ELEG 4603/5173L Lab # 5
Discrete-Time Fourier Transform

1. Read and understand the following Matlab code, which finds the DTFT of a filter with impulse response `h_fir`, and plot the amplitude (in dB) response.

```
% sampling frequency (Hz)
Fs = 8000;

% impulse response of an FIR filter
h_fir = [0.2, 0.1, 0.4, 0.2, 0.1];

% digital frequency
f_vec = [0:0.001:pi];

% DTFT
[H_dtft, f_vec] = dtft(h_fir, f_vec);

% analog frequency: F_vec
% digital frequency: f_vec
% convert digital frequency to analog frequency
F_vec = f_vec*Fs/(2*pi);

% plot the amplitude response in dB
plot(F_vec, 20*log10(abs(H_dtft)))
xlabel('analog frequency (Hz)');
ylabel('20*log10(|H|) dB');
grid on

The function dtft.m:
```

```
function [H_dtft, f_vec] = dtft(h_vec, f_vec)

if nargin == 1
    f_vec = -pi:0.001:pi;
end

H_dtft = zeros(size(f_vec));
for mm = 1:length(h_vec)
    H_dtft = H_dtft + h_vec(mm)*exp(-j*(mm-1)*...
        f_vec);
end
end
```

2. (a) Manually calculate the DTFT of the following signals, and plot the DTFT.

   (b) Using the DTFT program in the previous eample, calculate with Matlab the DTFT of the following signals. Plot the DTFT and compare the results from your manual calculation.

$$x(n) = u(n) - u(n-20) \tag{1}$$
$$x(b) = \exp(-2n)u(n) \tag{2}$$

3. Decimation and Interpolation. Consider the analog signal $x_a(t) = 20\text{sinc}(20t)$.

   (a) Sample the signal at a frequency 80 Hz. Calculate with Matlab the DTFT of $x(n) = x_a(nT_s)$, and plot the DTFT in $[-\pi, \pi]$.

   (b) Decimate the above samples by a factor of $M = 2$. Calculate with Matlab the DTFT of $x(n)$, and plot the DTFT in $[-\pi, \pi]$.

   (c) Interpolate the samples in part (a) by a factor of $L = 2$. Calculate with Matlab the DTFT of $x(n)$, and plot the DTFT in $[-\pi, \pi]$.