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Q1

a) i. $G(s) = \dfrac{(s+3)}{(s+4)(s+2+1j)(s+2-1j)}$

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

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

$= \dfrac{-8+3}{2} = -2.5$

$\theta_a = \dfrac{(2k+1)180^\circ}{3-1}$

$= \dfrac{(2k+1)180^\circ}{2}$

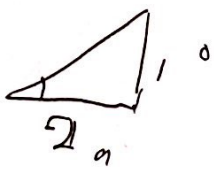
$= \pm 90, \pm 270$

iii. $\theta_1 = \theta_3 - \theta_2 - \theta_4 + 180$

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

$= 45^\circ - 90^\circ - 26.57 + 180^\circ$

$= 108.43^\circ$



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b) $OS = 10\%$ $\zeta = 0.5$ $\omega_n = 4.08$

i) $\cos\theta = \zeta$

$\theta = \cos^{-1} 0.5$

$= 60°$

$S = -2.4 + 3.29j$

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

$= 10.96$

iii) * 3rd pole

$$C1tf = \frac{10.96(s+3)}{(s+4)(s^2+4s+5) + 10.96(s+3)}$$

$=$

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iv) $T_s = \frac{4}{|real|} = \frac{4}{2.4} = 1.67s$

$T_p = \frac{\pi}{|img|} = \frac{\pi}{4} = 0.785s$

$k_p = \lim_{s \to 0} kG(s)$

$= \frac{10.96(s+3)}{(s+4)(s^2+4s+5)}$

$= \frac{10.96(3)}{(4)(5)} = 1.64$

$e_{ss} = \frac{1}{1+1.64} = 0.38$

Q 2

$G(s) = \frac{k(s^2-2s+5)}{(s+3)(s^2+4s+5)}$, $s_d = -0.88 \pm j1.72$ at $\%OS = 20\%$

a) $T_s = \frac{4}{|real|} = \frac{4}{0.88} = 4.55$

$T_{snew} = 2.7s$

$\%OS = 20\%$

$\zeta = \frac{-\ln(\frac{20}{100})}{\sqrt{\pi^2 + \ln^2(\frac{20}{100})}}$

$= \frac{1.6}{3.5} = 0.46$

P_d controller

$T_{snew} = 2.7 = \frac{4}{|real|}$

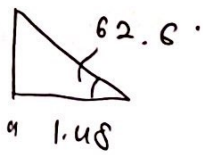
$|real| = 1.48$

$|img| = \tan 62.6 = \frac{o}{1.48}$

$= 2.888$

$s = -1.48 \pm 2.888j$

$T_p = \frac{\pi}{w_d} = \frac{\pi}{|img|}$



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$$k = \frac{|s+3||s^2+4s+5|}{|s^2+3s-2s|}$$

$s = -1.48 + 2.88j$

$$= \frac{|1.52||(1.52+2.88j)(7.024-2.99j)|}{|4.856+14.28j|}$$

$= 2.10$

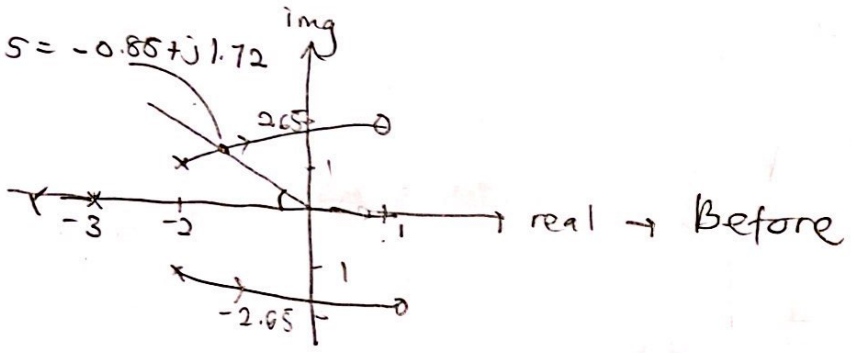
$$e_{ss} = \frac{1}{1+kp} = \frac{1}{1+1.12} = 0.47$$

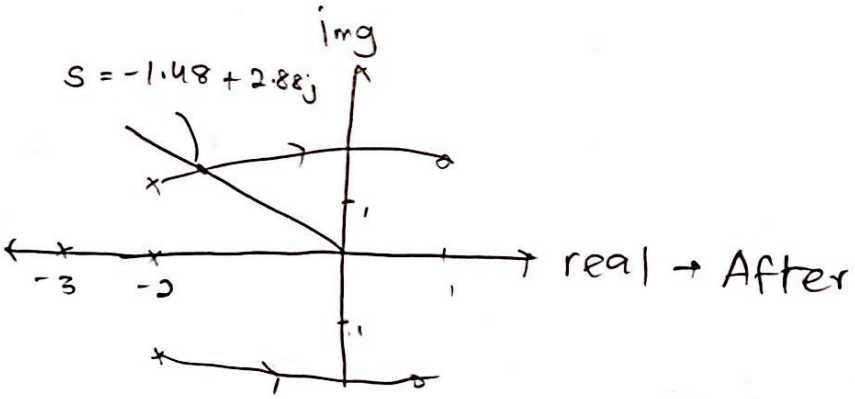
$$kp = \lim_{s\to 0} ck\,Gs$$

$$= \frac{(2.10)|s^2-2s+8|}{8|s+3||s^2+4s+5|}$$

$= 1.12$

b)





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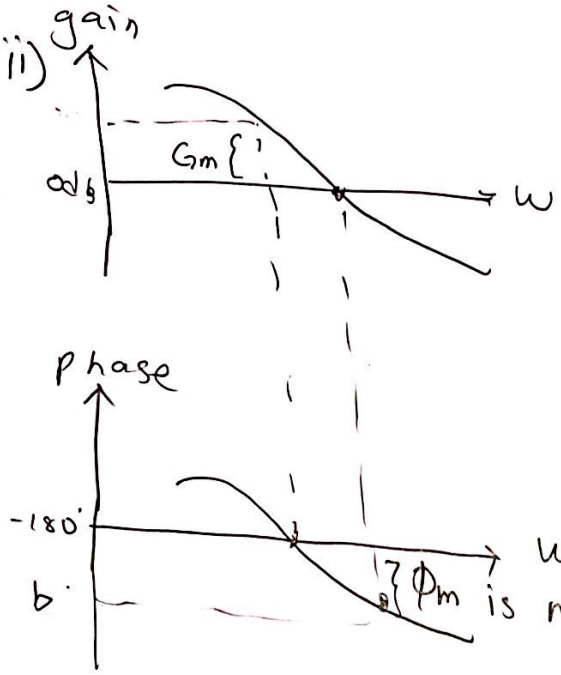
Q3

c) ii)



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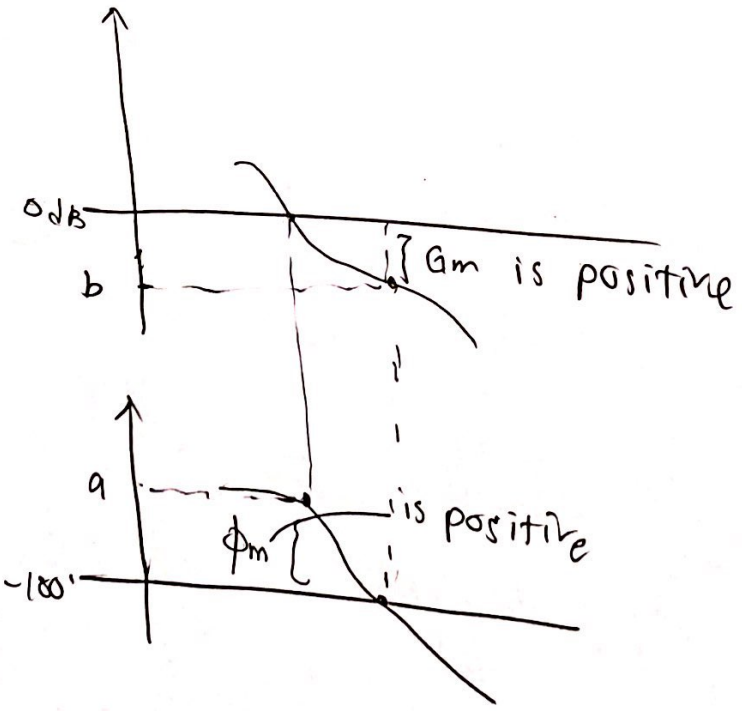
i)



} Stable