% Tune-Up Tuesday #9 for November 6, 2018

% For the following linear time-invariant (LTI) filter observed for n >= 0,
%
% $y[n]$ = 0.9 y[n-1] + (1/2) x[n] + (1/2) x[n-1]
%
% We can move the term 0.9 y[n-1] to the left-hand side:
%
% y[n] – 0.9 y[n-1] = (1/2) x[n] + (1/2) x[n-1]
%
% Take z-transform of both sides. All initial conditions are zero to satisfy LTI properties.

```
%
% Y(z) - 0.9 z^(-1) Y(z) = (1/2) X(z) + (1/2) z^(-1) X(z)
% (1 - 0.9 z-1) Y(z) = (1/2) X(z) + (1/2) z^(-1) X(z)
%        Y(z)   (1/2) + (1/2) z^(-1)   1    1 + z^(-1)
% H(z) = ---- = -------------------- = -  --------------
%        X(z)       1 - 0.9 z^(-1)     2  1 - 0.9 z^(-1)
```

% **i. Plot the poles and zeros in the z domain.**

```
feedforwardCoeffs = [ 1/2 1/2 ];
feedbackCoeffs = [ 1 -0.9 ];
figure;
zplane(feedforwardCoeffs, feedbackCoeffs);
```

% ***Answer:*** The transfer function in the z-domain has a zero at z = -1 and pole at z = 0.9.
% The pole has radius 0.9 and angle 0 rad/sample. If the pole were considered by itself,
% then the filter would pass low frequencies (centered at the angle of the pole) and
% attenuate high frequencies. The zero is on the unit circle at angle pi rad/sample,
% which causes more attenuation in high frequencies. ***Lowpass filter***.
% Magnitude response at discrete-time frequency w would be the distance from a point
% on the unit circle at z = exp(j w) to the zero location divided by the distance from the
% point on the unit circle to the pole location, multiplied by the filter gain (1/2).

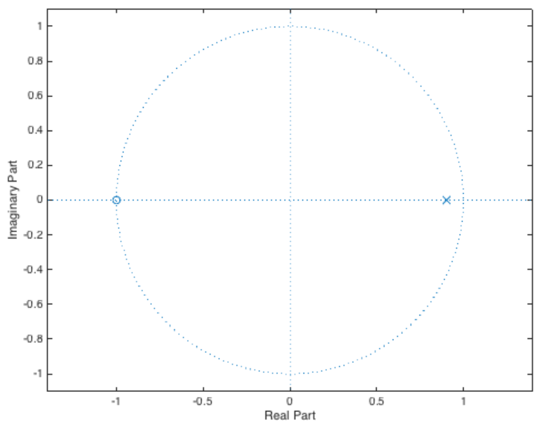
% **ii. Plot the magnitude response in linear units over the interval –pi <= w <= pi.**
% When freqz is called without any return values, it would plot the phase response
% as well as the magnitude response in dB using $A_{dB} = 20 \log_{10} |A|$:
% |A| A_{dB} |A| A_{dB} |A| A_{dB}
% 1.0 0dB 0.5 -6dB 0.0 -infinity
% Below, we ask freqz to return the values calculated for the frequency response
% and then plot the magnitude response in linear units instead of using deciBels.

```
W = -pi : 0.001 : pi;
[H, W] = freqz( feedforwardCoeffs, feedbackCoeffs, W );
figure;
plot(W, abs(H));
```

% ***Answer***: Magnitude response peaks at 10 at 0 rad/sample and then decreases
% to zero as the discrete-time frequency increases from 0 to pi. ***Lowpass filter***.

% **iii. Frequency selectivity?**
% Lowpass, highpass, bandpass, bandstop, allpass, notch. ***Lowpass filter***.

% ***Plots are on the next page.***



Imaginary Part
Real Part