Exercise 1: Autolpc function:

```
function [A, G, r, a] = autolpc(x, p)
%AUTOLPC Autocorrelation Method for LPC
% Usage: [A, G, r, a] = autolpc(x, p)
% x : input samples
% p : order of LPC
% A : prediction error filter, (A = [1; -a])
% G : rms prediction error
% r : autocorrelation coefficients
% a : predictor coefficients

x = x(:);
L = length(x);
r = zeros(p+1,1);
for i=0:p
   r(i+1) = x(1:L-i)' * x(1+i:L);
end
R = toeplitz(r(1:p));
a = R\r(2:p+1);
A = [1; -a];
G = sqrt(sum(A.*r));
end
```

Exercise 2~6:

```
% Exercise 2
load('s5.mat');
L=320;                      % Hamming window of 320 samples
win= hamming(L);
SH=s5(15800:15800+319);   % select the suit length array for window
AA=s5(17000:17000+319);
SH_win=SH.*win;
AA_win=AA.*win;
[A1,G1,r1,a1]=autolpc(SH_win,12);
[A2,G2,r2,a2]=autolpc(AA_win,12);

SH_freq=freqz(A1,1,10000,'whole');        % use the function freqz to get the frequency
 responses
SH_vtm_filter=freqz(G1,A1,10000,'whole'); % A is prediction error filter, G/A is the vo
cal
figure(1);
plot(20*log10(abs(SH_vtm_filter)));       % get the log magnitude
hold on;
plot(20*log10(abs(SH_freq)));
title('The prsdiction error filter and The vocal tract model filter for"SH"');
xlabel('Frequency');
ylabel('magnitudue(dB)');
legend('The vocal tract model filter for "SH"','The prsdiction error filter for "SH"')

AA_freq=freqz(A2,1,10000,'whole');
AA_vtm_filter=freqz(G2,A2,10000,'whole');
figure(2);
plot(20*log10(abs(AA_vtm_filter)));
hold on;
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```
plot(20*log10(abs(AA_freq)));
title('The prsdiction error filter and The vocal tract model filter for"AA"');
xlabel('Frequency');
ylabel('magnitudue(dB)');
legend('The vocal tract model filter for "AA"','The prsdiction error filter for "AA"')

figure(3)       % find the zeros of the prediction error filter for both cases
zplane(A1');
title(' zeros of the prediction error filter for "SH"');
figure(4)
zplane(A2')
title(' zeros of the prediction error filter for "AA"');

% Exercise 3
figure(5)                   % get DFT for SH
SH_DFT=fft(SH_win,10000);
plot(20*log10(abs(SH_DFT)));
hold on;
plot(20*log10(abs(SH_vtm_filter)));
title('The DFT of the windowed segment and vocal tract model for "SH"');
xlabel('Frequency');
ylabel('magnitudue(dB)');
legend('DFT for "SH"','vocal tract model for "SH"');

figure(6)                  % get DFT for AA
AA_DFT=fft(AA_win,10000);
plot(20*log10(abs(AA_DFT)));
hold on;
plot(20*log10(abs(AA_vtm_filter)));
title('The DFT of the windowed segment and vocal tract model for "AA"');
xlabel('Frequency');
ylabel('magnitudue(dB)');
legend('DFT for "AA"','vocal tract model for "AA"');


% Exercise 4
OO=s5(7200:7200+319);
OO_win=OO.*win;
OO_DFT=fft(OO_win,10000);
[A3,G3,r3,a3]=autolpc(OO_win,12);
OO_vtm_filter=freqz(G3,A3,10000,'whole');
figure(7)
plot(20*log10(abs(OO_DFT)));
hold on;
plot(20*log10(abs(OO_vtm_filter)));
title('The DFT of the windowed segment and vocal tract model for "O"');
xlabel('Frequency');
ylabel('magnitudue(dB)');
legend('DFT for "O"','vocal tract model for "O"');

II=s5(14500:14500+319);
II_win=II.*win;
II_DFT=fft(II_win,10000);
[A4,G4,r4,a4]=autolpc(II_win,12);
II_vtm_filter=freqz(G4,A4,10000,'whole');
figure(8)
plot(20*log10(abs(II_DFT)));
hold on;
plot(20*log10(abs(II_vtm_filter)));
title('The DFT of the windowed segment and vocal tract model for "I"');
```

```
xlabel('Frequency');
ylabel('magnitudue(dB)');
legend('DFT for "I"','vocal tract model for "I"');

% Exercise 5
% We choose SH in this part, [A1,G1,r1,a1]=autolpc(SH_win,12);
[A_p8,G_p8,r_p8,a_p8]=autolpc(SH_win,8);
SH_vtm_filter_p8=freqz(G_p8,A_p8,10000,'whole');
[A_p10,G_p10,r_p10,a_p10]=autolpc(SH_win,10);
SH_vtm_filter_p10=freqz(G_p10,A_p10,10000,'whole');
[A_p20,G_p20,r_p29,a_p20]=autolpc(SH_win,20);
SH_vtm_filter_p20=freqz(G_p20,A_p20,10000,'whole');
        figure(9)
        plot(20*log10(abs(SH_DFT)));
        hold on;
        plot(20*log10(abs(SH_vtm_filter_p8)));
        hold on;
        plot(20*log10(abs(SH_vtm_filter_p10)));
        hold on;
        plot(20*log10(abs(SH_vtm_filter)));
        hold on;
        plot(20*log10(abs(SH_vtm_filter_p20)));
        xlabel('Frequency');
        ylabel('magnitudue(dB)');
        legend('DFT for "SH"','vocal tract model for "SH" in p=8', ...
            'vocal tract model for "SH" in p=10', ...
            'vocal tract model for "SH" in p=12', ...
            'vocal tract model for "SH" in p=20');

        % Exercise 6
        y = filter([1, -0.98], 1, s5);
        SH_y=y(15800:15800+319);
        SH_y_win=SH_y.*win;
        [A_y,G_y,r_y,a_y]=autolpc(SH_y_win,12);
        SH_y_freq=freqz(A_y,1,10000,'whole');
        figure(10)
        plot(20*log10(abs(SH_freq)));
        hold on;
        plot(20*log10(abs(SH_y_freq)));
        title('Comparison for whether apply a preemphasis filter');
        xlabel('Frequency');
        ylabel('magnitudue(dB)');
        legend('Without new filter','With new filter');
```