(1.6.9) Echo Canceler:

$$r(n) = x(n) + \left(\frac{2}{3}\right) x(n-10)$$

$$R(z) = X(z)\left[1 + (2/3)z^{-10}\right]$$

$$H(z) = \frac{R(z)}{X(z)} = \left[1 + (2/3)z^{-10}\right]$$

to remove echo $H(z) \cdot G(z) = 1$

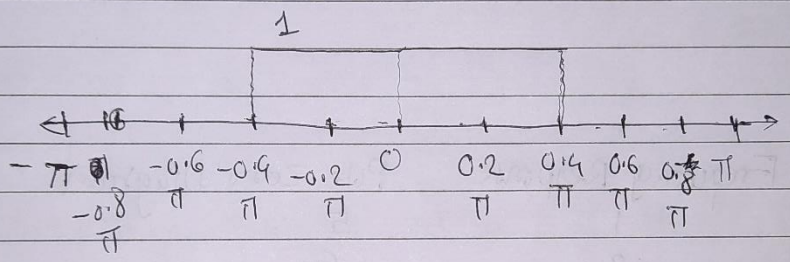
$$G(z) = \frac{1}{H(z)} = \frac{1}{1 + (2/3)z^{-10}}$$

1.8.10

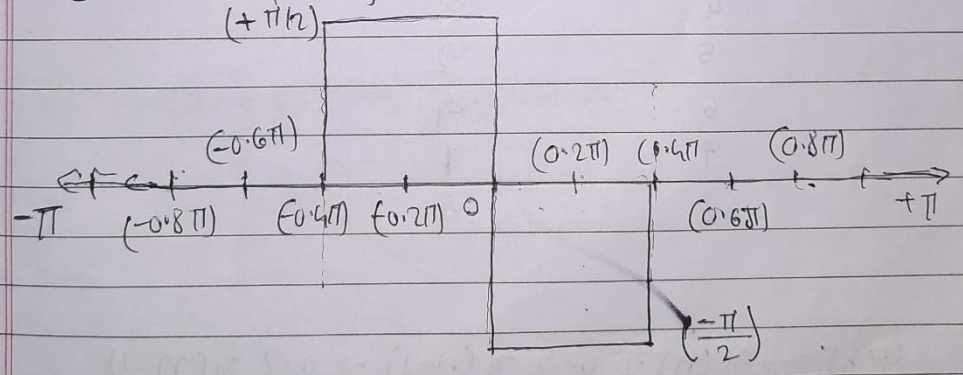
$$H^f(\omega) = \begin{cases} -j, & 0 < \omega \leq 0.4\pi \\ j, & -0.4\pi \leq \omega < 0\pi \\ 0, & 0.4\pi < |\omega| \leq \pi \end{cases}$$

	$\lvert H^f(\omega)\rvert$	$\angle(H^f(\omega))$	
$-j$	1	$(-\pi/2)$	$0 < \omega \leq 0.4\pi$
$+j$	1	$(1/2)\pi$	$-0.4\pi \leq \omega < 0$
0	0	0	$0.4\pi < \lvert\omega\rvert \leq \pi$

(a) Frequency Response magnitude



(b) Frequency Response phase.



(c) $x(n) = 2 \cdot \cos(0.3\pi n) + 0.7 \cdot \cos(0.7\pi n) + (-1)^n$

output

$$y(n) = 2 \cdot (1) \cdot \cos(0.3\pi n - (0.5)\pi) + (0.7)(0) \cdot \cos(0.7\pi n) + (0) \cdot (-1)^n$$

$$y(n) = 2 \cdot \cos(0.3\pi \cdot n - 0.5\pi)$$

(1.8.19)

$x_1(n) = \cos(0.9\pi n) \cdot u(n-4)$

$x_2(n) = (0.75) \cdot \cos(0.07\pi n) \cdot u(n-4) + (0.25) \cdot (-1)^n \cdot u(n-4)$

Input signal	system	output signal
1	1	3
1	2	2
2	1	4
2	2	1

(1.8.22)

Frequency Response	Pole-zero Diagram
1	5
2	6
3	7
4	3
5	2
6	4
7	1
8	8

(1.9.3)

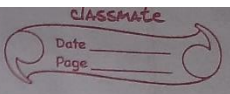
$y(n) = x(n) + 0.5\, x(n-1) + 0.2\, y(n-1)$

$Y(z) \cdot [1 - 0.2 z^{-1}] = X(z)[1 + 0.5 z^{-1}]$

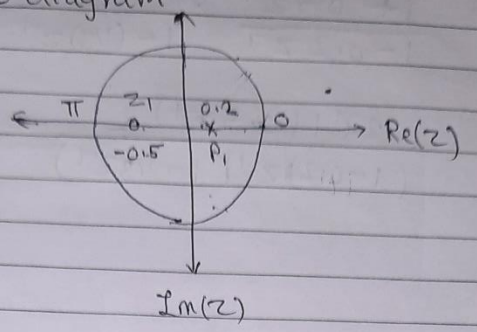
$H(z) = \dfrac{1 + 0.5 z^{-1}}{1 - 0.2 z^{-1}}$

$P_1 = 0.2$ $\quad z_1 = -0.5$

1.9.3



(a) Pole-Zero diagram



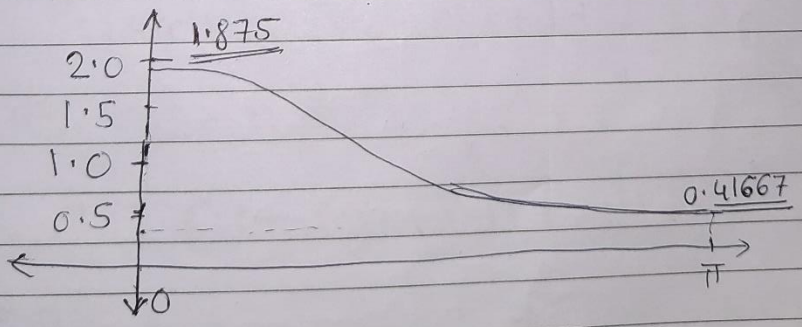
(b) DC gain of the system. $H_f(e^{j\omega}) = \frac{1+(0.5)(e^{j\omega})}{1-(0.2)(e^{j\omega})}$

$$|H_f(0)| = \frac{(1+0.5)}{(1-0.2)} = \frac{1.5}{0.8} = 1.875$$

(c) Frequency response at $\omega = \pi$ $H(e^{j\pi}) = \frac{1+0.5 \cdot e^{j\pi}}{1-0.2\, e^{j\pi}}$

$$|H_f(e^{j\pi})| = \frac{0.5}{1.2} = 0.41667$$

(d) Frequency Response Magnitude.



(e) $x(n) = 2\left(\frac{1}{3}\right)^n \cdot u(n)$

$$X(z) = \frac{2}{1-(1/3)z^{-1}}$$

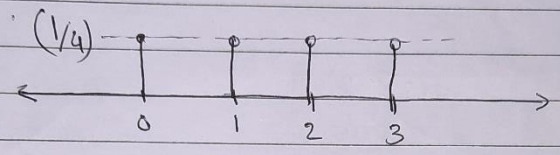
1.9.12

$$y(n) = \left(\frac{1}{4}\right) \sum_{k=0}^{3} x(n-k)$$

(a) $y(n) = \left(\frac{1}{4}\right) [x(n) + x(n-1) + x(n-2) + x(n-3)]$

Impulse response $x(n) = \delta$

$$h(n) = \frac{1}{4} [\delta(n) + \delta(n-1) + \delta(n-2) + \delta(n-3)]$$



(b) $H(z) = (1/4)[1 + z^{-1} + z^{-2} + z^{-3}]$

Maximum power of z is 3

there are 3 roots of equation therefor 3 Zeros

(c) $H^f(e^{j\omega}) = (1/4)[1 + e^{-j\omega} + e^{-2j\omega} + e^{-3j\omega}]$

Dc gain $\omega = 0$

$$|H(e^0)| = (1/4)[1+1+1+1] = 1$$

(d) $H^f(0.5\pi) = H(e^{j0.5\pi}) = \frac{1}{4}(1 + e^{-j0.5\pi} + e^{-j1.0\pi} + e^{-j1.5\pi})$

$= (1/4)[1 + (-j) + (-1) + (+j)]$

$= 0$

(e) $Hf(\pi) = H(e^{j\pi}) = (1/4)(1 + e^{-j\pi} + e^{-2j\pi} + e^{-3j\pi})$

$= (1/4)(1 + (-1) + 1 + (-1))$

$= 0$

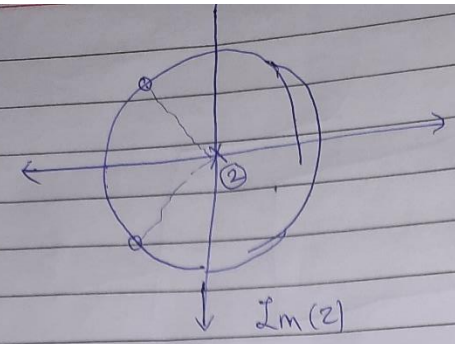
(1.11.1)

Impulse Response	Frequency Response	Pole-Zero Diagram
1	2	3
2	4	1
3	3	2
4	1	4

(1.11.4)

Impulse Response	Pole-Zero Diagram	Frequency Response.
1	3	7
2	6	8
3	5	2
4	7	1
5	4	6
6	8	3
7	1	5
8	2	4

1.10.1



$z_1 = 1 \cdot e^{j0.75\pi}$ $\quad z_2 = 1 \cdot e^{-j0.75\pi}$

Unity DC gain $|Hf(0)| = 1$

$$H(z) = \frac{k\,(z - e^{j0.75\pi})(z - e^{-j0.75\pi})}{z^2}$$

$$= \frac{k\,(z^2 - z \cdot 2 \cdot \cos(0.75\pi) + 1)}{z^2}$$

$$H(1) = k\,[2 - 2\cos(0.75\pi)] = 1$$

$$k = \frac{1}{2 - 2\cos(0.75\pi)} = 0.2928$$

$$\frac{Y(z)}{X(z)} = H(z) = (0.2928)\,(1 - 2z^{-1}(-0.707) + z^{-2})$$

(a) $y(n) = (0.2928) \cdot x(n) + (0.414) \cdot x(n-1) + (0.2928) \cdot x(n-2)$

(c) Frequency Response magnitude $|Hf(\omega)|$