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Theoretical calculations:-

$y[n] = \frac{1}{2}y[n-1] + x[n]$

$y[n] - \frac{1}{2}y[n-1] = x[n]$

Taking ZT on either sides

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

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

$Y(z)\left(1 - \frac{1}{2}z^{-1}\right) = X(z)$

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

We know that $H(z) = \frac{Y(z)}{X(z)} = \frac{1}{(1-\frac{1}{2}z^{-1})}$ — ①

Then frequency response of system is obtained when $z$ is replaced with $e^{j\Omega}$

$$H(e^{j\Omega}) = \frac{1}{1-\frac{1}{2}e^{-j\Omega}} = \frac{1}{1-\frac{1}{2}(\cos\Omega - j\sin(\Omega))}$$

$$|H(e^{j\Omega})| = \frac{1}{\sqrt{(1-\frac{1}{2}\cos\Omega)^2 + (\frac{1}{2}\sin\Omega)^2}} \quad \text{— ②}$$

By using ② we get magnitude response.

$$\angle H(e^{j\Omega}) = -\tan^{-1}\left(\frac{\frac{1}{2}\sin\Omega}{1-\frac{1}{2}\cos\Omega}\right) \quad \text{— ③}$$

By using ③ we get phase response.

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1) Write a program to find the frequency response, magnitude response and phase response when phase response of a system described by the difference equation also plot the poles and zeros of a transfer function of the system.

a) $y[n] = \frac{1}{2} y[n-1] + x[n]$

```
clc
num = [1];
den = [1, -0.5];
figure(1);
zplane (num, den);
[h omega] = freqz (num, den);
magh = abs(h);
ph = angle(h);
figure(2);
subplot (211); plot (omega, magh);
xlabel ('omega'); ylabel ('Mag');
title ('Mag response');
subplot (212); plot (omega, ph);
xlabel ('omega'); ylabel ('phase');
title ('Phase response');
```

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Theoretical calculations:-

$$y[n] = x[n] - \tfrac{1}{4}x[n-1]$$

Taking ZT on either sides

we get $Y(z) = X(z) - \tfrac{1}{4}X(z)\,z^{-1}$

$$Y(z) = X(z)\left(1 - \tfrac{1}{4}z^{-1}\right)$$

$$\frac{Y(z)}{X(z)} = 1 - \tfrac{1}{4}z^{-1}$$

we know that $H(z) = \dfrac{Y(z)}{X(z)}$

$$H(z) = 1 - \tfrac{1}{4}z^{-1} \quad \text{— ①}$$

Then frequency response is obtained when z is replaced with $e^{j\Omega}$.

$$H(e^{j\Omega}) = 1 - \tfrac{1}{4}e^{-j\Omega} \quad \text{— ②}$$

Frequency response of a system.

$$|H(e^{j\Omega})| = \sqrt{\left(1 - \tfrac{1}{4}\cos\Omega\right) + \left(\tfrac{1}{4}\sin\Omega\right)^2} \quad \text{— ③}$$

Eqn ③ will give the magnitude response for different values of $\Omega$.

$$\angle H(e^{j\Omega}) = \tan^{-1}\left(\frac{\tfrac{1}{4}\sin\Omega}{1 - \tfrac{1}{4}\cos\Omega}\right) \quad \text{— ④}$$

Eqn ④ will give the phase response for different values of $\Omega$.

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b) $y[n] = x[n] - \frac{1}{4}x[n-1]$

```
clc
num = [1, -0.25];
den = [1];
figure(1);
zplane(num, den);
[h, omega] = freqz(num, den);
magh = abs(h);
ph = angle(h);
figure(2);
subplot(211); plot(omega, magh);
xlabel('omega'); ylabel('Mag');
title('Mag response');
subplot(212); plot(omega, ph);
xlabel('omega'); ylabel('phase');
title('Phase response');
```