

Question One

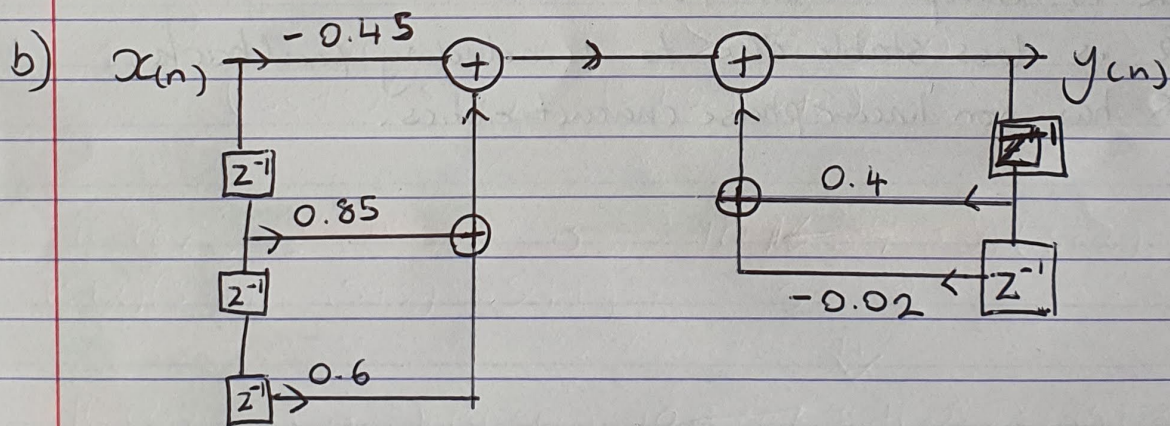
a)
$$\frac{Y_z}{X_z} \quad y(n) - 0.4y(n-1) + 0.02y(n-2) = -0.45x(n) + 0.85x(n-1) + 0.6x(n-3)$$

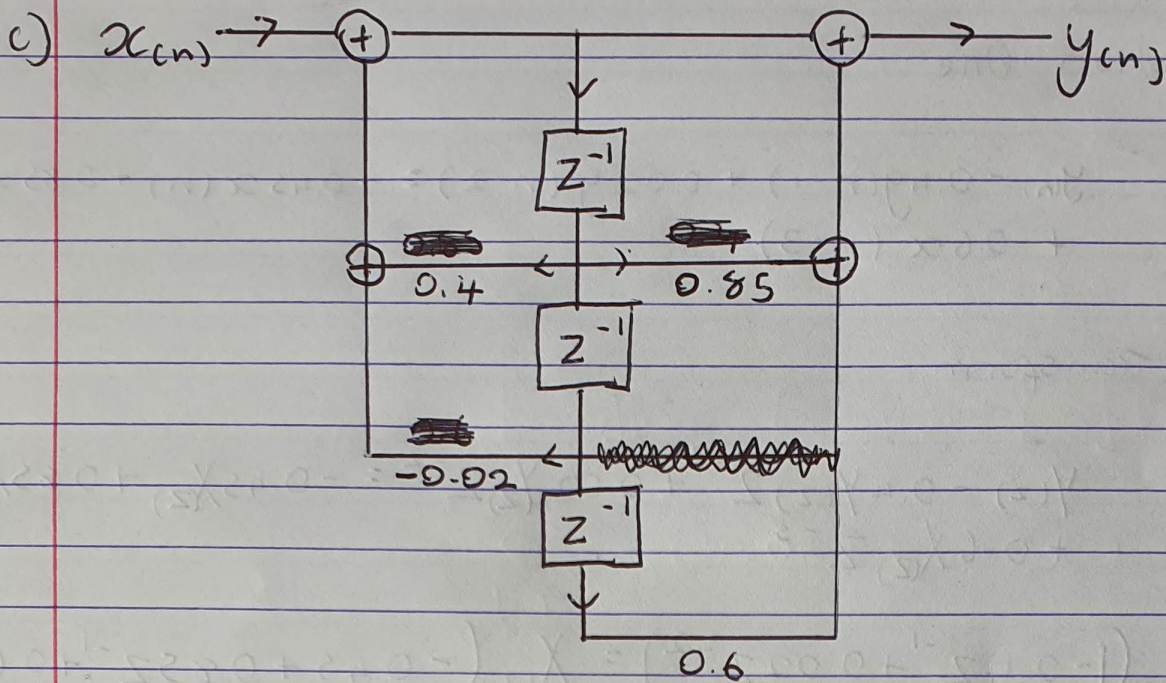
Z Transform

$$Y(z) - 0.4Y(z)Z^{-1} + 0.02Y(z)Z^{-2} = -0.45X(z) + 0.85X(z)Z^{-1} + 0.6X(z)Z^{-3}$$

$$Y(z)(1 - 0.4Z^{-1} + 0.02Z^{-2}) = X(z)(-0.45 + 0.85Z^{-1} + 0.6Z^{-3})$$

$$\frac{Y_z}{X_z} = \frac{-0.45 + 0.85Z^{-1} + 0.6Z^{-3}}{1 - 0.4Z^{-1} + 0.02Z^{-2}}$$





d) Direct form II has half as many delay blocks.

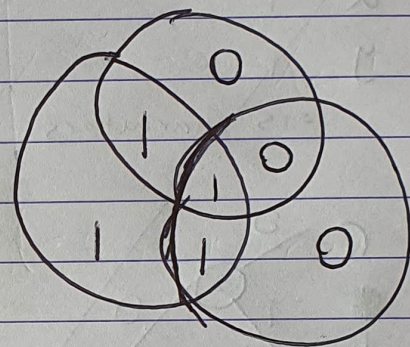
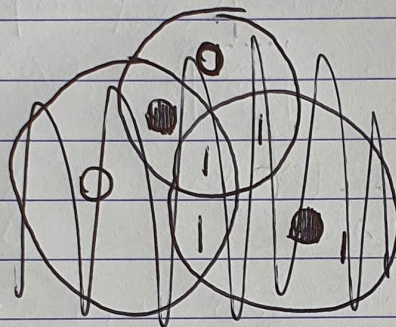
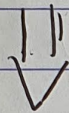
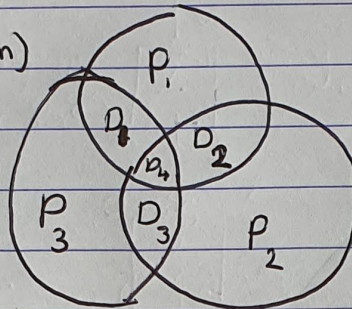
e) IIR is cheaper than FIR

IIR is less stable due to it including feedback

IIR has non linear phase characteristics.

Question Two

a) 1 0 1 1 (even)
 D_1, D_2, D_3, D_4



1 0 1 1 0 0 1
 $D_1, D_2, D_3, D_4, P_1, P_2, P_3$

b) 1 0 1 1 0 0 1 0 1 0 1 0 0 0 1 0

(even)

P_1 - wrong
 P_2 - right
 P_3 - wrong
 P_4 - wrong

error

$8 + 4 + 1 = 13^{\text{th}}$ bit - change to 1

P_1 - ✓

P_2 - ✓

P_3 - ✓

P_4 - ✓

c)

94

0 3

51

- 2

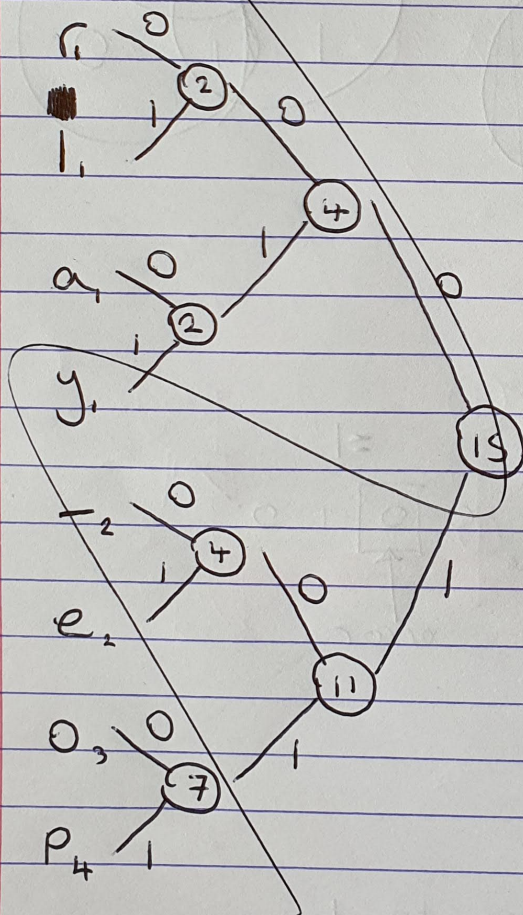
22

41

$$a \setminus 1$$

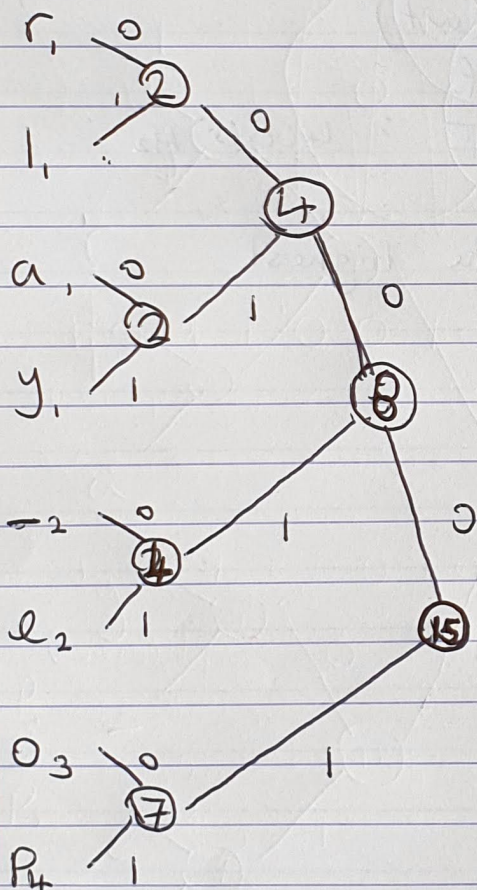
g

= 15 characters



0) ~~p~~ 4
~~o~~ 3
~~r~~ 1
~~-~~ 2
~~e~~ 2
~~i~~ 1
 a 1
 y 1

= 15 characters



r = 0000
 l = 0001
 a = 0010
 y = 0011
 - = 010
 e = 011
 o = 10
 p = 11

Question Three

a) 1, $4 \cos(6000\pi t) = A \cos(\omega t)$

$$6000\pi = \omega = 2\pi f$$

$$f = \frac{6000\pi}{2\pi} = 3000 \text{ Hz}$$

2, $2 \cos(16000\pi t) = A \cos(\omega t)$

$$16000\pi = \omega = 2\pi f$$

$$f = \frac{16000\pi}{2\pi} = 8000 \text{ Hz}$$

3, $2 \cos(8000\pi t) = A \cos(\omega t)$

$$8000\pi = \omega = 2\pi f$$

$$f = \frac{8000\pi}{2\pi} = 4000 \text{ Hz}$$

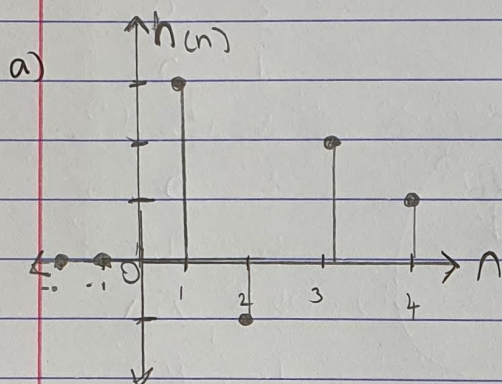
Niquist sample rate = x2 of the highest

$$\therefore = 16000 \text{ Hz}$$

b)

- c) - a sample rate of at least two times the highest ~~sum~~ frequency.
- Low pass filter to remove higher frequencies.

Question Four



b)

n	0	1	2	3
$h(n)$	3	-1	2	1
$x(n)$				

Question Six

~~passband ripple $A_p = 0.1$ dB~~

a) minimum stop-band attenuation $A_s = 50$ dB

$$A_s = -20 \log_{10}(\delta_s)$$

$$\delta_s = \log_{10}^{-1} \left[\frac{-50}{20} \right] = 0.00316$$

passband ripple $A_p = 0.1$ dB $A_p = 20 \log_{10}(1 + \delta_p)$

$$\delta_p = \log_{10}^{-1} \left[\frac{0.1}{20} \right] - 1 = 0.0116$$

referring to window functions table hamming is suitable. hamming window has $\Delta F = 3.3/N$

~~$N = 3.3$~~ $\Delta F = \Delta f / f_s = \frac{100}{8 \times 10^3} = 0.0125$

$$N = \frac{3.3}{0.0125} = 264$$

$\therefore$ round up to the nearest odd number
so number of taps = 265

~~16/11~~

$$b) \quad w[n] = 0.54 - 0.46 \cos \left[\frac{2\pi n}{N-1} \right] \quad \text{from window function table}$$

$$w[n] = 0.54 - 0.46 \cos \left[\frac{2\pi n}{264} \right]$$

$$\text{ideal response} \quad h_p[n] = 2F_c \cdot \frac{\sin(n\Omega_c)}{n\Omega_c}$$

$$\Omega_c = 2\pi(F_p + 0.5 \cdot \Delta F) = 2\pi(\dots)$$

$$f_p = 300$$

$$F_p = \frac{f_p}{f_s}$$

$$= \frac{300}{8 \times 10^3} = 0.0375$$

$$\Omega_c = 2\pi(F_p + 0.5 \cdot \Delta F) = 2\pi(0.0375 + 0.0125) = 2\pi(0.05)$$

$$h_p[n] = \frac{\sin(2\pi \cdot 0.05 \cdot n)}{\pi n}$$

$$\cancel{h_p[s] = \frac{\sin(2\pi \cdot 0.05 \cdot s)}{\pi(s)}}$$

$$h_p[s] = \frac{\sin(2\pi \cdot 0.05 \cdot s)}{\pi s} \times \left[0.54 - 0.46 \cos \left[\frac{2\pi s}{264} \right] \right]$$

$$= 1.745 \times 10^{-3} \times 0.14$$

$$= 2.443 \times 10^{-4}$$