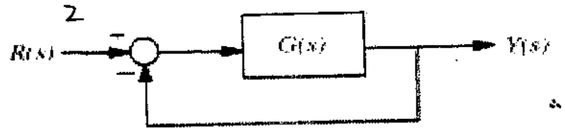
KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
ELECTRICAL ENGINEERING DEPARTMENT

EE380 [081]	SEC#	Quiz # 9
Name: Key Solution	ID:	Grade:

Consider the feedback control system. Sketch the root locus and find the break-away and break-in points. Also find the angle of departures from complex poles and angles of arrivals to the complex zeros.



Ch. Eqn.: $1 + G(s) = 0$

$\therefore \quad 1 + \dfrac{K(s^2+2s+2)}{s(s^2+4)} = 0$

where

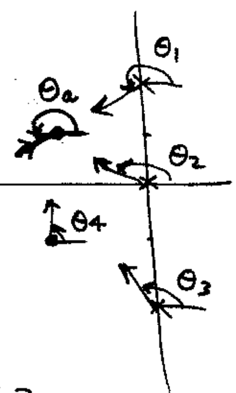
$$G(s) = \frac{K(s+1+j)(s+1-j)}{s(s+2j)(s-2j)}.$$

$$\boxed{K = -\frac{s(s^2+4)}{s^2+2s+2}}$$

$\dfrac{dK}{ds} = s^4 + 4s^3 + 2s^2 + 8 = 0 \Rightarrow \dfrac{dK}{ds} = (s+2)(s^3+2s^2-2s+4) = 0 \Rightarrow \begin{cases} s = -2 \\ s \simeq -3.07 \end{cases}$

Angle of arrival : θ_a

$[\theta_1+\theta_2+\theta_3] - [\theta_4+\theta_a] = 180$



$225 + 135 + [180 - \tan^{-1}3]$

$- [90 + \theta_a] = 180$

$\therefore \quad 90 + \theta_a = 360 - \tan^{-1}3$

$\therefore \quad \boxed{\theta_a = 270 - \tan^{-1}3 \simeq 198.6^\circ}$

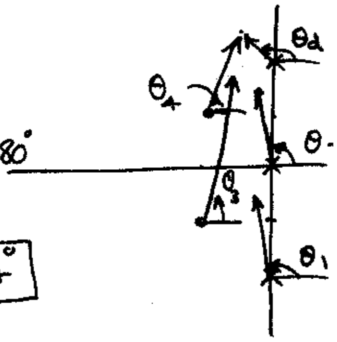
Angle of departure : θ_d

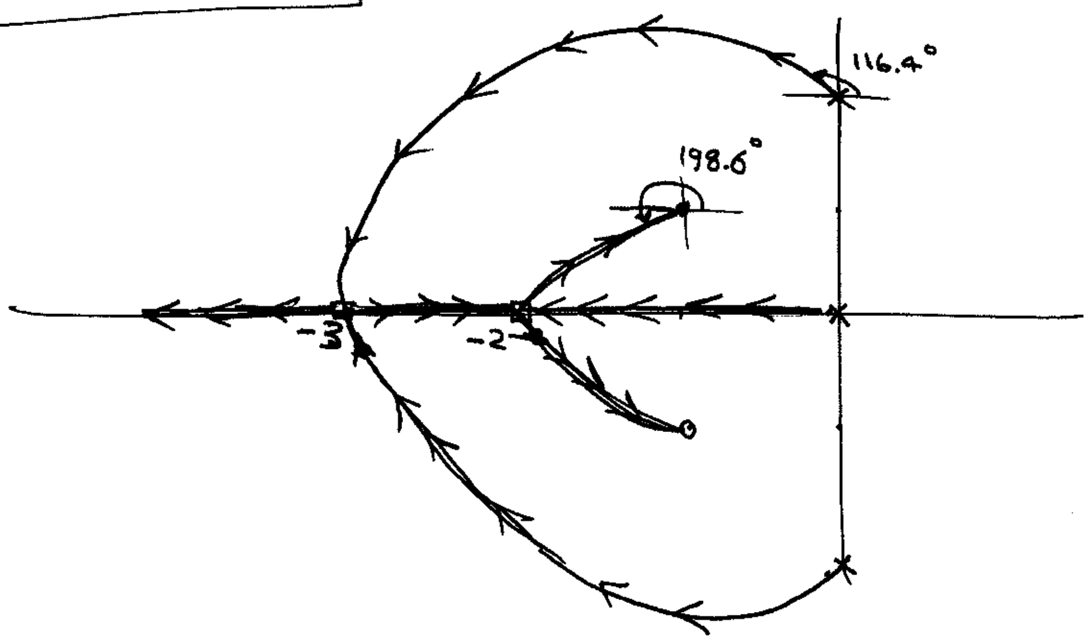
$[\theta_1+\theta_2+\theta_d] - [\theta_3+\theta_4] = 180^\circ$

$[90+90+\theta_d] - [\tan^{-1}3 + 45] = 180^\circ$

$\therefore \quad \theta_d = \tan^{-1}3 + 45$

$\boxed{\theta_d = 71.4 + 45 = 116.4^\circ}$





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EE380 [081]	SEC# 4	Quiz # 9
Name:__________	ID:__________	Grade:__________

A mechanical system has the closed-loop transfer function given by

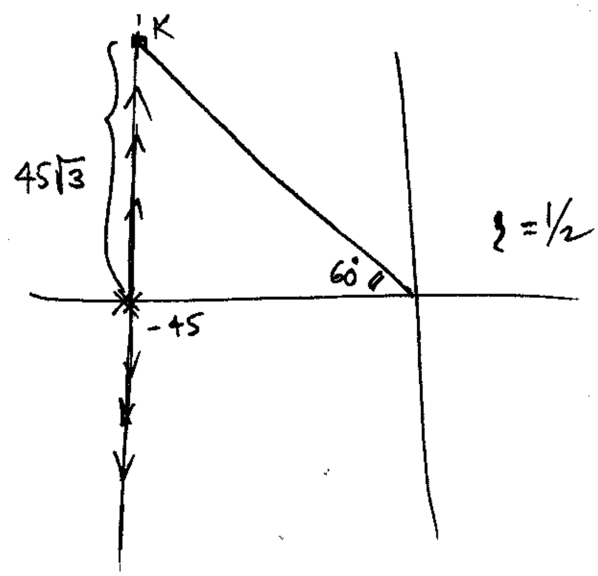
$$T(s) = \frac{K}{(s+45)^2 + K}.$$

Using the root-locus method, determine the value of the gain K so that the closed-loop system has a damping factor $\zeta = \frac{1}{2}$.

$$1 + \frac{K}{(s+45)^2} = 0$$

$$|K| = (45\sqrt{3})(45\sqrt{3})$$

$$= 2025 \times 3 = 6075$$



For $\zeta = \frac{1}{\sqrt{2}} = \frac{\sqrt{2}}{2}$

$$K = 45 \times 45$$

$$= 2025$$