EEE302 CONTROL SYSTEMS
LECTURE ASSIGNMENT

NAME AND NUMBER : TURHAN CAN KARGIN - 150403005

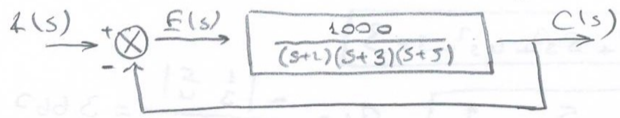
5 QUESTION HOMEWORK-2: ROUTH–HURWITZ STABILITY CRITERION

Assignment

Turhan Can Kargin
:150403005

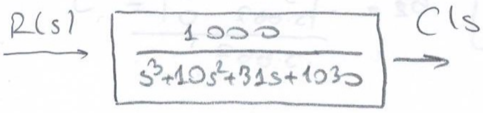
Question-1: → Control System Engineering - Norman 6th. Edition - Example 6.1

* Make the Routh table for the system in Figure.



Solution =

$$\frac{R(s)}{C(s)} = \frac{\dfrac{1000}{(s+2)(s+3)(s+5)}}{1+\dfrac{1000}{(s+2)(s+3)(s+5)}} = \frac{1000}{s^3+10s^2+31s+1030}$$



s^3	1	31	0
s^2	$\cancel{10}$ 1	$\cancel{1030}$ 103	0
s	$\dfrac{-\begin{vmatrix}1 & 31\\ 1 & 103\end{vmatrix}}{1}=-72$	$\dfrac{-\begin{vmatrix}1 & 0\\ 1 & 0\end{vmatrix}}{1}=0$	$\dfrac{-\begin{vmatrix}1 & 0\\ 1 & 0\end{vmatrix}}{1}=0$
1	$\dfrac{-\begin{vmatrix}1 & 103\\ -72 & 0\end{vmatrix}}{-72}=103$	$\dfrac{-\begin{vmatrix}1 & 0\\ -72 & 0\end{vmatrix}}{-72}=0$	$\dfrac{-\begin{vmatrix}1 & 0\\ -72 & 0\end{vmatrix}}{-72}=0$

Question-2: → Control system engineering - Norman 6th edition
Problem - 1

* Tell how many roots of the following polynomial are in the right half plane, in the left plane, and on the jw axis.

$$\boxed{P(s) = s^5 + 3s^4 + 5s^3 + 4s^2 + s + 3}$$

Solution=

s^5	1	5	1
s^4	3	4	3
s^3	a_1	a_2	0
s^2	b_1	b_2	0
s^1	c_1	0	0
1	d_1	0	0

$$a_1 = \frac{-\begin{vmatrix} 1 & 5 \\ 3 & 4 \end{vmatrix}}{3} = 3.667$$

$$a_2 = \frac{-\begin{vmatrix} 1 & 1 \\ 3 & 3 \end{vmatrix}}{3} = 0$$

$$b_1 = \frac{-\begin{vmatrix} 3 & 4 \\ 3.667 & 0 \end{vmatrix}}{3.667} = 4$$

$$b_2 = \frac{-\begin{vmatrix} 3 & 3 \\ 3.667 & 0 \end{vmatrix}}{3.667} = 3$$

$$c_1 = \frac{-\begin{vmatrix} 3.667 & 0 \\ 4 & 3 \end{vmatrix}}{4} = -2.75$$

$$d_1 = \frac{-\begin{vmatrix} 4 & 3 \\ -2.75 & 0 \end{vmatrix}}{-2.75} = 3$$

$$\rightarrow \quad 1 \xrightarrow{0} 3 \xrightarrow{0} 3.667 \xrightarrow{0} 4 \xrightarrow{1} -2.75 \xrightarrow{2} 3$$
$$\quad + \quad + \quad + \quad + \quad - \quad +$$

→ There are 2 roots in the right half plane and 3 in the left half plane

Question-3: Automatic control system - Kuo - Example 2.13.5

* Consider that the characteristic equation of a closed-loop control system is

$$\boxed{s^3 + 3Ks^2 + (K+2)s + 4 = 0}$$

Find the range of K so that system is stable.

Solution=

s^3	1	$K+2$
s^2	$3K$	4
s^1	$\frac{3K(K+2)-4}{3K}$	0
1	4	

* from the s^2 row, the condition of stability is $K > 0$, and from the s^1 row, the condition of stability is, $3K^2 + 6K - 4 > 0$

$\longrightarrow K < -2.528$ or $K > 0.528$

* Therefore, K must satisfy $\boxed{K > 0.528}$

Question-4: Ogata 5th edition – 5.21

* Consider the following characteristic equation:

$$\boxed{s^4 + 2s^3 + (4+K)s^2 + 9s + 25 = 0}$$

Using Routh stability criterion, determine the range of K for stability.

Solution=

s^4	1	$4+K$	25
s^3	2	9	0
s^2	$\frac{2K-1}{2}$	25	0
s^1	$\frac{18K-109}{2K-1}$	0	0
1	25	0	0

* for stability, we need

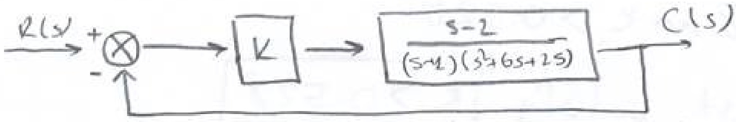
$$2K - 1 > 0 \;,\; 18K - 108 > 0$$

$$\downarrow$$

$$K > 0.5 \;,\; \underline{\underline{K > 6.056}}$$

* For stability K must be greater than 6.056

Question-5: Consider the closed loop system shown in Figure. Determine the range of K for stability. Assume that $K>0$.



Solution:

$$\frac{C(s)}{R(s)} = \frac{\dfrac{K(s-2)}{(s+1)(s^2+6s+25)}}{1+\dfrac{K(s-2)}{(s+1)(s^2+6s+25)}} = \frac{K(s-2)}{s^3+7s^2+(31+K)s+25-2K}$$

* Characteristic equation $= s^3+7s^2+(31+k)s+25-2K$

s^3	1	$31+k$	0
s^2	7	$25-2K$	0
s	$\dfrac{192+9K}{7}$	0	0
1	$25-2K$	0	0

$\longrightarrow$ $192+9K>0 \rightarrow K>-21.3$

$2K<25 \longrightarrow K<12.5$

$K>0$

$$\boxed{*\ 12.5>K>0}$$