System Dynamics and Control 1 Stability - Problems

6.3 Tell how many roots of the following polynomial are in the RHP, in the LHP, and on the  $j\omega$ -axis  $P(s) = s^5 + 3s^4 + 5s^3 + 4s^2 + s + 3$ System Dynamics and Control 2 Stability - Problems 2 Stability - Problems 2 Stability - Problems 3 Stability - Problems 4 Stability - Problems 5 Stability - Problems 2 Stability - Problems 6.2 Tell how many roots of the following polynomial are in the RHP, in the LHP, and on the  $j\omega$ -axis  $P(s) = s^5 + 6s^3 + 5s^2 + 8s + 20$ 

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**6.3** Using the Routh table, tell how many poles of the following function are in the RHP, in the LHP, and on the  $j\omega$ -axis

$$T(s) = (s+8)/(s^5 - s^4 + 4s^3 - 4s^2 + 3s - 2)$$

System Dynamics and Control 4 Stability - Problems 6.4 Determine how many closed-loop poles lie in the RHP, in the LHP, and on the  $j\omega$ -axis

$$T(s) = (s^3 + 2s^2 + 7s + 21)/(s^5 - 2s^4 + 3s^3 - 6s^2 + 2s - 4)$$

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6.5 How many poles are in the RHP, in the LHP, and on the  $j\omega$ -axis for the open-loop system

R(s)  $s^2 + 4s - 3$  C(s)  $s^4 + 4s^3 + 8s^2 + 20s + 15$ 

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6.6 How many poles are in the RHP, in the LHP, and on the  $j\omega$ -axis for the open-loop system

 $\begin{array}{c|c}
R(s) & -6 & C(s) \\
\hline
s^6 + s^5 - 6s^4 + s^2 + s - 6 & -6
\end{array}$ 

6.7 Use matlab to find the pole locations for the system of



6.9 Determine whether the unity feedback system is stable if

$$T(s) = \frac{G(s)}{1 + G(s)} = \frac{C(s)}{(s+1)(s+2)(s+3)(s+4)}$$

$$T(s) = \frac{G(s)}{1 + G(s)} = \frac{240}{s^4 + 10s^3 + 35s^2 + 50s + 264}$$

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6.10 Use matlab to find the pole locations for the system of 
$$G(s) = \frac{G(s)}{(s+1)(s+2)(s+3)(s+4)}$$

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**6.11** Consider the unity feedback system with  $G(s) = 1/4s^2(s^2 + 1)$ . Using the Routh-Hurwitz criterion, find the region of the s-plane

where the poles of the closed-loop system are located 
$$T(s) = \frac{G(s)}{1+G(s)} = \frac{1}{4s^4+4s^2+1}$$

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6.12 In the system of the given figure, let

the system of the given figure, let 
$$G(s) = \frac{K(s+2)}{s(s-1)(s+3)}$$

Find the range of K for closed-loop stability

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6.13 Given the unity feedback system of the given figure with

$$G(s) = \frac{84}{6(s^7 + 5c^6 + 12c^5 + 25c^4 + 45c^3 + 50c^2)}$$

$$G(s) = \frac{64}{s(s^7 + 5s^6 + 12s^5 + 25s^4 + 45s^3 + 50s^2 + 82s + 60)}$$

tell how many poles of the closed-loop TF lie in the RHP, in the LHP, and on the  $j\omega$ -axis

6.14 Using the Routh-Hurwitz criterion and the unity feedback

$$G(s) = \frac{1}{2s^4 + 5s^3 + s^2 + 2s}$$

tell whether or not the closed-loop system is stable

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tell how many closed-loop poles are located in the RHP, in the LHP, and on the  $j\omega$ -axis

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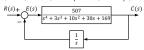
15 6.16 Using matlab find closed-loop poles are located in the RHP, in the LHP, and on the  $j\omega$ -axis

$$\frac{R(s) + E(s)}{-1} = \frac{G(s)}{G(s)} = \frac{8}{s(s^6 - 2s^5 - s^4 + 2s^3 + 4s^2 - 8s - 4)}$$

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6.19 Using the Routh-Hurwitz criterion, tell how many closed-loop poles of the system lie in the LHP, in the RHP, and on the  $j\omega$ -axis



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6.20 Determine if the unity feedback system

$$G(s) = \frac{K(s^2 + 1)}{(s+1)(s+2)}$$

can be unstable

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6.22 In the system

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

Find the range of *K* for closed-loop stability when

$$a.a < 0, b < 0$$
  $b.a < 0, b > 0$   $c.a > 0, b < 0$   $b.a > 0, b > 0$ 

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6.23 For the unity feedback system with



$$G(s) = \frac{K(s+3)(s+5)}{(s-2)(s-4)}$$

determine the range of K for stability

System Dynamics and Control 20 Stability - Problems 6.28 Find the range of gain *K* to ensure stability in the unity feedback

System  $G(s) = \frac{K(s-2)(s+4)(s+5)}{s^2+12}$ 

$$T(s) = \frac{G(s)H(s)}{1 + G(s)H(s)} = \frac{Ks^3 + 7Ks^2 + 2Ks - 40K}{Ks^3 + (7K + 1)s^2 + 2Ks + (12 - 4K)}$$

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**6.33** Given the unity feedback system with 
$$R(s)+\underbrace{F(s)}_{G(s)}G(s)=\frac{K(s+4)}{s(s+1.2)(s+2)}$$

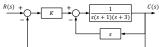
find the following

- a. The range of K that keeps the system stable
- b. The value of K that makes the system oscillate
- c. The frequency of oscillation when  $\it K$  is set to the value that makes the system oscillate

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6.35 For the given system, find the value of gain K that will make the system oscillate. Also, find the frequency of oscillation



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6.36 Given the unity feedback system with



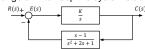
a. Find the range of K for stability

b. Find the frequency of oscillation when the system is marginally stable  $\underline{\textbf{Solution}}$ 

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6.42 Find the range of K to keep the system stable



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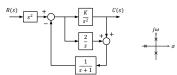
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6.43 Find the value of K in the system that will place the closed loop poles as shown



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Stability - Problems

6.44 The closed-loop TF of a system is

$$T(s) = \frac{s^2 + K_1 s + K_2}{s^4 + K_1 s^3 + K_2 s^2 + 5s + 1}$$

Determine the range of  $K_1$  in order for the system to be stable. What is the relationship between  $K_1$  and  $K_2$  for stability?

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Carbilla - Darblan

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6.50 A system is represented in state space as

$$\dot{\boldsymbol{x}} = \begin{bmatrix} 0 & 1 & 3 \\ 2 & 2 & -4 \\ 1 & -4 & 3 \end{bmatrix} \boldsymbol{x} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \boldsymbol{u}, \, \boldsymbol{y} = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix} \boldsymbol{x}$$

Determine how many eigenvalues are in RHP, in LHP, on  $j\omega$ -axis

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 ${\bf 6.51}$  Use matlab to find the eigenvalues of the following system

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & -4 \\ -1 & 1 & 8 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \mathbf{u}, \, \mathbf{y} = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} \mathbf{x}$$

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Stability Drobloms

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**6.52** The following system in state space represents the forward path of a unity feedback system. Use the Routh-Hurwitz criterion to determine if the closed-loop system is stable

$$\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 3 \\ -3 & -4 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u, y = \begin{bmatrix} 0 & 1 & 1 \end{bmatrix} x$$

6.52 The following system in state space represents the forward path of a unity feedback system. Using matlab to determine if the closed-loop system is stable

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 3 \\ -3 & -4 & -5 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u, y = \begin{bmatrix} 0 & 1 & 1 \end{bmatrix} \mathbf{x}$$