Question 1

(a) (i) $G(s) = \dfrac{k(s+3)}{(s+4)(s^2+4s+5)}$

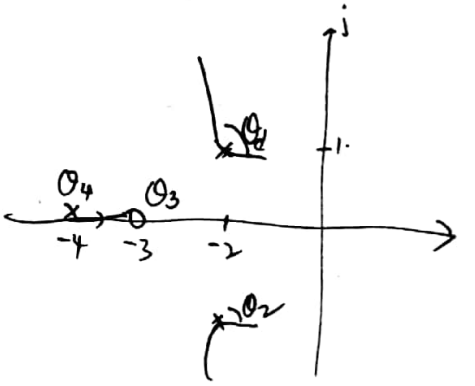
$(s+2+j)(s+2-j)$
$= s^2+4s+5$

(ii) $\sigma_a = \dfrac{(-4-(2+j)-(2-j))-(-3)}{3-1}$

$= -2.5$ #

$\theta_a = \dfrac{(2k+1)\pi}{2} = \dfrac{\pi}{2}, \dfrac{3\pi}{2}$ #

(iii) Angle of Departure



$-\theta_d - \theta_2 + \theta_3 - \theta_4 = 180°$

$-\theta_d - 90° + \tan^{-1}\left(\frac{1}{1}\right) - \tan^{-1}\left(\frac{1}{2}\right) = 180°$

$\theta_d = -251.6°$
$= 108.4°$ #

(b) $\zeta = 0.59$ $OS\% = 10\%$ $\omega_n = 4.08$

(i) $\theta = \cos^{-1} 0.59$
$= 53.84°$

dominant closed-loop poles
$= -2.2 + 1.32j$ #

(ii) $K = \dfrac{L_1 L_2 L_3}{L_4}$

$= 1.27$ #

$L_1 = \sqrt{0.32^2 + 0.2^2} = 0.3774$

$L_2 = 2.3286$

$L_3 = 2.2321$

$L_4 = 1.5435$

Question 1

b)(iii) Third pole = -4

$$\text{Ratio} = \frac{|-4|}{|-2.2|} = 1.818 < 5$$

∴ This system is not second order approximation.

(iv) $T_s = \frac{4}{|R_{real}|} = \frac{4}{|-2.2|} = 1.818\,s$

$$T_p = \frac{\pi}{|I_{mg}|} = \frac{\pi}{1.32} = 2.38\,s$$

dom poles = $-2.2 + 1.32j$

$$K = \frac{|s+4||s^2+4s+5|}{|s+3|} \qquad \overset{sub}{s = -2.2+1.32j}$$

$$= 1.23$$

$$K_p = \lim_{s \to 0} \frac{1.23(s+3)}{(s+4)(s^2+4s+5)}$$

$$= 0.1845$$

$$\therefore e_{ss} = \frac{1}{1+K_p} = \frac{1}{1.1845} = 0.8442$$ //

Question 2

$$G(s) = \frac{K(s^2-2s+8)}{(s+3)(s^2+4s+5)}$$

dom. pole = $-0.88 \pm j1.72$ at 20% OS

(a) $T_{s\,old} = \frac{4}{0.88} = 4.54$

$T_{s\,new} = \frac{3}{5} \times 4.54 = 2.73\,s$

$T_{s\,new} = 2.73 = \frac{4}{\zeta \omega_n}$

$\omega_n = \frac{4}{2.73 \times 0.456} = 3.213$

Real_CL_poles $= -\zeta\omega_n = -1.465$

Img CL poles $= j\omega_d = j\omega_n\sqrt{1-\zeta^2} = j2.86$

CL poles $= -1.465 + j2.86$

$OS = \left(e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}}\right) \times 100\%$

$= 20\%$

$\zeta = 0.456$

$T_p = \frac{\pi}{1.72} = 1.826\,s$

$K = \frac{|s+3||s^2+4s+5|}{|s^2-2s+8|}$ $\quad s = -0.88 + j1.72$

$= 1.07$

$K_v = \lim_{s\to 0} sG(s) = \lim_{s\to 0}$

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Question 3

(a) $G(s) = \frac{12}{s(s+6)}$

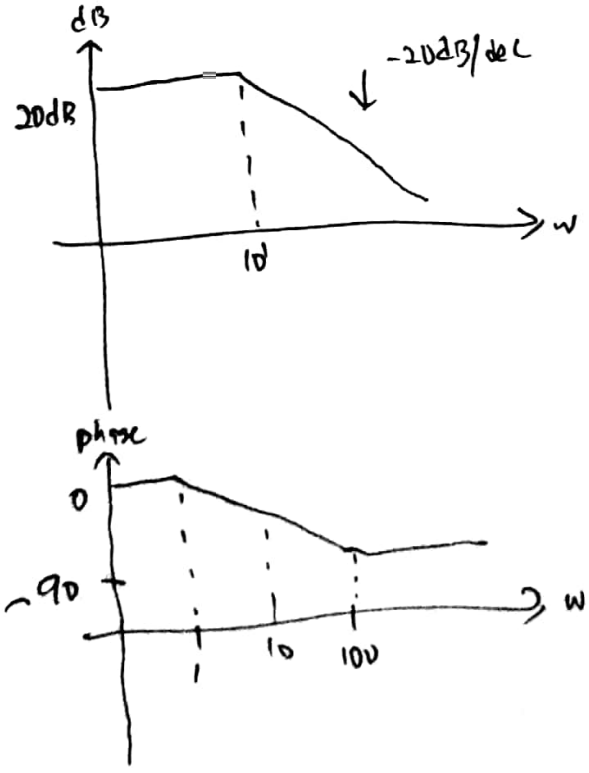
(i) ~~20log12 - 20log~~

$20\log|G(jw)| = 20\log 12 - 20\log(jw) - 20\log|(jw+6)|$

(ii) $w = 20$

~~20log~~$|G(jw)| = 32.74\ dB$

(b) $G(s) = \frac{100}{s+10} = \frac{100}{10} \frac{1}{\frac{s}{10}+1} = 10 \frac{1}{\frac{s}{10}+1}$

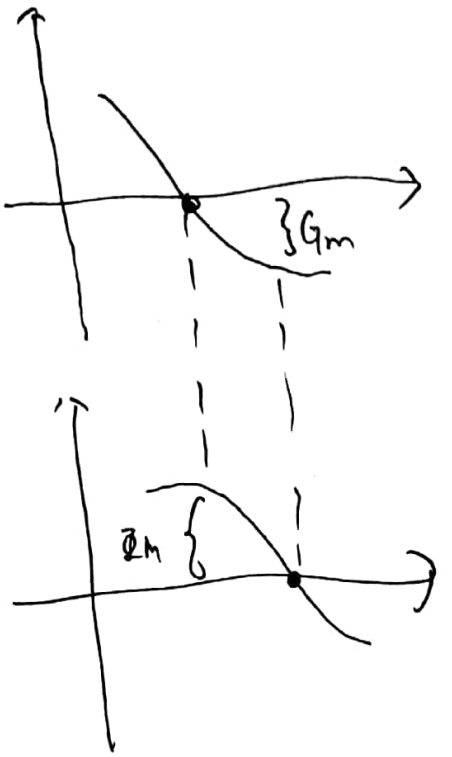


constant = 10 =
$20\log 10 = 20dB$

Question 3

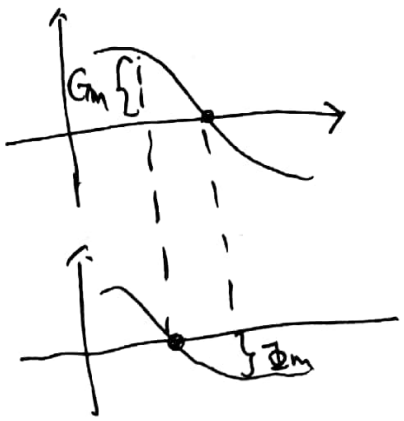
(c)

(i)



Gm and Φm is positive

∴ The system is stable



Gm and Φm is negative

∴ The system is unstable