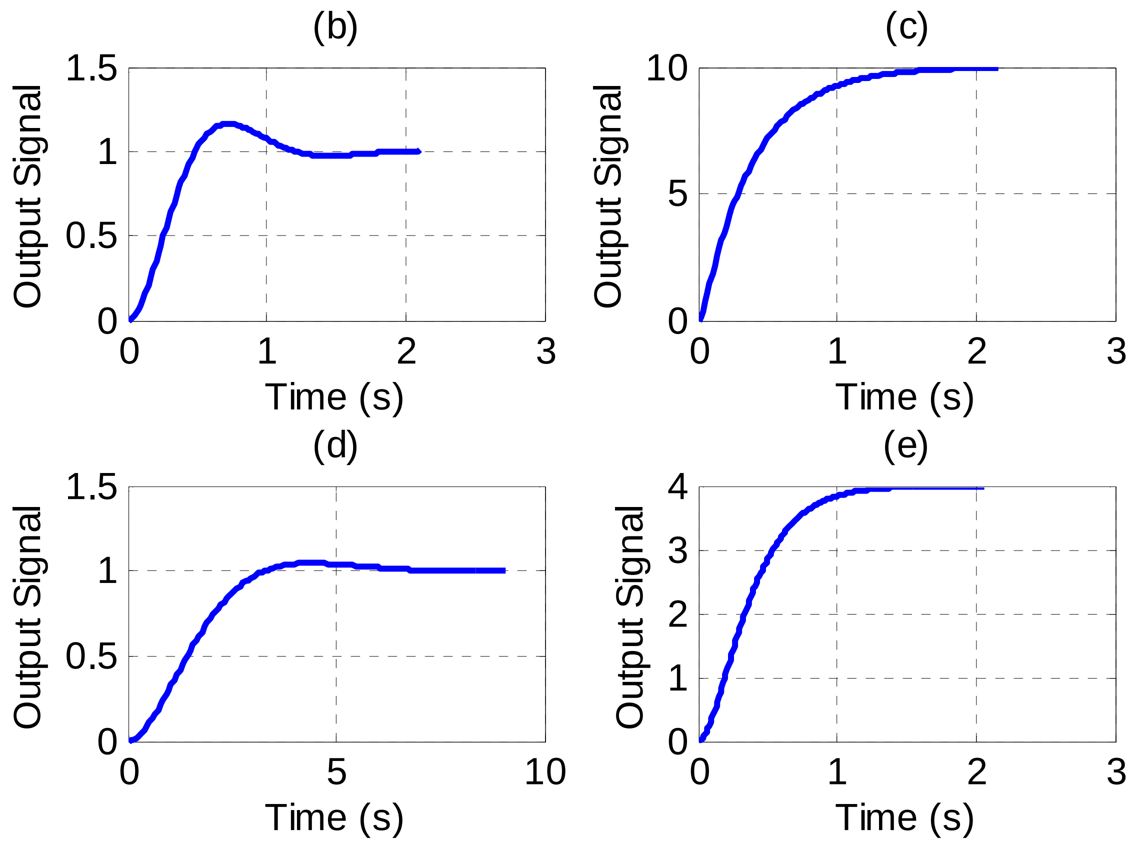
(b)) In an experiment, the engineer observes the following unit step response, that is, the measurement $y_m(t)$, where measurement noise can be seen. By comparing the measured data to the predicted t_r, %OS, and final value of $y(t)$ from part (a), determine the most significant error in the transfer function. For full credit, briefly explain your reasoning within the space provided.



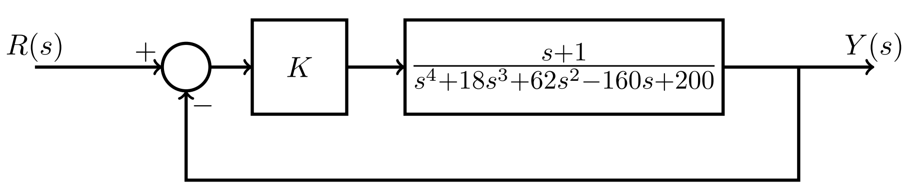
2. Match the following systems with transfer functions $G_i(s)$ to the associated unit step response plot. Indicate your answer by filling in the table with the appropriate plot (a)-(e). To obtain partial credit in case of an incorrect answer, you must show the work that led to your selection. *Hint: note that both the x and y axes have different scales. Also note that* $37 * 2.7 \approx 100$.

System	Step Response Plot
$G_1(s)=\dfrac{25}{s^2+5s+25}$	
$G_2(s)=\dfrac{1}{s^2+1.4s+1}$	
$G_3(s)=\dfrac{1}{s^2+.4s+1}$	
$G_4(s)=\dfrac{100}{(s+5)^2}$	
$G_5(s)=\dfrac{1000}{(s+37)(s+2.7)}$	



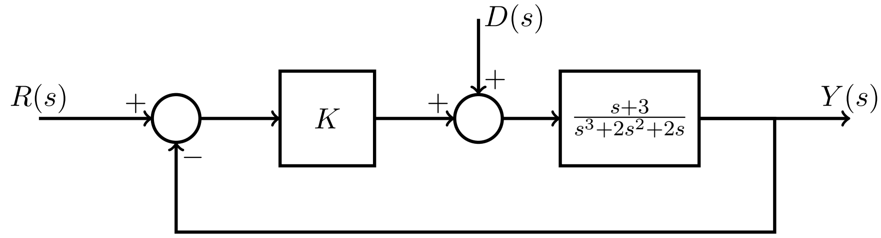


3. Consider the following feedback system

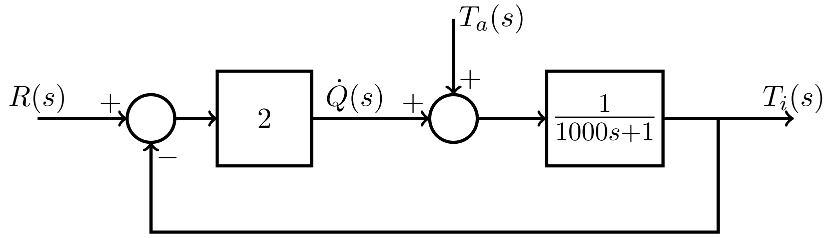


Find the range for K that results in a stable closed loop system

4. For the following feedback control system, we wish to decrease the effect of the disturbance on the output $y(t)$ by varying K. What is smallest possible change in $y(t)$ at steady state due to a step disturbance? Hint: the feedback system must be stable.

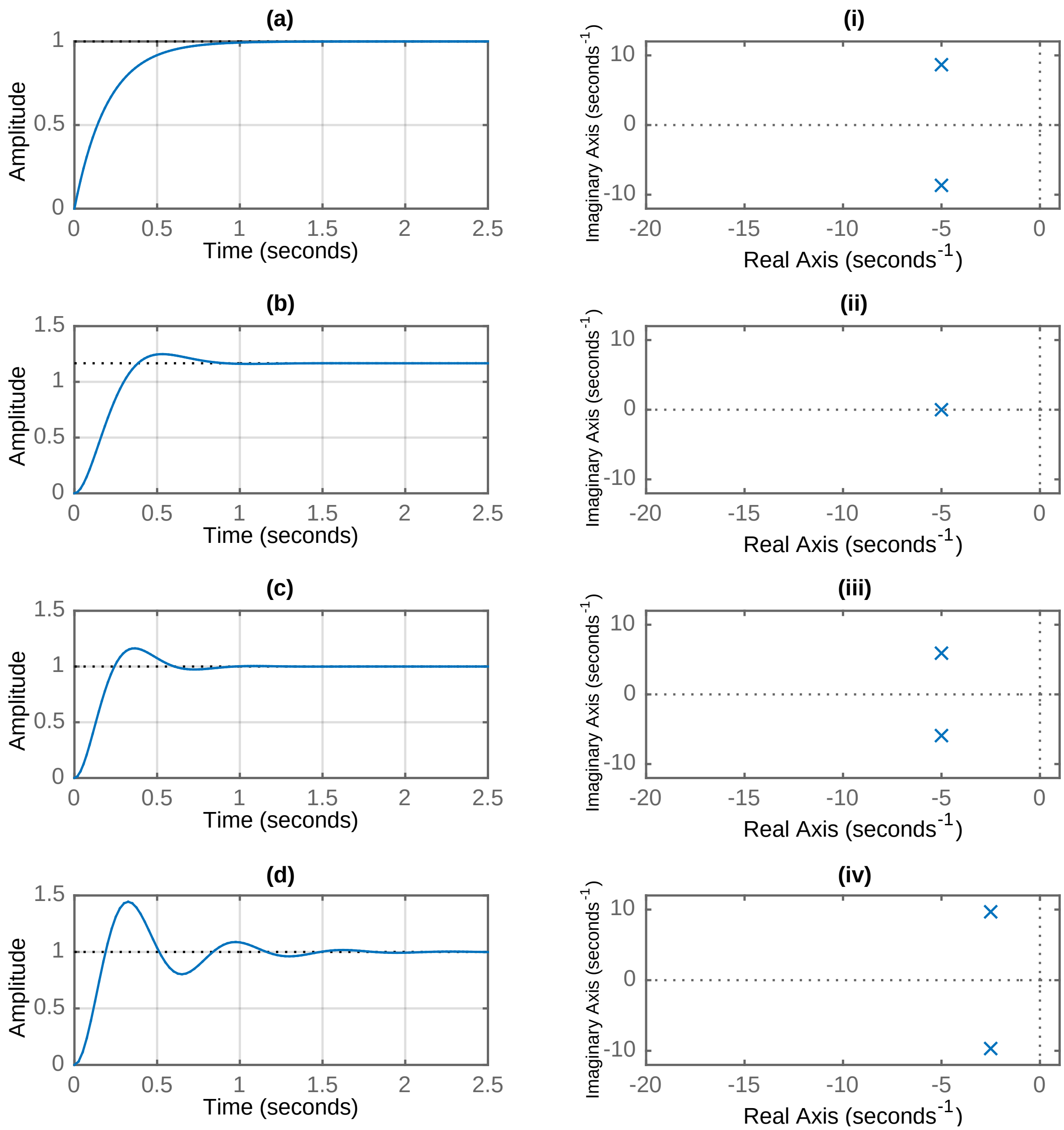


5. A poorly insulated, leaky cabin with interior temperature T_i is impacted by both the cabin's heater, which supplies heat flow $\dot{Q}$, and outdoor ambient temperature T_a as shown in the block digram below, where $\dot{Q}(s)$ is determined by a proportional controller and $R(s)$ represents the thermostat set point.

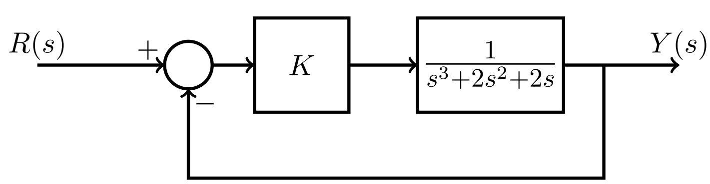


   (a) Find the transfer function from the ambient outdoor temperature T_a to the indoor temperature T_i.
   (b) If a cold front suddenly moves in and the outdoor temperature changes by $-10°$, that is, $T_a(t) = -10u(t)$, by how much will the indoor temperature $T_i(t)$ change in steady-state?
   (c) Check your answer in Matlab using the transfer function `'sys'` you derived in (a) and `'step(-10*sys)'`.

6. Quiz Question Friday: Match the step response with the plot of the system poles in the complex plane. Mark on the plots the features of the step response that allow you to estimate the poles, and the features of the poles that allow you to estimate the step response.



7. Quiz Question Monday: Consider the following feedback system



Find the range for K that results in a stable closed loop system

Solutions:

1. (a) $t_r = 1.1s$, $\%OS = 45\%$, and $y_{ss} = 2$
   (b) Most significant error is the final value (DC gain or erroneous zero location)
2. (a) $G_1 = B$
   (b) $G_2 = D$
   (c) $G_3 = A$
   (d) $G_4 = E$
   (e) $G_5 = C$
3. 356<K<756
4. effect of disturbance bounded below by $1/4$.
5. (a) $\frac{T_i(s)}{T_a(s)} = \frac{1}{1000s+3}$
   (b) $-10/3$deg
   (c) No partial solution