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$$\frac{Y(s)}{R(s)} = \frac{n(s)}{d(s)}$$

Routh Array

$$d(s) = s^n + a_1 s^{n-1} + \cdots + a_n = 0$$

$$\forall_{i=1,n} \quad a_i > 0$$ (necessary condition)

Sufficient condition

s^n	1	a_2	a_4	$\cdots$
s^{n-1}	a_1	a_3	a_5	$\cdots$
s^{n-2}				
$\vdots$				
s^0				

Special Cases

$$d(s) = s^4 + 2s^3 + 2s^2 + 4s + 3$$

s^4	1	2	3
s^3	2	4	0
s^2	$0\ (\epsilon)$	3	
s^1	$\frac{4\epsilon - 6}{\epsilon}$	0	
s^0	3		

negative

There are two poles in the RHS plane

$$d(s) = s^4 + 2s^3 + 2s^2 + 4s + 3$$

$s \leftarrow s+1$

$$s = 1/x$$

$$d(x) = \frac{1}{x^4} + \frac{2}{x^3} + \frac{2}{x^2} + \frac{4}{x} + 3 = 0$$

$$= 3x^4 + 4x^3 + 2x^2 + 2x + 1 = 0$$

x^4	3	2	1
x^3	4	2	
x^2	0.5	1	
x^1	-6	0	
x^0	1		

2 sign changes

$\Rightarrow$ Two poles in RHS plane

Special case 2

$$d(s) = s^4 + 3s^3 + 6s^2 + 12s + 8 = 0$$

s^4	1	6	8
s^3	3	12	0
s^2	2	8	
s^1	0(4)	0	
s^0	8		

Entire row = 0

$2s^2 + 8 \leftarrow$ Aux eqn

$$\frac{d}{ds}(2s^2 + 8)$$

$$4s + 0$$

Auxiliary eqn is a factor of $d(s)$

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$$2s^2 + 8 = 0$$

$$s^2 + 4 = 0$$

$$s_{1,2} = \pm j2 \quad \text{of } d(s)$$

$$
\begin{array}{r|l}
 & s^2 + 3s + 2 \\
\hline
s^2 + 4 & s^4 + 3s^3 + 6s^2 + 12s + 8 \\
 & s^4 \quad - \quad + 4s^2 \\
\hline
 & 3s^3 + 2s^2 + 12s \\
 & 3s^3 \qquad\qquad 12s \\
\hline
 & 2s^2 + 8 \\
 & 2s^2 + 8
\end{array}
$$

$$d(s) = (s^2+4)(s^2+3s+2)$$

$$= (s^2+4)(s+1)(s+2)$$

$$\downarrow$$

$$\pm j2, \; -1, \; -2$$