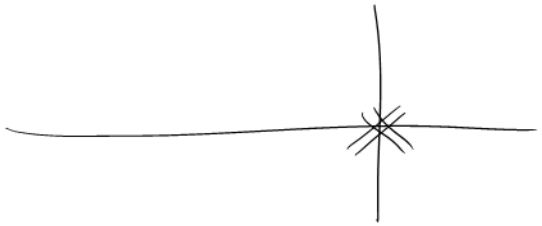
LECTURE 31

Ex 1

$$CE = 1 + K\frac{1}{s^2} = 0$$

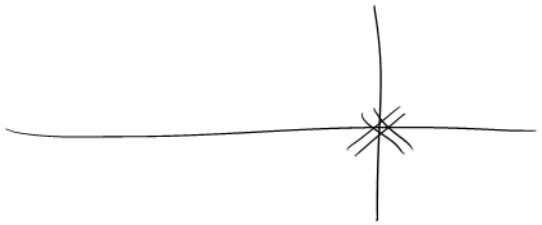
$$L(s) = \frac{1}{s^2}$$

- $a(s) \Rightarrow m = 0$ ZEROS
- $b(s) \Rightarrow n = 2$ POLES @ 0



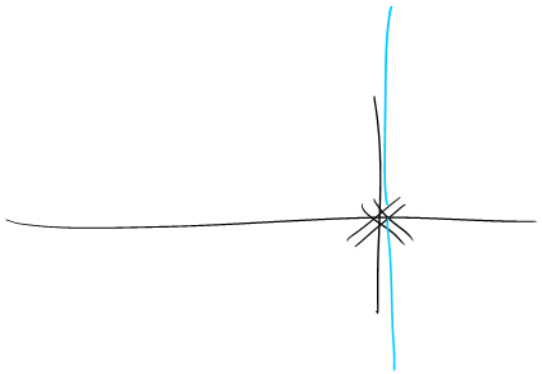
RULE 1

POLES ⟶ ZEROS



RULE 2

REAL AXIS ✗ (NO!)

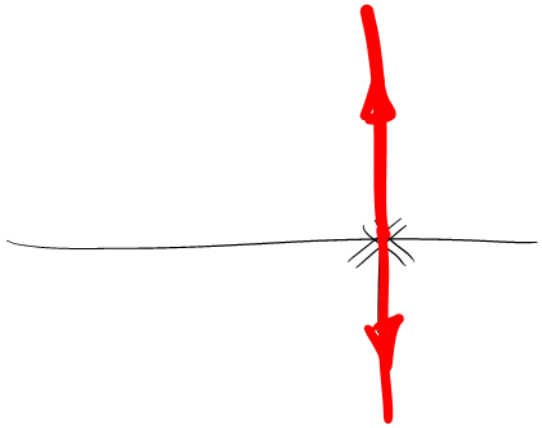


RULE 3

$$\phi_{ASYM} = \frac{180 + 360(\ell - 1)}{2} = \pm 90^\circ$$

$$\alpha_{ASYM} = \frac{0}{2} = 0$$

(ADAPTED FROM SATISH NAIR)



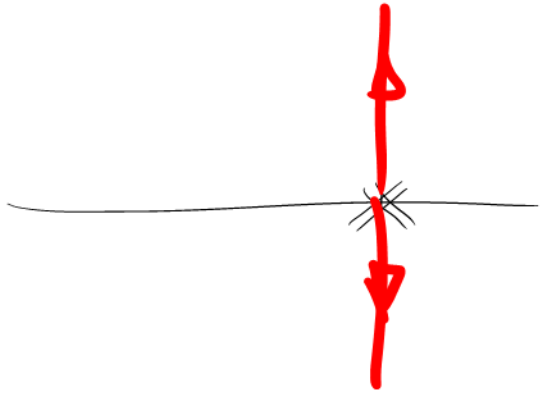
Rule 4

$$\phi_{req} = \frac{0 - 0 - 180 - 360(e-1)}{2}$$

@ $e = 0$

$$= \pm 90^\circ$$

Rule 5



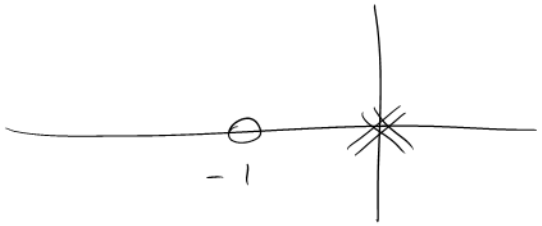
NOT APPLICABLE

Ex 2

$$e_c = 1 + K\frac{s+1}{s^2} = 0$$

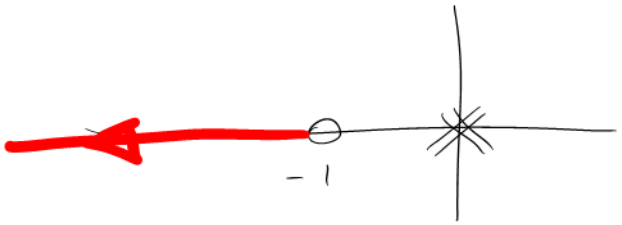
$$L(s) = \frac{s+1}{s^2}$$

- $a(s) \Rightarrow m = 1$ zero @ -1
- $b(s) \Rightarrow n = 2$ poles @ 0



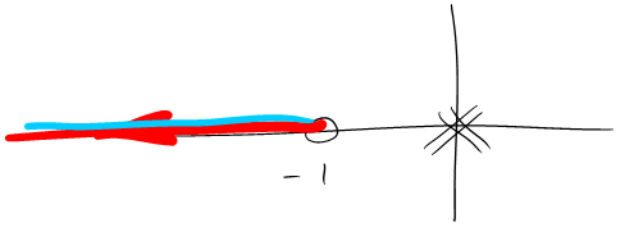
Rule 1

Poles ⟶ Zeros



Rule 2

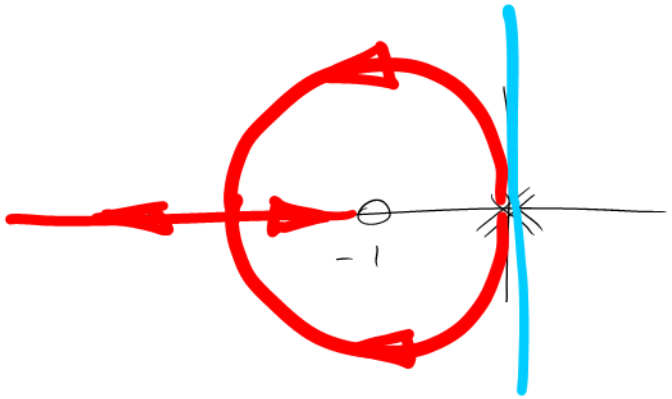
Real axis ✓



Rule 3

$$\phi_{Asym} = 180 + 360(l-1) = 180°$$

$$\alpha_{Asym} = \frac{-1}{1} = -1$$



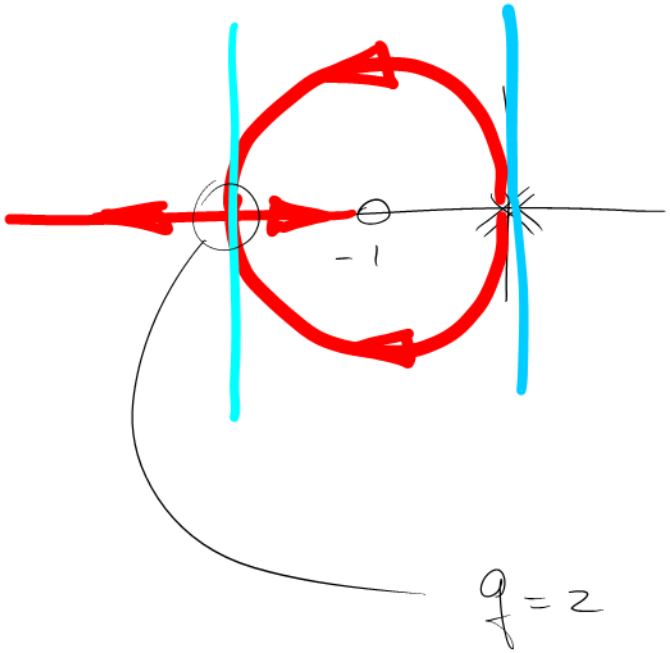
Rule 4

$$\phi_{\substack{DCP \\ @0}} = \frac{0 - 0 - 180 - 360(\ell - 1)}{2}$$

$$= \pm 90^\circ$$

$$\phi_{\substack{ARR \\ @-1}} = 180^\circ + 180^\circ + 180^\circ + 360(\ell - 1)$$

$$= 180^\circ$$



Rule 5

$$\frac{180^\circ + 360(\ell - 1)}{2} = \pm 90^\circ$$

Ex 3

$$D(s) = K_p + \frac{K_D s}{s/p + 1} \quad \text{(PD control)}$$

→ non-monic form

$$\Rightarrow D(s) = K_p + pK_D \frac{s}{s+p} =$$

$$= \frac{K_p s + pK_p + pK_D s}{s+p} =$$

$$= (K_p + pK_D) \frac{s + \frac{pK_p}{K_p + pK_D}}{s+p}$$

$$L(s) = 1 + D(s)G(s) =$$

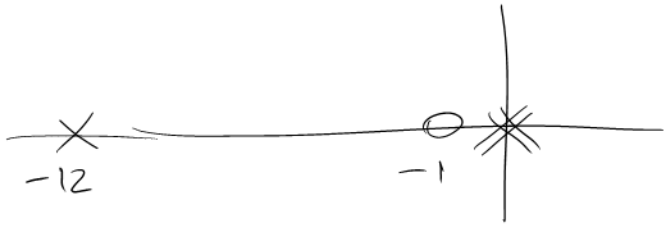
$$= 1 + \underbrace{(K_p + pK_D)}_{K} \frac{s + \overbrace{\frac{pK_p}{K_p + pK_D}}^{z}}{s^2(s+p)}$$

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

Ex 3

$$e_c = 1 + K\frac{s+1}{(s+12)s^2}$$

$$L(s) = \frac{s+1}{s^2(s+12)} \quad \begin{cases} a(s) \Rightarrow m = 1 \text{ ZERO } @ -1 \\ b(s) \Rightarrow n = 3 \text{ POLES } @ 0, -12 \end{cases}$$

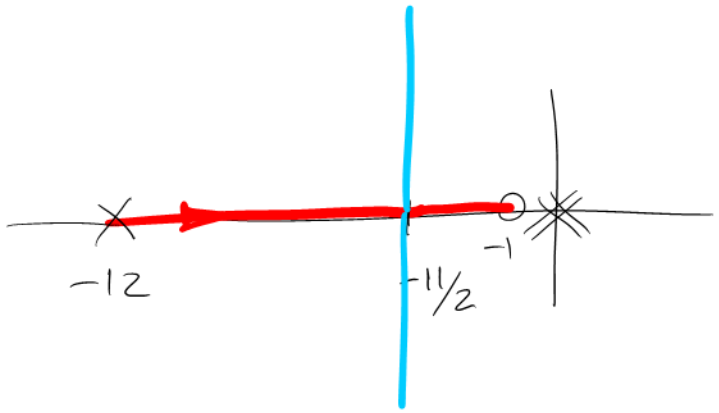


RULE 1

POLES ⟶ ZEROS

RULE 2

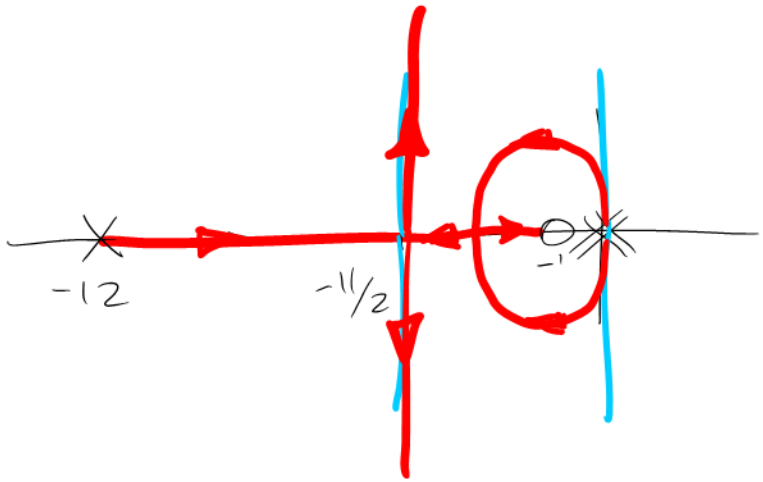
REAL AXIS ✓



RULE 3

$$\Phi_{ASYM} = \frac{180 + 360(l-1)}{2} = \pm 90°$$

$$\alpha_{ASYM} = \frac{-12 - 0 - 0 + 1}{2} = -11/2$$



Rule 4

$$\phi_{DCP\ @0} = \frac{0+0-0-180-360(\ell-1)}{2}$$

$$= \pm 90^\circ$$

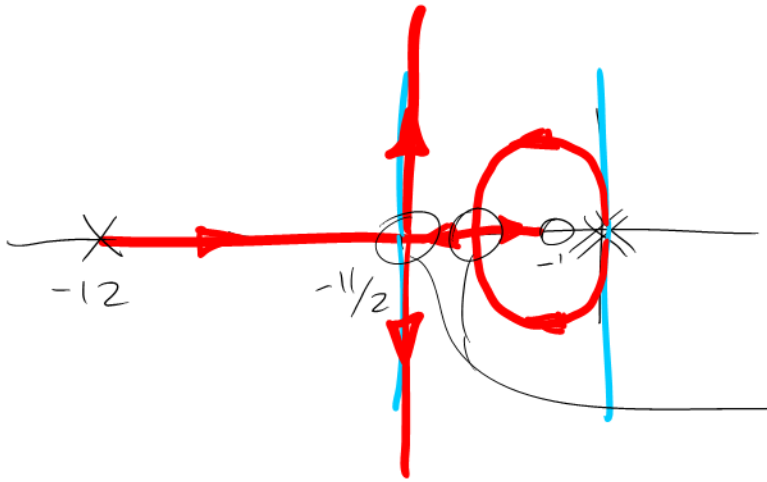
$$\phi_{DCP\ @-12} = \frac{180+180-180-180-360(\ell-1)}{1}$$

$$= 0^\circ$$

$$\phi_{DRR\ @-1} = 180+180+0+180+360(\ell-1)$$

$$= 180^\circ$$

Rule 5

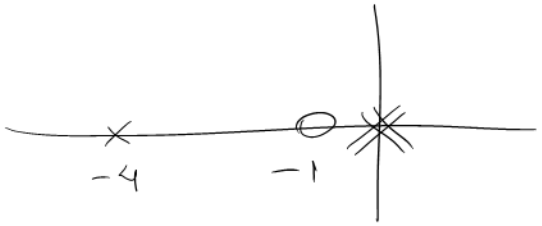


$$\frac{180^\circ + 360(\ell-1)}{2} = \pm 90^\circ$$

Ex 4

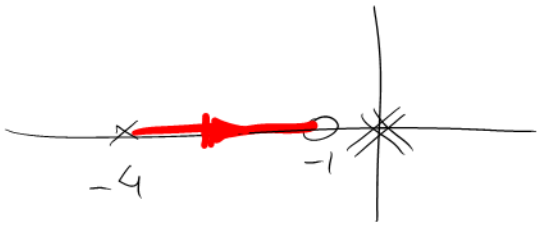
$$e_c = 1 + K\frac{s+1}{(s+4)s^2}$$

$$L(s) = \frac{s+1}{s^2(s+4)} \quad \begin{matrix} - a(s) \Rightarrow m = 1 \text{ ZERO } @ -1 \\ - b(s) \Rightarrow n = 3 \text{ POLES } @ 0, -4 \end{matrix}$$



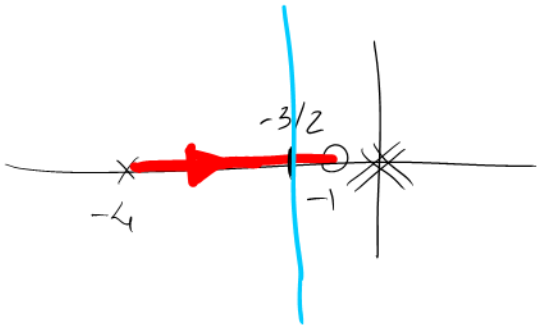
RULE 1

POLES ⟶ ZEROS



RULE 2

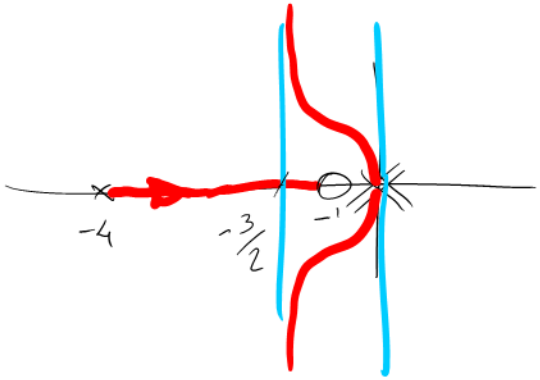
REAL AXIS ✓



RULE 3

$$\Phi_{ASYM} = \frac{180 + 360(l-1)}{2} = \pm 90^\circ$$

$$\alpha_{ASYM} = \frac{-4-0-0+1}{2} = -3/2$$



RULE 4

$$\phi_{DCP\ @0} = \frac{0+0-0-180-360(\ell-1)}{2}$$

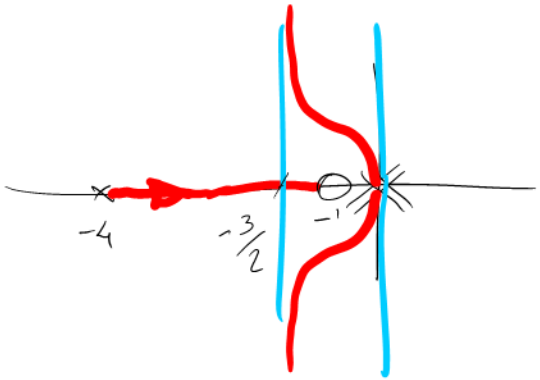
$$= \pm 90^\circ$$

$$\phi_{DCP\ @-4} = \frac{180+180-180-180-360(\ell-1)}{1}$$

$$= 0^\circ$$

$$\phi_{DRR\ @-1} = 180+180+0+180+360(\ell-1)$$

$$= 180^\circ$$



RULE 5

NOT APPLICABLE