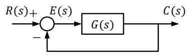
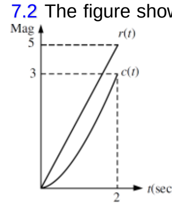
7.1 Find the steady-state errors for the following test inputs: $25u(t)$, $37tu(t)$, $42t^2u(t)$ for the unity feedback system



$$G(s)=\frac{450(s+8)(s+12)(s+15)}{s(s+38)(s^2+2s+28)}$$

7.2 The figure shows the ramp input $r(t)$ and the output $c(t)$ of a system. Assuming the output's steady state can be approximated by a ramp, find



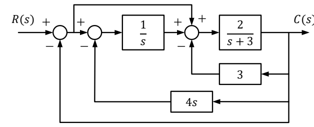
a. the steady-state error;

b. the steady-state error if the input becomes $r(t)=2.5tu(t)$

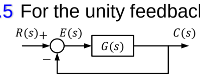
7.3 Find the steady-state errors if the input is $80t^2u(t)$ for the unity feedback system

$$G(s)=\frac{60(s+3)(s+4)(s+8)}{s^2(s+6)(s+17)}$$

7.4 For the system shown in the figure, what steady state error can be expected for the following test inputs: $15u(t)$, $15tu(t)$, $15t^2u(t)$



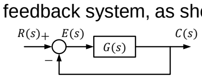
7.5 For the unity feedback system shown in the figure, where



$$G(s)=\frac{500}{(s+24)(s^2+8s+14)}$$

find the steady-state error for inputs of $30u(t)$, $70tu(t)$, and $81t^2u(t)$

7.6 An input of $25t^3u(t)$ is applied to the input of a Type 3 unity feedback system, as shown in the figure, where



$$G(s)=\frac{210(s+4)(s+6)(s+11)(s+13)}{s^3(s+7)(s+14)(s+19)}$$

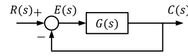
7.7 The steady-state error in velocity of a system is defined to be

$$\left.\left(\frac{dr}{dx}-\frac{dc}{dx}\right)\right|_{t\to\infty} \quad \text{where, } r\text{: the system input}$$
$$c\text{: the system output}$$

Find the steady-state error in velocity for an input of $t^3u(t)$ to a unity feedback system with a forward TF of

$$G(s)=\frac{100(s+1)(s+2)}{s^2(s+3)(s+10)}$$

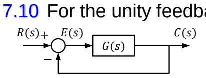
7.8 What is the steady-state error for a step input of 15 units applied to the unity feedback system, where



$$G(s)=\frac{1020(s+13)(s+26)(s+33)}{(s+65)(s+75)(s+91)}$$

7.9 A system has $K_p=4$. What steady state error can be expected for inputs of $70u(t)$ and $70tu(t)$?

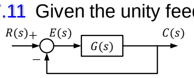
7.10 For the unity feedback system shown in the figure, where



$$G(s)=\frac{5000}{s(s+75)}$$

a. What is the expected percent overshoot for a unit step input?
b. What is the settling time for a unit step input?
c. What is the steady-state error for an input of $5u(t)$?
d. What is the steady-state error for an input of $5tu(t)$?
e. What is the steady-state error for an input of $5t^2u(t)$?

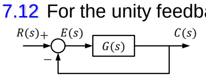
7.11 Given the unity feedback system shown in the figure, where



$$G(s)=\frac{100500(s+5)(s+14)(s+23)}{s(s+27)(s+\alpha)(s+33)}$$

Find the value of α to yield a $K_v=25000$

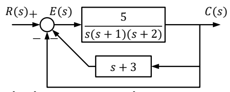
7.12 For the unity feedback system of the figure, where

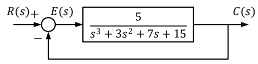


$$G(s)=\frac{K(s+2)(s+4)(s+6)}{s^2(s+5)(s+7)}$$

find the value of K to yield a static error constant of $10{,}000$

7.13 For the system shown in the figure





a. Find K_p, K_v, and K_a

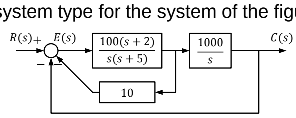
b. Find the steady-state error for an input of $50u(t)$, $50tu(t)$, $50t^2u(t)$

c. State the system type

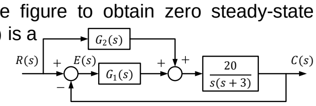
7.14 A Type 3 unity feedback system has $r = 10t^3$ applied to its input. Find the steady-state position error for this input if the forward TF is

$$G(s) = \frac{1030(s^2+8s+23)(s^2+21s+18)}{s^3(s+6)(s+13)}$$

7.15 Find the system type for the system of the figure

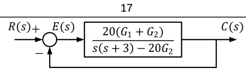


7.16 What are the restrictions on the feedforward TF $G_2(s)$ in the system of the figure to obtain zero steady-state error for step inputs if $G_1(s)$ is a



a. type 0 TF b. type 1 TF c. type 2 TF

7.16



$$E(s) = \frac{s(s+3)-20G_2}{s(s+3)+20G_1}R(s)$$

$$e(\infty) = \lim_{s\to 0} sE(s) = -\lim_{s\to 0}\frac{G_2(s)}{G_1(s)}$$

to obtain zero steady-state error for step inputs, $G_2(s)$ must be lower order than $G_1(s)$. Therefore, if $G_1(s)$ is a

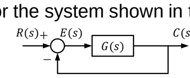
a. type 0 TF → G_2 must be zero

b. type 1 TF → G_2 must be type 0

c. type 2 TF → G_2 must be type 1

$e(\infty) = \lim_{s\to 0} sE(s) = \lim_{s\to 0}\frac{sR(s)}{1+G(s)}$ (7.11)

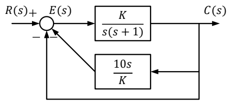
7.19 For the system shown in the figure

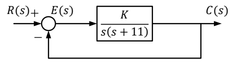


$$G(s) = \frac{K(s+a)}{s(s+2)(s+13)}$$

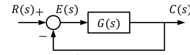
Find the value of Ka so that a ramp input of slope 40 will yield an error of 0.006 in the steady state when compared to the output

7.20 Given the system of the figure, design the value of K so that for an input of $100tu(t)$, there will be a 0.01 error in the steady state





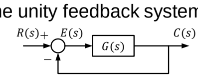
7.21 Find the value of K for the unity feedback system where



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

if the input is $10t^2u(t)$, and the desired steady-state error is 0.061 for this input

7.22 The unity feedback system of the figure, where



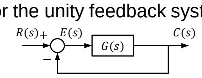
$$G(s) = \frac{K(s^2+3s+30)}{s^n(s+5)}$$

is to have $1/6000$ error between an input of $10tu(t)$ and the output in the steady state

a. Find K and n to meet the specification

b. What are K_p, K_v, and K_a

7.23 For the unity feedback system of the figure, where



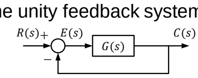
$$G(s) = \frac{K(s^2+6s+6)}{(s+5)^2(s+3)}$$

a. Find the system type

b. What error can be expected for an input of $12u(t)$?

c. What error can be expected for an input of $12tu(t)$?

7.27 The unity feedback system of the figure, where



$$G(s) = \frac{K(s+\alpha)}{(s+\beta)^2}$$

is to be designed to meet the following specifications: steady-state error for a unit step input $= 0.1$, damping ratio $= 0.5$, natural frequency $= \sqrt{10}$. Find K, α, and β

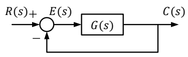
7.28 A second-order, unity feedback system is to follow a ramp input with the following specifications: the steady-state output position shall differ from the input position by 0.01 of the input velocity; the natural frequency of the closed-loop system shall be $10 rad/s$. Find the following

a. The system type

b. The exact expression for the forward-path TF

c. The closed-loop system's damping ratio

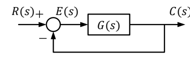
7.29 The unity feedback system of the figure, where



$$G(s) = \frac{K(s+\alpha)}{s(s+\beta)}$$

is to be designed to meet the following requirements: The steady-state position error for a unit ramp input equals $1/10$; the closed-loop poles will be located at $-1 \pm j1$. Find K, α, and β in order to meet the specifications

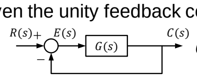
7.30 Given the unity feedback control system of the figure, where



$$G(s) = \frac{K}{s^n(s+a)}$$

find the values of n, K, and a in order to meet specifications of 12% overshoot and $K_v = 110$

7.31 Given the unity feedback control system of the figure, where



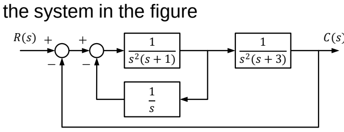
$$G(s) = \frac{K}{s(s+a)}$$

find the following

a. K and a to yield $K_v = 1000$ and a 20% overshoot

b. K and a to yield a 1% error in the steady state and a 10% overshoot

7.32 Given the system in the figure



Find the following

a. The closed-loop TF

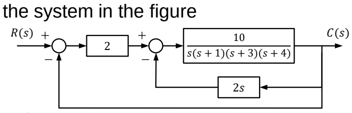
b. The system type

c. The steady-state error for an input of $5u(t)$

d. The steady-state error for an input of $5tu(t)$

e. Discuss the validity of your answers to Parts c and d

7.33 Given the system in the figure



Find the following

a. The closed-loop TF

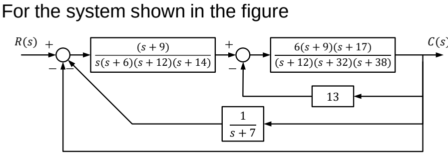
b. The system type

c. The steady-state error for an input of $5u(t)$

d. The steady-state error for an input of $5tu(t)$

e. Discuss the validity of your answers to Parts c and d

7.34 For the system shown in the figure



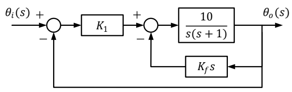
Use matlab to find the following

a. The system type

b. K_p, K_v, and K_a

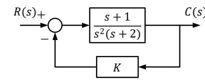
c. The steady-state error for inputs of $100u(t)$, $100tu(t)$, and $100t^2u(t)$

7.35 The system of the figure is to have the following specifications: $K_v = 10, \zeta = 0.5$



Find the values of K_1 and K_f required for the specifications of the system to be met

7.44 Given the system shown in the figure

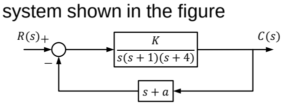


find the following

a. The system type

b. The value of K to yield 0.1% error in the steady state

7.50 Given the system shown in the figure



find the sensitivity of the steady-state error to parameter a. Assume a step input. Plot the sensitivity as a function of parameter a

7.55 For each of the following closed-loop systems, find the steady-state error for unit step and unit ramp inputs. Use both the final value theorem and input substitution methods

a. $\dot{\boldsymbol{x}} = \begin{bmatrix} -5 & -4 & -2 \\ -3 & -10 & 0 \\ -1 & 1 & -5 \end{bmatrix} \boldsymbol{x} + \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} r, \quad y = \begin{bmatrix} -1 & 2 & 1 \end{bmatrix} \boldsymbol{x}$

b. $\dot{\boldsymbol{x}} = \begin{bmatrix} 0 & 1 & 0 \\ -5 & -9 & 7 \\ -1 & 0 & 0 \end{bmatrix} \boldsymbol{x} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} r, \quad y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \boldsymbol{x}$

c. $\dot{\boldsymbol{x}} = \begin{bmatrix} -9 & -5 & -1 \\ -1 & 0 & -2 \\ -3 & -2 & -5 \end{bmatrix} \boldsymbol{x} + \begin{bmatrix} 2 \\ 3 \\ 5 \end{bmatrix} r, \quad y = \begin{bmatrix} 1 & -2 & 4 \end{bmatrix} \boldsymbol{x}$