

1. Analysis of Periodic Signals in the Frequency Domain

- Consider the signal $x(t) = \sin(2\pi f t + \theta) + \cos(2\pi 4000 t)$, plot this signal for $f = \frac{1}{10}$ and $\theta = \frac{\pi}{6}$ using the command `plot`. Generate a discrete time vector with length 100000 with time interval `[0,10]`s and assume the sampling rate of `10kHz`.
- Plot the phase and magnitude of the spectrum of the above mentioned signal using the function `fft`.
- Apply `fftshift` function on the result and plot the output's magnitude. Describe the difference made.
- Try to use three periods of the signal to determine and sketch the magnitude and phase of the spectrum. How and why these plots differ from the previous parts?
- Now define the function below to implement a discrete time lowpass filter

```
Output = FFT_LP (input, cutoff_frequency, passband_gain)
```

That implement a discrete time lowpass filter and cutoff frequency is over $[0, \pi]$. Use `ifft` with the `'symmetric'` option for calculating the inverse Fourier transform in the function, and explain what it does.

- Apply this filter on the signal `x` and try to diminish the higher frequency component (4 kHz). Plot the result in both time and frequency domains (use `fftshift`).

2. Z transform

- Consider the following difference equation for $0 \leq n < 300$:

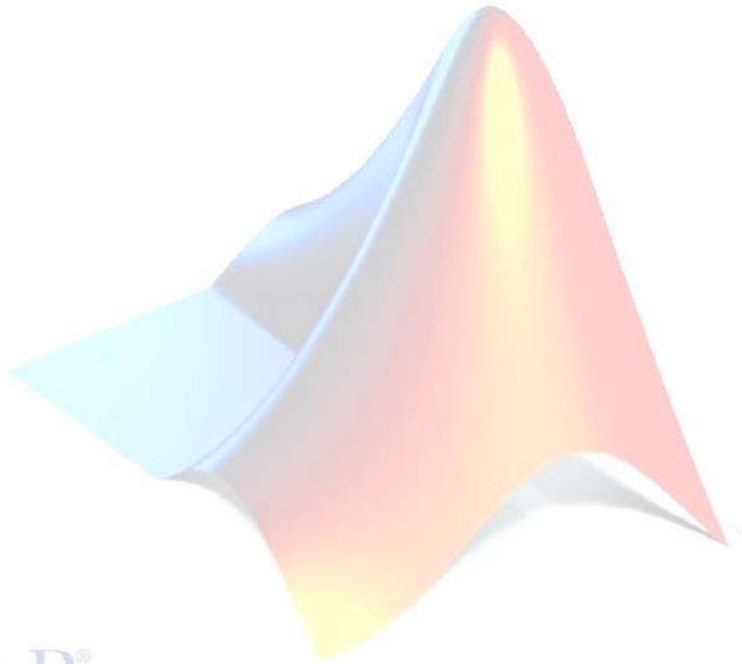
$$y[n] - y[n - 1] + 0.9 y[n - 2] = x[n] - x[n - 2]$$

Calculate the impulse response of the above mentioned filter for $0 \leq n < 300$ without using MATLAB's built in functions and display your impulse response using `stem`.

- Using `impz` and `steps` functions calculate the impulse and step response and display them in two separate figures.
- Calculate and show the output of the filter for input sequence $x_1[n] = \sin\left(\frac{3\pi n}{8} + \frac{\pi}{16}\right) + \cos\left(\frac{5\pi n}{8}\right)$ over $0 \leq n < 300$ using the `filter` function.
- Calculate and plot the magnitude of the DFT of the above sequence.

- e) Downsample and unsample $x_1[n]$ by the factor of 3 using `downsample` and `upsample` functions. Calculate and show the filter output for the two new signals.
- f) Utilize `freqz` and `zplane` commands in order to display the pole-zero diagram of the filter, then discuss whether the filter is stable or not. Also, try to explain the results obtained in parts (c) and (d) based on the diagram and your knowledge.

MATLAB®



MATLAB®