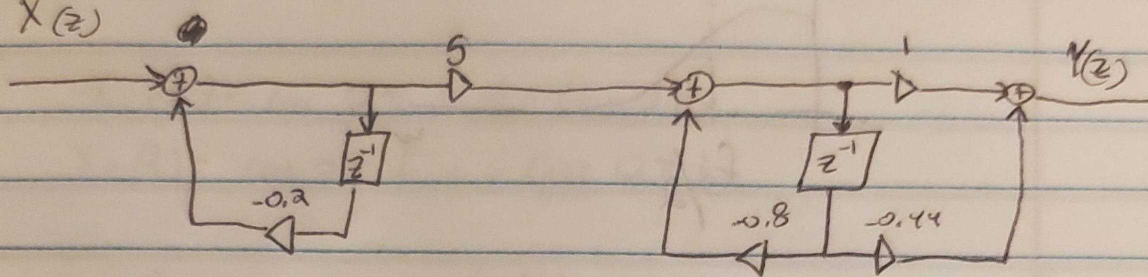
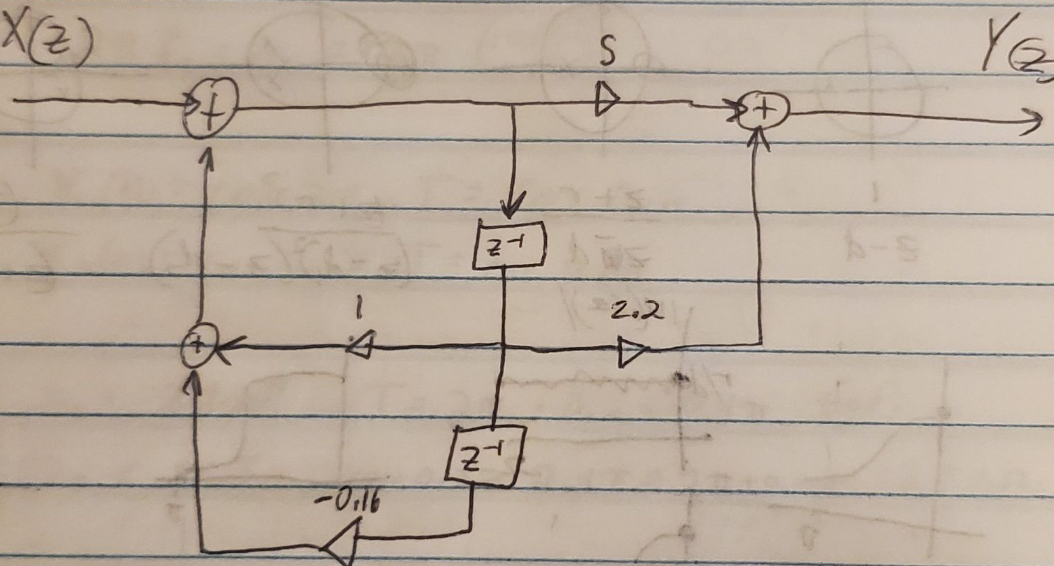
5.4-3

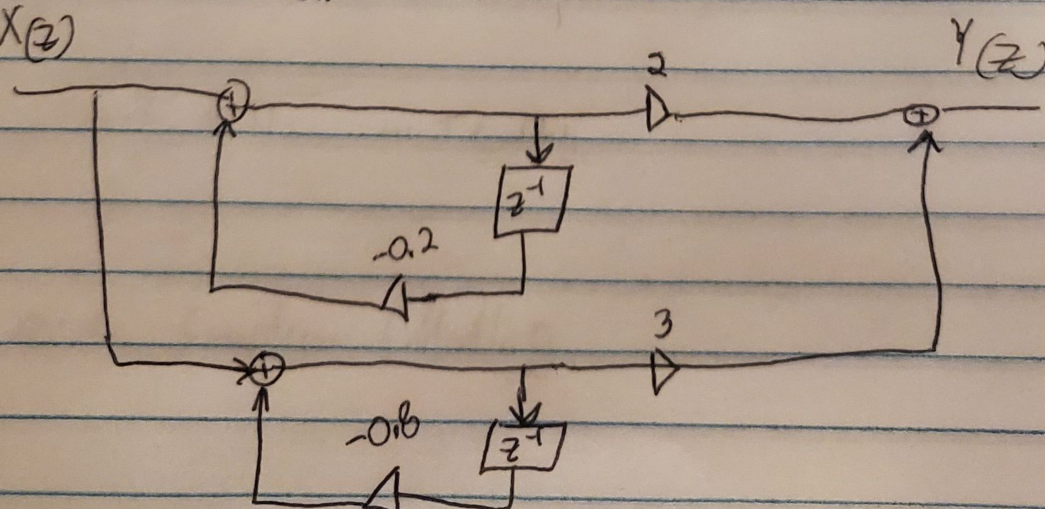
a) $H(z) = \dfrac{5z + 2.2}{z^2 + z + 0.16} = \dfrac{5(z + 0.44)}{(z + 0.2)(z + 0.8)}$

$= \left(\dfrac{5}{z + 0.2}\right)\left(\dfrac{z + 0.44}{z + 0.8}\right)$

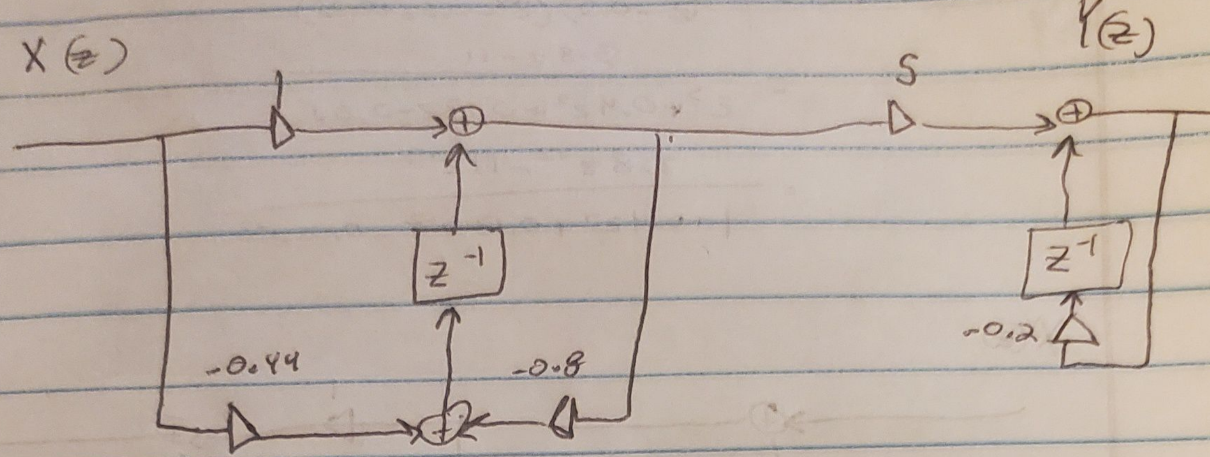


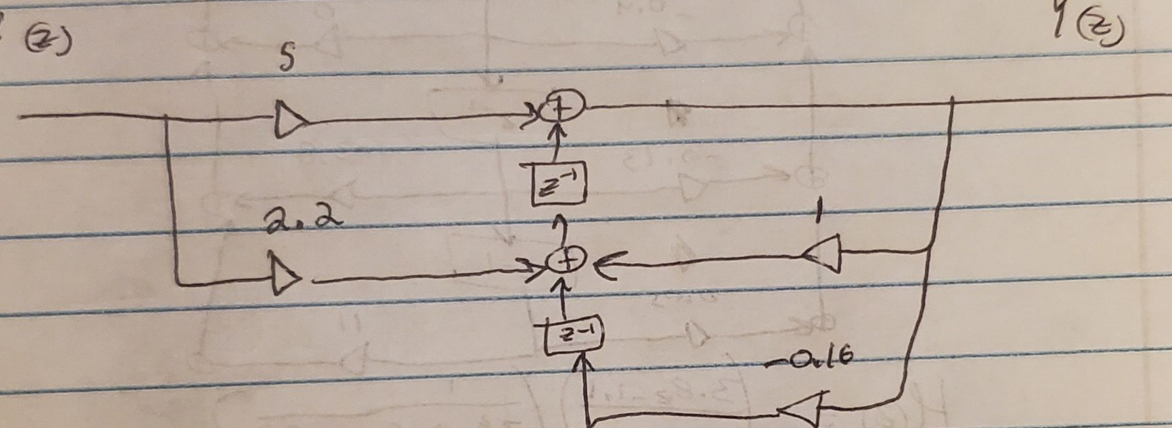


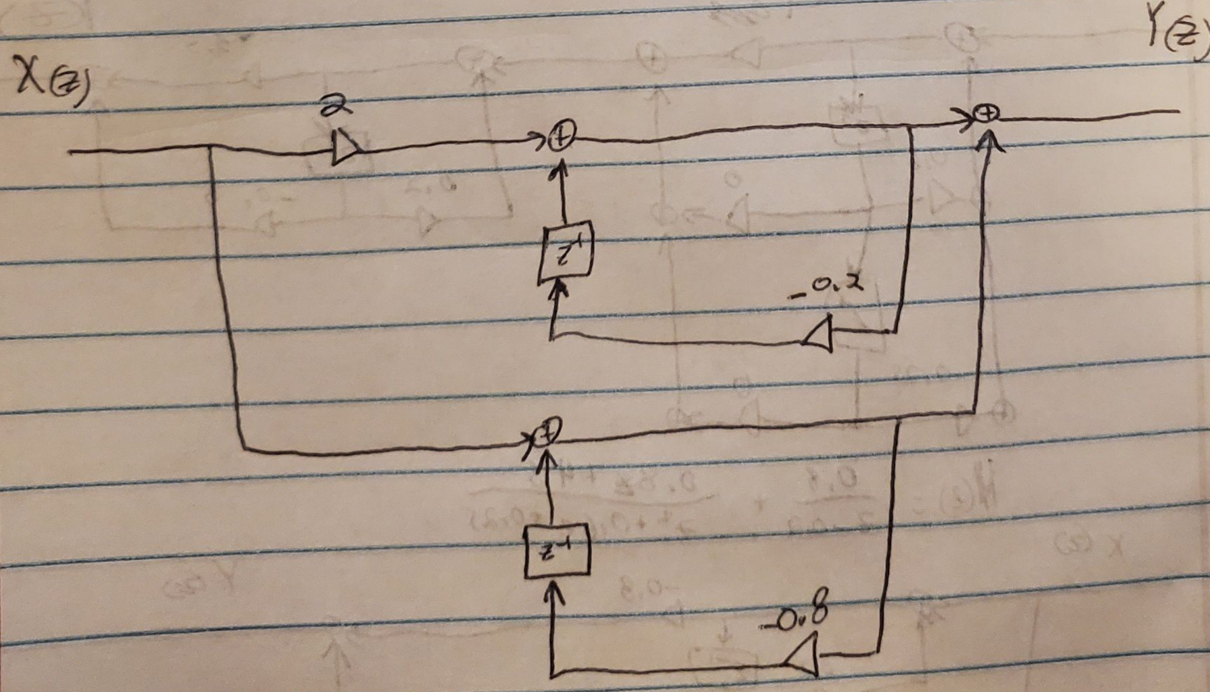
$H(z) = \dfrac{2}{x + 0.2} + \dfrac{3}{x + 0.8}$



b)



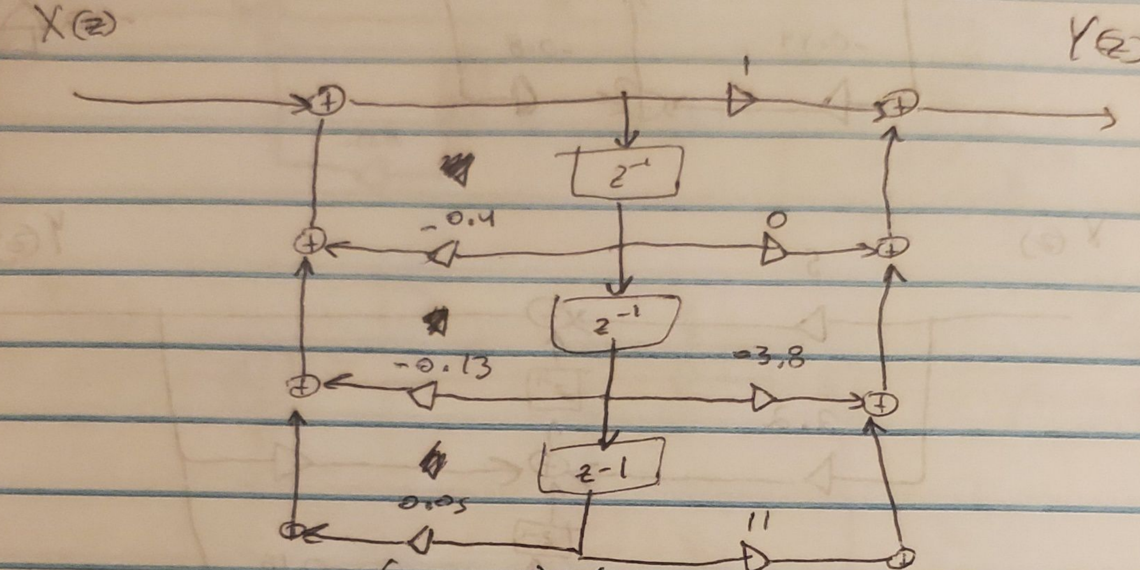




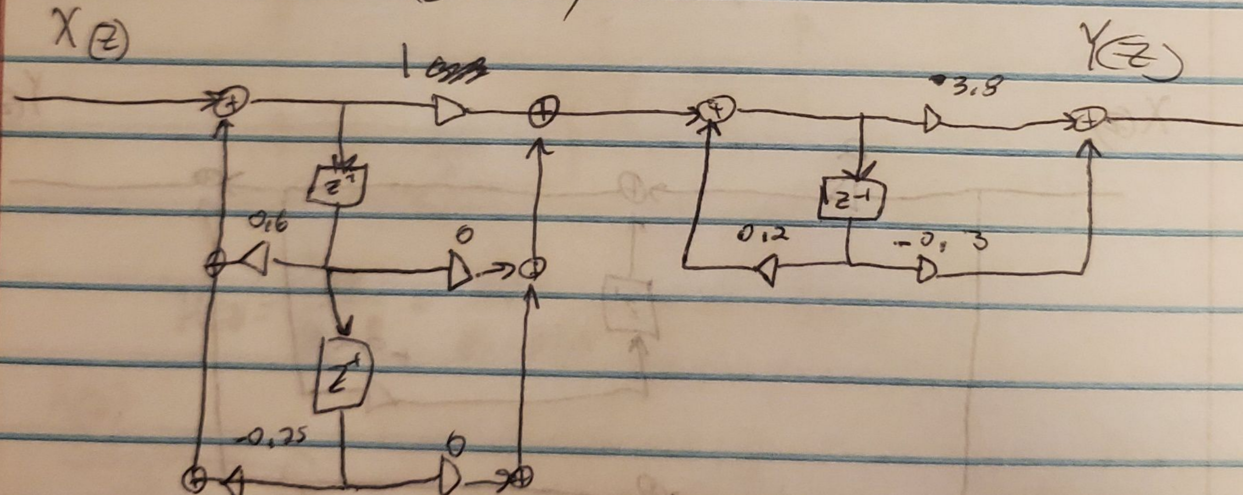
5.4-4 $H(z) = \dfrac{3.8z - 1.1}{(z-0.2)(z^2-0.6z+0.25)}$

$$= \frac{3.8z - 11}{z^3+0.4z^2+0.13z-0.05}$$

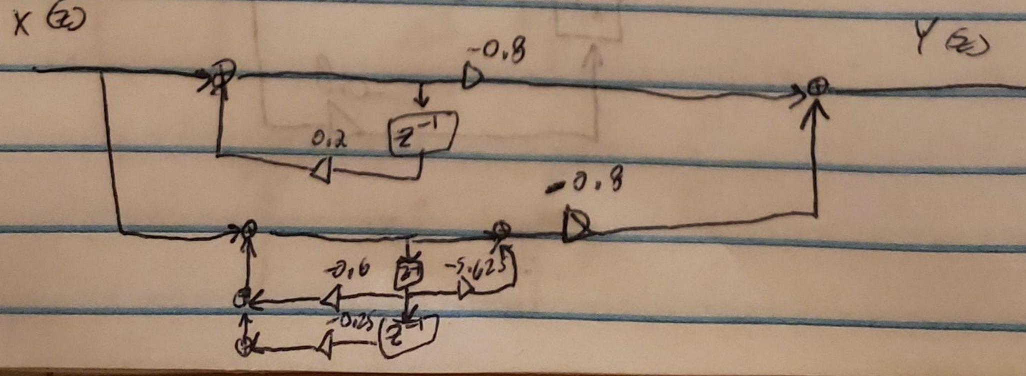
$$= \frac{3.8z^{-2} - 11z^{-3}}{1+0.4z^{-1}+0.13z^{-2}-0.05z^{-3}}$$



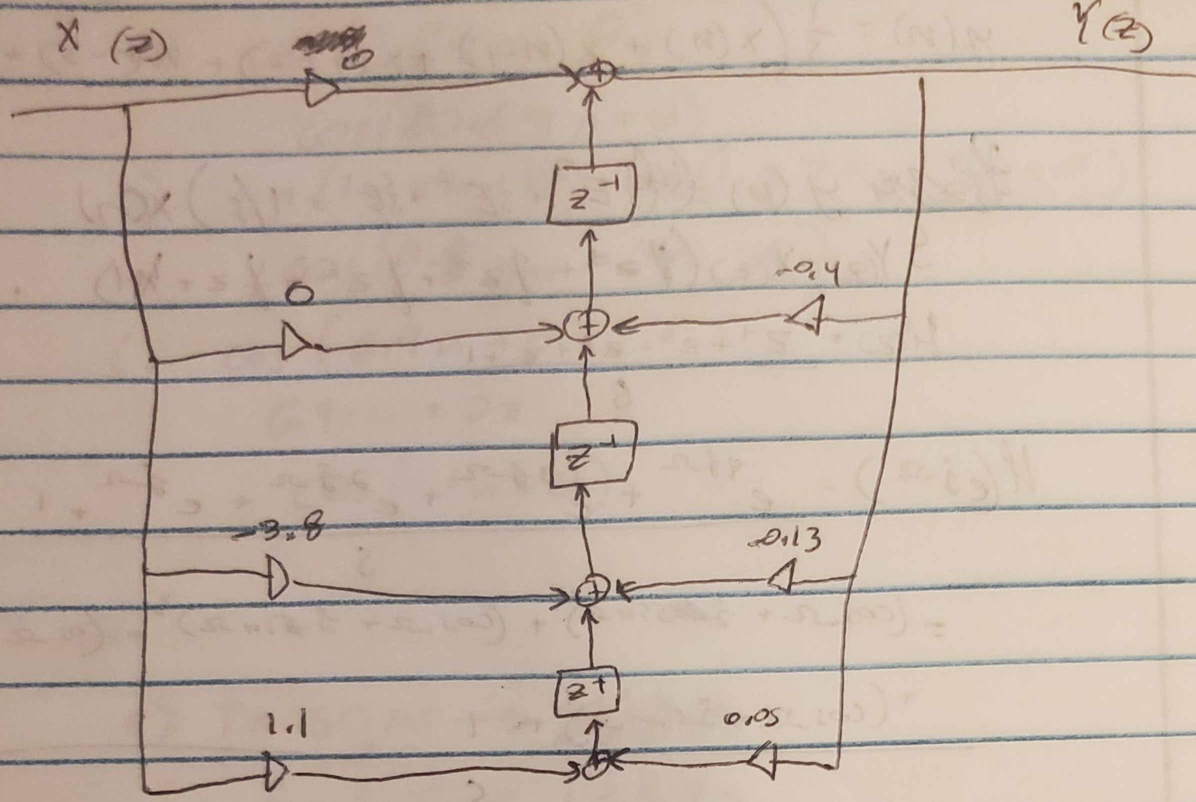
$$H(z) = \left(\frac{3.8z-1.1}{z-0.2}\right)\left(\frac{1}{z^2-0.6z+0.25}\right)$$

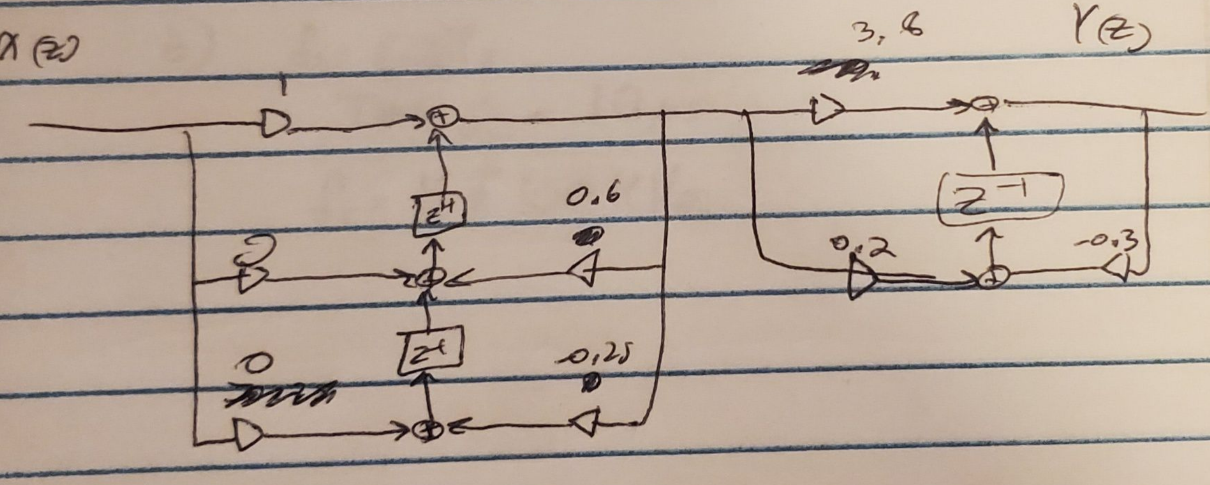


$$H(z) = \frac{0.8}{z-0.2} + \frac{0.8z+4.5}{z^2+0.6z+0.25}$$



b)





5.5-6

$$y(n) = \frac{1}{5}\left(x(n) + x(n-1) + x(n-2) + x(n-3) + x(n-4)\right)$$

$$y(n) = \left(\tfrac{1}{5}E^4 + \tfrac{1}{5}E^3 + \tfrac{1}{5}E^2 + \tfrac{1}{5}E + 1/5\right)x(n)$$

$$5\,Y(z) = X(z)\left(z^4 + z^3 + z^2 + z + 1\right)$$

$$H(z) = \frac{z^4 + z^3 + z^2 + z + 1}{5}$$

$$H(e^{j\Omega}) = \frac{e^{4j\Omega} + e^{3j\Omega} + e^{2j\Omega} + e^{j\Omega} + 1}{5}$$

$$= \frac{(\cos\Omega + j\sin\Omega)^4 + (\cos\Omega + j\sin\Omega)^3 + (\cos\Omega + j\sin\Omega)^2 + (\cos\Omega + j\sin\Omega)^1 + 1}{5}$$

5.5-8

$$y(n+1) - 0.5y(n) = x(n+1) + 0.8x(n)$$

$$Y(z)(z-0.5) = X(z)(z+0.8)$$

$$H(z) = \frac{z+0.8}{z-0.5}$$

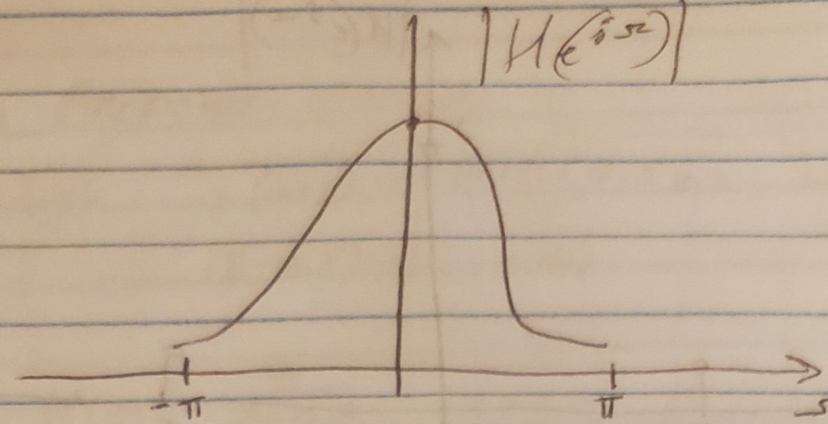
a) frequency response $\quad H_e(e^{j\Omega}) = H(z)\Big|_{z=e^{j\Omega}} = \frac{e^{j\Omega}+0.8}{e^{j\Omega}-0.5}$

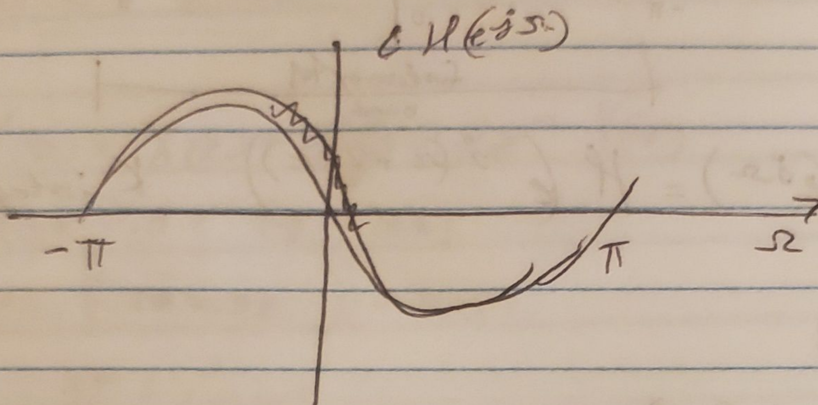
$$= \frac{\cos\Omega + j\sin\Omega + 0.8}{\cos\Omega + j\sin\Omega - 0.5}$$

$$|H(e^{j\Omega})| = \sqrt{\frac{(\cos\Omega+0.8)^2 + j\sin^2\Omega}{(\cos\Omega-0.5)^2 + j\sin^2\Omega}} = \sqrt{\frac{\cos^2\Omega + 1.6\cos\Omega + 0.64 + \sin^2\Omega}{\cos^2\Omega - \cos\Omega + 0.25 + \sin^2\Omega}}$$

$$= \sqrt{\frac{1.64 + 1.6\cos\Omega}{1.25 - \cos\Omega}} = \sqrt{H(e^{j\Omega})H^*(e^{-j\Omega})}$$

$$\angle H(e^{j\Omega}) = \tan^{-1}\left(\frac{\sin\Omega}{\cos\Omega+0.8}\right) - \tan^{-1}\left(\frac{\sin\Omega}{\cos\Omega-0.5}\right)$$





b) $x(n) = \cos\left(0.5n - \frac{\pi}{3}\right)$

$\uparrow$
Ω

$y(n) = \left| H\left(e^{j0.5}\right) \right| \cos\left(0.5n - \pi/3 + \angle H\left(e^{j0.5}\right)\right)$

abs(H(exp(0.5 * j)))   angle(H(exp(0.5 * j)))

8.5-9

$x(n) = e^{j\Omega n} u(n) \qquad H(e^{j\Omega}) \cdot e^{j\Omega n} u(n)$

$Y(z) = H(z) X(z)$

$X(z) = \frac{z}{z - e^{j\Omega}}$

$Y(z) = \frac{z}{z - e^{j\Omega}} H(z) \qquad H(z) = \frac{B(z)}{A(z)} = \frac{B(z)}{(z-p_1)(z-p_2)\cdots}$

$\frac{Y(z)}{z} = \frac{B(z)}{(z-p_1)(z-p_2)\cdots(z-e^{j\Omega})} = \frac{C_0}{z-e^{j\Omega}} + \frac{C_1}{z-p_1} + \frac{C_2}{z-p_2} + \cdots$

$z - e^{j\Omega} = 0 \qquad C_0 = \frac{B(z)}{(z-p_1)(z-p_2)\cdots} = H(z)$

$Y(z) = z\frac{C_0}{z-e^{j\Omega}} + z\sum_{i=1}^{N}\frac{C_i}{z-p_i} = H(e^{j\Omega})\frac{z}{z-e^{j\Omega}} + \sum_{i=1}^{N}\frac{C_i z}{z-p_i}$

$y(n) = H(e^{j\Omega}) e^{j\Omega n} u(n) + \sum_{i=1}^{N} C_i p_i^{n} u(n)$

5.5-10

a) $\cos(0.8\pi n + \theta)$

$\cos(0.8\pi n + \theta)$

b) $\sin(1.2\pi n + \theta) = \cos(1.2\pi n - \pi/2 + \theta)$

$\cos(0.8\pi n - \pi/2 - \theta)$

c) $\cos(6.9n + \theta)$

$6.9 = 1.1 + 2\pi$

$\cos(1.1n + \theta)$

5.5-12

a) $T = 50\,\mu s \rightarrow$

$f_h < \frac{1}{2T} = 10\,kHz$

b) $f_h = 50\,kHz$

$T < \frac{1}{2f_h} = 10\,\mu s$

$f_s = 1/T \geq 100\,kHz$