1. Linear prediction analysis is used to obtain a 6-order all-pole model for a segment of voiced speech that was sampled at a rate of $F_s = 10000$ Hz. Determine the root angle of the pole corresponding to first two formant. $F_1=288\,\text{Hz}$, $F_2=719\,\text{Hz}$, $F_3 = 2294\,\text{Hz}$, $BW_1=92\,\text{Hz}$, $BW_2=65\,\text{Hz}$, $BW_3=50\,\text{Hz}$

A. Range of 20$^0$ to 21$^0$ and range of 35$^0$ to 36$^0$.
B. Range of 10$^0$ to 11$^0$ and range of 25$^0$ to 26$^0$.
C. Range of 15$^0$ to 16$^0$ and range of 30$^0$ to 31$^0$.
D. Range of 18$^0$ to 19$^0$ and range of 28$^0$ to 29$^0$.

$[ F_1 = 288 \, \text{Hz}, F_2 = 719 \, \text{Hz}, F_s = 10 \, \text{KHz}, \theta_1=(F_1\times2\pi)/F_s = 10.360 ; \theta_2=(F_2\times2\pi)/F_s = 25.880 ]$

2. 5 sec. speech segment is encoded using LPC coefficient and the LPC coefficient are extracted for each frame (frame length (L) = 5 pitch period) with a frame rate 100 frames/s. How many frames’s LPC coefficient can be extract from the above speech signal? Where the $F_0$ of the speech segment is 250 Hz and sampling frequency $F_s=16\,\text{kHz}$

A. 450 Frames
B. 600 Frames
C. 500 Frames
D. 550 Frames

[ No. of frames in 5 sec. = 5 \times 100 = 500 frames ]

3. 2 sec. speech segment is encoded using LPC coefficient and the LPC coefficient are extracted for each frame (frame length (L) = 5 pitch period) with a frame rate 100 frames/s. Determine the required order of the LPC analysis. Where the $F_0$ of the speech segment is 250 Hz and sampling frequency $F_s=16\,\text{kHz}$.

A. 15 - 17
B. 32 - 34
C. 25 - 27
D. 20 - 22

[ F_s = 16 \, \text{kHz}; \text{Order of LPC} = (F_s/1000) + 2 + 2 = (16\times10^3/10^3) +2 +2 = 20; 
and (F_s/1000) + 2 + 4 = (16\times10^3/10^3) +2 +4 = 22 ]

4. A signal is sampled at 16 KHz, 16 bit, encoded with 16th order LPC. Each of the LPC coefficients is encoded with 2 byte, Gain in 2 byte. Voiced unvoiced $F_0$ information is encoded using 1 byte. Calculate the compression ratio if frame rate is 100 frame/sec?
5. A speech signal frame has energy \( E_n^0 = 2000 \) using the autocorrelation method the frame is analyzed and 3 PARCOR coefficient \( \{k_1, k_2, k_3\} \) are computed. Find the energy of the linear prediction residual \( E_n^3 = \sum m e_n^2[m] \) that would obtain by inverse filtering the speech signal frame. The inverse filter is designed using the above 3 PARCOR coefficients. Where

\[
k_1 = 0.52; \quad k_2 = -0.25; \quad k_3 = 0.36
\]

A. 
B. 
C. 
D. 

\[
E_n^3 = E_n^0(1-K_1^2)(1-K_2^2)(1-K_3^2)
\]
\[
= 2000(1-(0.52)^2)(1-(-0.25)^2)(1-(0.36)^2) = 2000 \times 0.73 \times 0.937 \times 0.871 = 1191.54
\]

6. If the order of the LPC analysis is 3 and LPC coefficients are \( \{\alpha_1, \alpha_2, \alpha_3\} \) compute the model gain for a signal \( x[n] = \{1, 2, 1, -1, 2\} \) where \( \alpha_1 = 0.52; \quad \alpha_2 = -0.25; \quad \alpha_3 = 0.36
\]

A. Range of 1 to 1.5
B. Range of 2 to 2.5
C. Range of 5 to 5.5
D. Range of 3 to 3.5

\[
G = 5.36; \quad \text{So, } G = \sqrt{5.36} = 2.315
\]

7. Figure-1 represents the LPC Spectrum of a speech segment determine the order of the LPC analysis.
8. A voiced speech signal frame analyzed using the autocorrelation method and 3 PARCOR coefficients \( \{k_1, k_2, k_3\} \) are computed. If the same speech signal segment is generated from using lossless tube modeling and cross sectional area of the first tube section is 1 derive the cross sectional area of the other tubes. Where

\[
\begin{align*}
  k_1 &= 0.52; \quad k_2 = -0.25; \quad k_3 = 0.36
\end{align*}
\]

A. \( A_1 = 1; \ A_2 = \text{Range of 7 to 8}; \ A_3 = \text{Range of 5 to 6}; \ A_4 = \text{Range of 8 to 9} \)
B. \( A_1 = 1; \ A_2 = \text{Range of 5 to 6}; \ A_3 = \text{Range of 3 to 4}; \ A_4 = \text{Range of 6 to 7} \)
C. \( A_1 = 1; \ A_2 = \text{Range of 3 to 4}; \ A_3 = \text{Range of 1 to 2}; \ A_4 = \text{Range of 4 to 5} \)
D. \( A_1 = 1; \ A_2 = \text{Range of 9 to 10}; \ A_3 = \text{Range of 7 to 8}; \ A_4 = \text{Range of 10 to 11} \)

\[A_1 = 1; \ A_2 = 3.166; \ A_3 = 1.9; \ A_4 = 4.036\]

9. Lattice formulation of \( i^{th} \) order prediction error filter was defined as given in equations. Which one of the following figures indicates the signal flow graph of the error filter?

\[
\begin{align*}
  e^i[m] &= e^{i-1}[m] - k_i b^{i-1}[m - 1] \\
  b^i[m] &= b^{i-1}[m - 1] - k_i e^{i-1}[m] \\
  e^0[m] &= b^0[m] = s[m]
\end{align*}
\]

A. 

B. 

[Image of signal flow graphs]
10. Autocorrelation method based 20th order LPC analysis was performed for a voiced speech signal with the frame rate of 100 frame/sec. If the length of the window used for this analysis is 20 ms determine length of the error signal [where sampling frequency of the speech signal is 16 kHz].

A. 253
B. 551
C. 153
D. 341