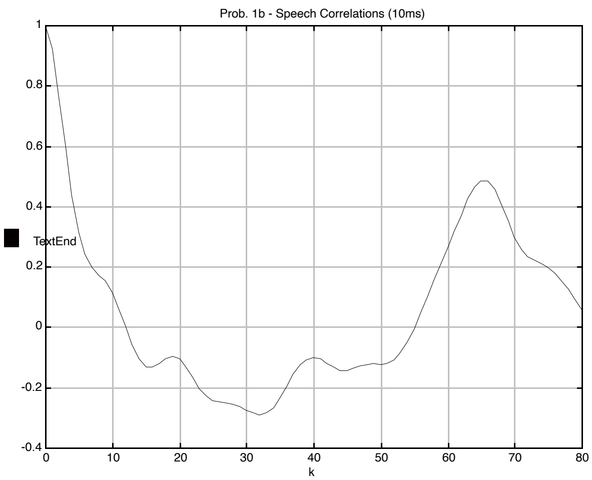
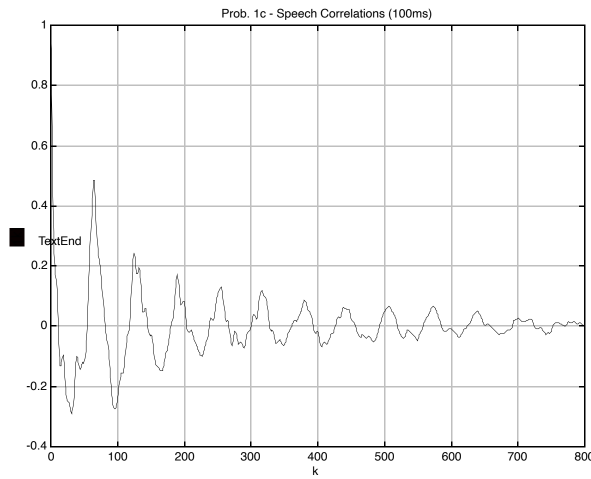
Solution #1 Software Tools for Random Signal Analysis

1. a) mu = -2.9384e-17, var = 1.0000

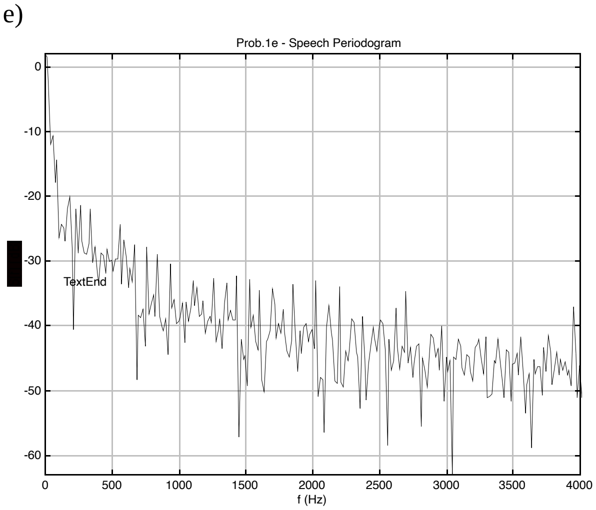
b) c) Correlation plats should be similar (your mileage will vary)





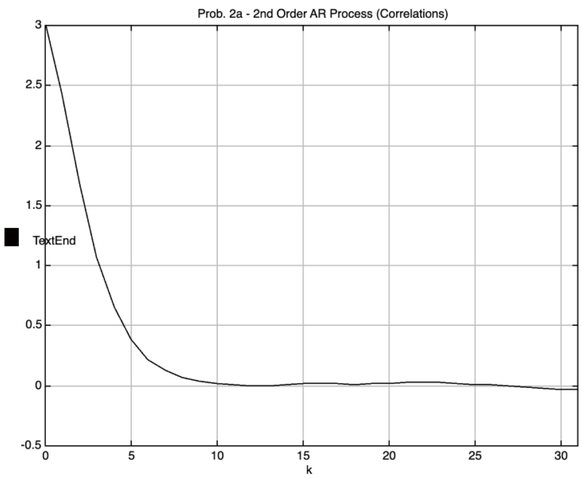
d) In general, the long-term speech signal will have a first zero crossing with lag corresponding to 1ms and a second zero crossing with a lag corresponding to 5-10ms. The overall correlation function will look like a damped oscillation.

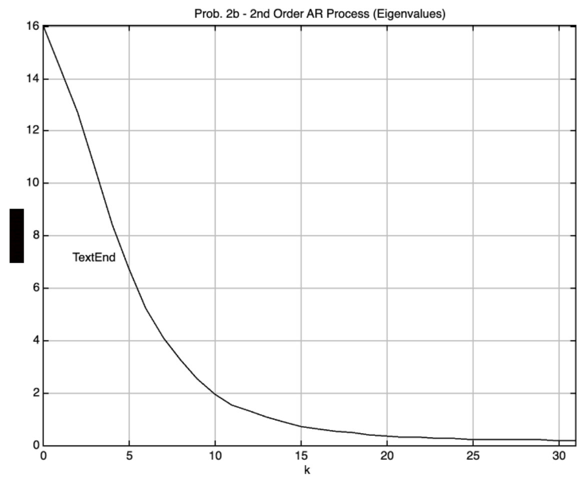
e)



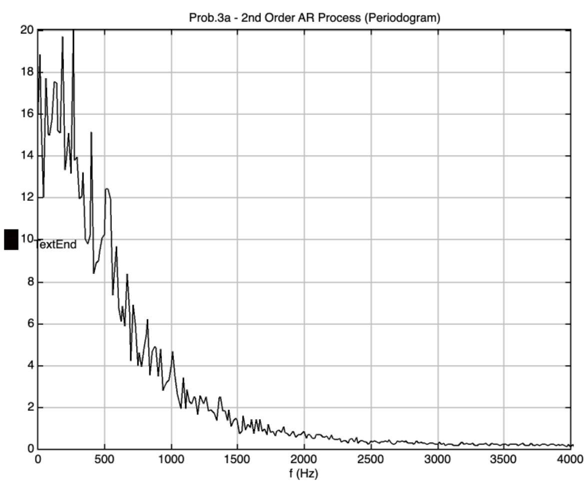
The periodogram (which is an estimate of the PSD) of the speech signal is lowpass in nature and decays about 20dB per decade.

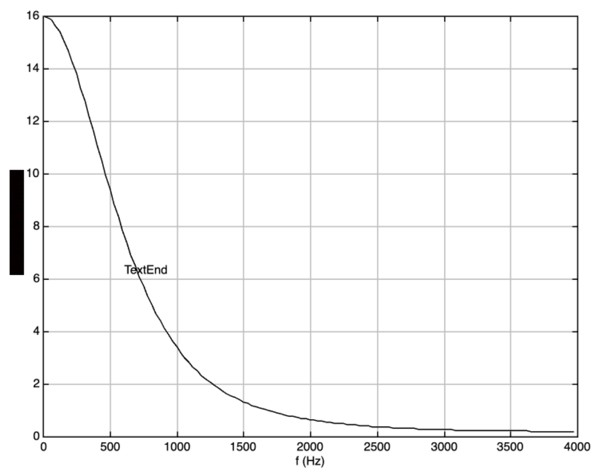
2. a) b)





3. a) b)





Magnitude-squared response of the AR filter is similar (as expected) to the periodogram of the AR process.

c) The periodogram of the AR process is also similar to the eigenvalue distribution of the correlation matrix of the AR process.

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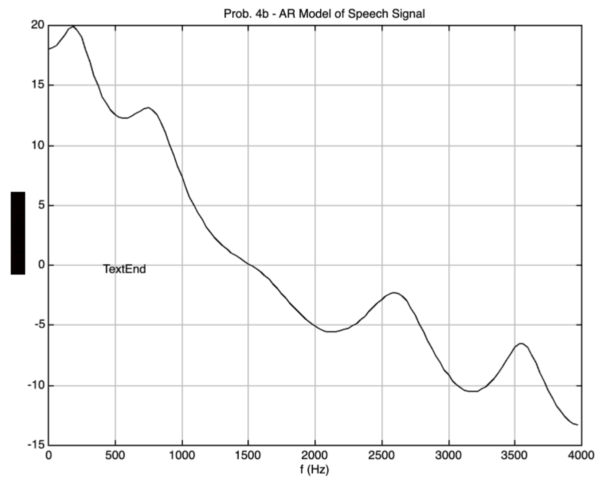
4. a) Your AR parameters should be similar (your mileage will vary), b)

```
a =
    1.0000
   -1.4209
    0.5818
   -0.1647
    0.2598
   -0.1084
   -0.1020
    0.0365
    0.1569
   -0.3543
    0.3276
   -0.1832
    0.1389
   -0.0720
    0.0304
```



```
% EE594 - Fall 2002 - Homework #1

%---
% 1
%---
[u,fs,bits] = wavread('deleon.wav');
u = u - mean(u);
u = u ./ sqrt(cov(u));  % normalize to unit variance (will distort on
playback)

% a
mu = mean(u)
var = cov(u)

% b
M = 80;
r = correlation(u,u,M);
plot([0:M],r,'k');
ylabel('r(k)');
xlabel('k');
title('Prob. 1b - Speech Correlations (10ms)');
grid;

% c
M = 800;
r = correlation(u,u,M);
plot([0:M],r,'k');
ylabel('r(k)');
xlabel('k');
title('Prob. 1c - Speech Correlations (100ms)');
grid;

% e
S = periodogram(u,512);  % truncates
figure
periodogram_plot(S,0,fs);
```

```
title('Prob.1e - Speech Periodogram');
ylabel('S(f) (dB)');
xlabel('f (Hz)');

N = length(u);
num_segments = floor(N/512);
start = 1;
stop = 512;
S_sum = zeros(512,1);
for k = 1:num_segments
   S_sum = S_sum + periodogram(u(start:stop),512);
   start = stop+1;
   stop = stop + 512;
end
S = S_sum / num_segments;
figure
periodogram_plot(S,0,fs);
title('Prob.1d - Speech Periodogram (Averaged)');
ylabel('S(f) (dB)');
xlabel('f (Hz)');


%---
% 2
%---
N = 2048;
a = [1 -1 0.25]';
M = 31;

% a
r = zeros(M+1,1);
for runs = 1:25
   runs
   u = AR_synthesizer(a,N,1);
   rr = correlation(u,u,M);
   r = r + rr;
end;
r = r ./ 25;  % average correlations
figure;
plot([0:M],r(1:M+1),'k');
title('Prob. 2a - 2nd Order AR Process (Correlations)');
ylabel('r(k)');
xlabel('k');
axis([0 M -0.5 3 ]);
grid;

% b
R = toeplitz(r);
lambda = sort(eig(R));
figure;
plot([0:M],lambda(M+1:-1:1),'k')
ylabel('lambda(k)');
xlabel('k');
title('Prob. 2b - 2nd Order AR Process (Eigenvalues)');
axis([0 M 0 max(lambda)]);
grid;
```

```
%---
% 3
%---
% a
S = zeros(512,1);
for runs = 1:25
   runs
   u = AR_synthesizer(a,N,1);
   SS = periodogram(u,512);
   S = S + SS;
end;
S = S ./ 25;  % average periodogram

figure;
periodogram_plot(S,0,8000);
title('Prob.3a - 2nd Order AR Process (Periodogram)');
ylabel('S(f) (dB)');
xlabel('f (Hz)');

figure;
periodogram_plot(S,1,8000);
title('Prob.3a - 2nd Order AR Process (Periodogram)');
ylabel('S(f)');
xlabel('f (Hz)');

% b
fr_plot(1,a,8000,2);
title('Prob. 3b - 2nd Order AR Model (Magnitude Response)')

%---
% 4
%---
[u,fs,bits] = wavread('deleon.wav');
u = u - mean(u);  % remove DC component
u = u ./ sqrt(cov(u));  % normalize to unit variance (will distort on
playback)

% a
a = AR_coef_est(u,14)

% b
fr_plot(1,a,8000,0);
figure(1);
title('Prob. 4b - AR Model of Speech Signal')
```