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Question 1

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

Zero :-

$s = -3$

Pole :-

$s = -4, -2 \pm j1$

(ii) Asymptote point, σ_a

$$\sigma_a = \frac{[(-4-(-2-j1)-(-2+j1)] - (-3)}{3-1}$$

$= 0$

Angle of Asymptote

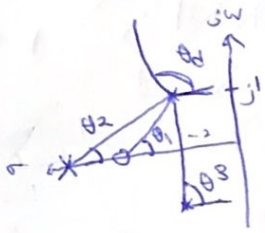
$= \dfrac{(2k+1)180}{2}$

$= 90^\circ, 270^\circ$

(iii) Angle of departure.

$\theta_d = 45 - 26.57 - 90 + 180$

$= 108.43$



b) (i) $OS\% = 10\%$

$\zeta = 0.59$

$\omega_n = 4.08$ rad/s

Dominant CL pole $= -\zeta\omega_n + j\omega_d = -2.4 + j3.3$

$\zeta\omega_n = 0.59 \times 4.08$ $\quad \omega_d = \omega_n\sqrt{1-\zeta^2}$

$= 2.4$ $\quad = 3.3$

(ii) Gain, k

$k = \dfrac{|s+4||s^2+4s+5|}{|s+3|}$, $s = -2.4 + j3.3$

$k = \dfrac{|s+4||s+2-j1||s+2+j1|}{|s+3|}$

$= \dfrac{6.08 \times 37.97}{7.08}$

$= \dfrac{6.08 \times 18.66}{7.08}$

$= 21.3$

(iii)

Third pole $= -7$

Second approximaxition not valid.

(iv) $T_s = \dfrac{4}{|Real|}$

$= \dfrac{4}{2.4}$

$= 1.67$

$T_p = \dfrac{\pi}{3.3}$

$= 0.95s$

$e_{ss} = \dfrac{1}{1+k_p}$

$= \dfrac{1}{1+3.195}$

$= 0.24$

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

$= 3.195$

Question 2

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

$S_d = -0.88 \pm j1.72$, OS % = 20

(a) PD controller.

OS % = 20%

$$T_s = \frac{4}{|Real|} = \frac{4}{0.88} = 4.55s$$

$$\zeta = \frac{-\ln(0.2)}{\sqrt{\pi^2 + \ln^2(0.2)}}$$

$$= 0.46$$

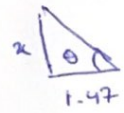
$$\theta = \cos^{-1}(0.46)$$

$$= 62.6^\circ$$

$$T_{s\,new} = \frac{3}{5} \times 4.55$$

$$= 2.73s$$

$$2.73 = \frac{4}{|Real|}$$



$$Real = \frac{4}{2.73}$$

$$= 1.47$$

$$\tan 62.6 = \frac{x}{1.47}$$

$$x = 2.84$$

$$S_{d\,new} = -1.47 + j2.84$$

$$G_{PD} = s+2$$

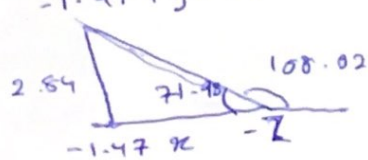
$$G_{PD}G = \frac{k(s+2)(s^2-2s+8)}{(s+3)(s^2+4s+5)}$$

$$\angle s+2 + \angle s-1+j\sqrt{7} + \angle s-1-j\sqrt{7} - \angle s+3 - \angle s+2-j1 - \angle s+2+1j = 180$$

$s = -1.47 + j2.84$

$$\angle s+2 + \angle 114.24 + \angle 175.5 - \angle 61.69 - \angle 73.93 - \angle 82.14 = 180$$

$$\angle s+2 = 108.02$$



$$x = \frac{2.84}{\tan 71.98}$$

$$x = 0.92$$

$$-z = -0.55$$

$G_{PD} = s + 0.55$

$$k = \frac{|s+3||s+2-j1||s+2+j1|}{|s-\#1-\sqrt{7}||s-1+\sqrt{7}j|}$$

$$= \frac{|6.2||5.3||5.3|}{|3.44||3.44|}$$

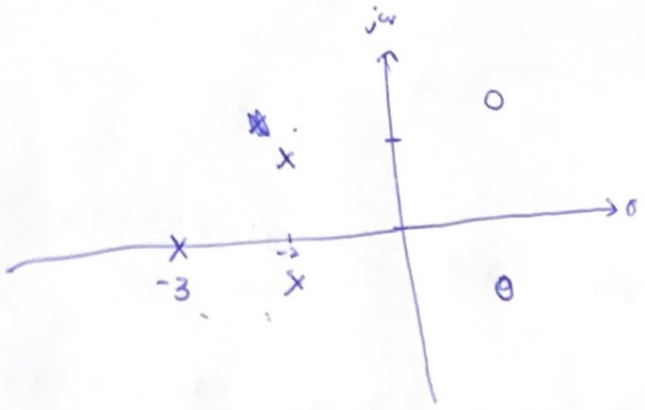
$$= 14.72$$

$$G_{PD}\,G(s) = \frac{14.72(s+0.55)(s^2-2s+8)}{(s+3)(s^2+4s+5)}$$

$$k_p = 0.55 \times 14.72$$
$$= 8.096$$

$$k_d = 14.72 -$$

b) Compensated



Question 3

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

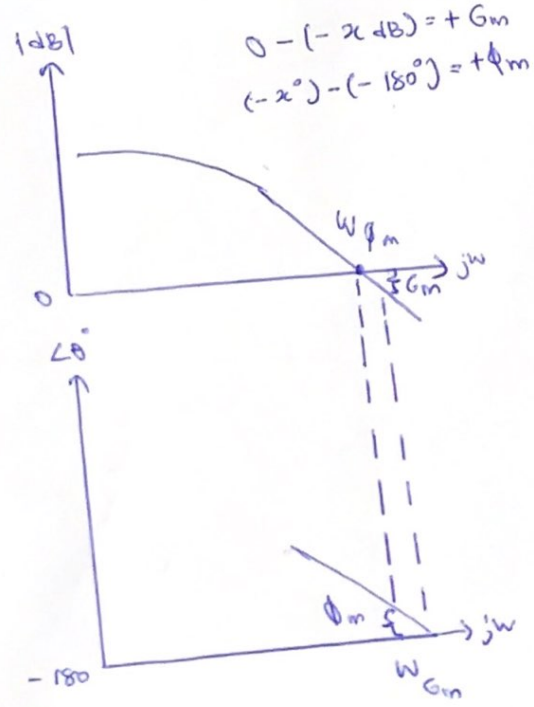
(i) $|G(jw)| = 20\log 12 - 20\log|jw| - 20\log|j(jw+6)|$

(ii) $|G(jw)| = 21.58 - 24.02 - 26.39$

$= -30.83$ dB

(b)

(c) (i) Stable system



(ii) Unstable system