# Prob. 1

The autocorrelations from long-term speech is generally a decaying oscillation as seen in Fig. 1.

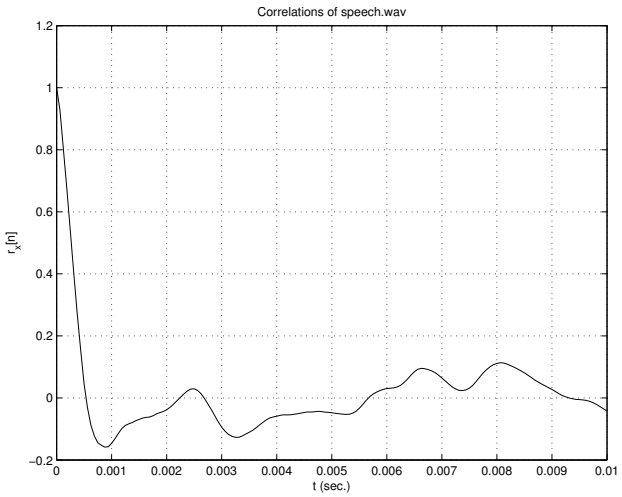



Figure 1: "Autocorrelations of speech.wav."

# Prob. 2

Figures are shown in Fig. 2. (a) For the vowel /aa/, we see a periodic autocorrelation. (b) For the unvoiced plosive /k/ it does not look like an impulse with a periodic component as expected. (c) For the unvoiced fricative /f/, we see an impulsive autocorrelation and near uncorrelatedness for positive lags. (d) For the voiced plosive /g/, we see the periodic structure with larger period than the vowel as expected. These mostly agree with the figures in the text.

# Prob. 3

See attached for solution to textbook problem 5.2.

# Prob. 4

Figures are shown in Fig. 3. We see with enough parameters, we are able to model the AR process with the all-pole filter.

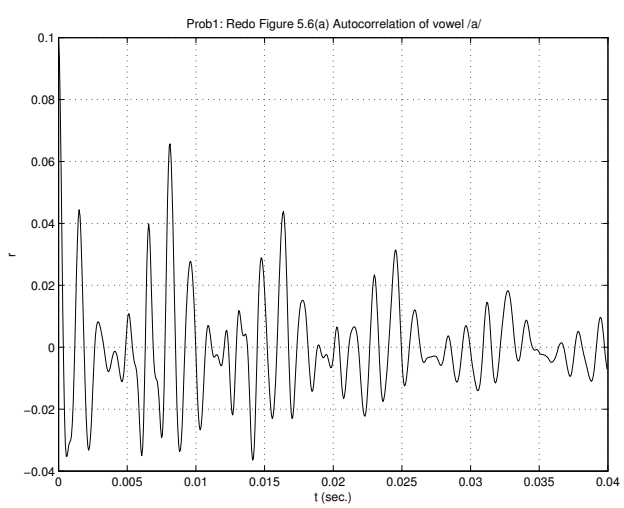
# Prob. 5

Figures are shown in Fig. 4. We used 12th order models to model the power spectrum of the different phonemes. We see that we can model the vocal tract response reasonably well.

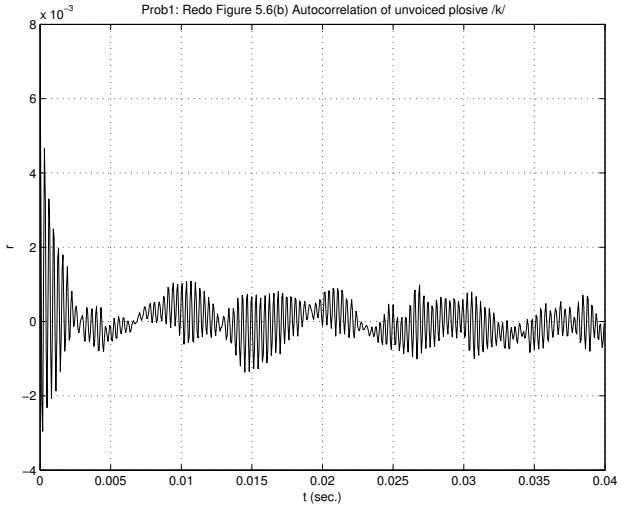
# Prob. 6

Figures are shown in Fig. 5. Note the scale on the residuals. These figures match very well the textbook.

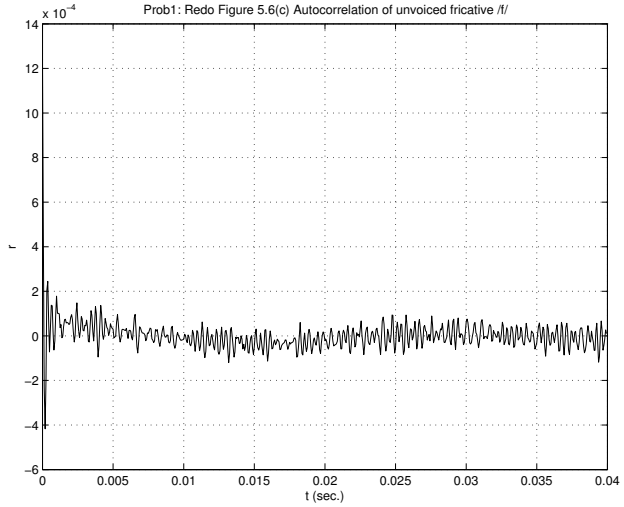
 



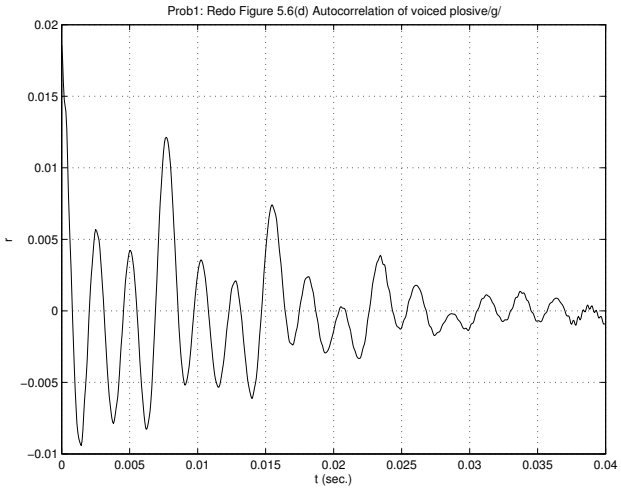

(a) /aa/




(b) /k/




(c) /f/




(d) /g/

Figure 2: Redo of Example 5.2, Figure 5.6.

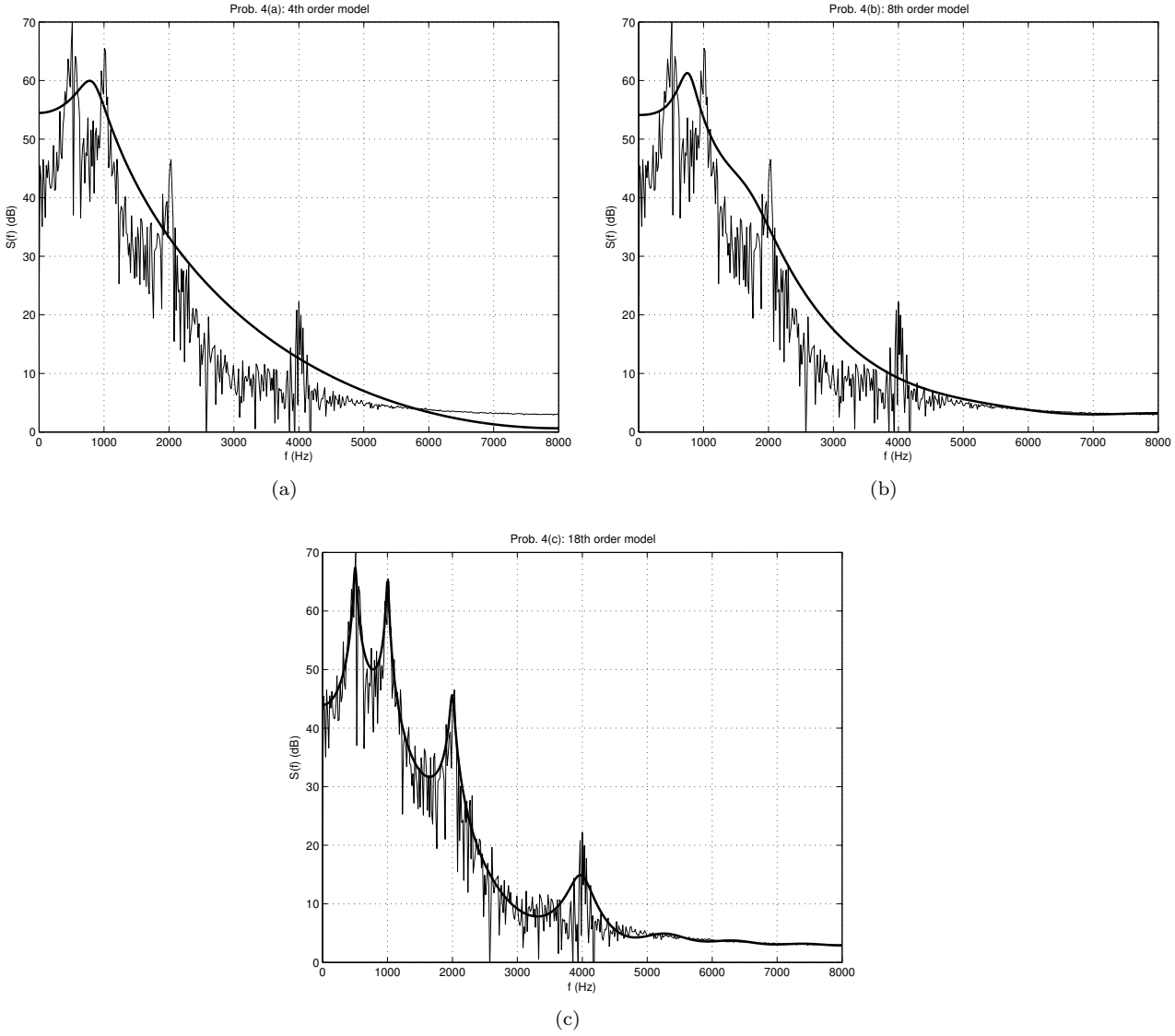



Figure 3: Model of AR process for model order (a) $p = 4$, (b) $p = 8$, and (c) $p = 18$.

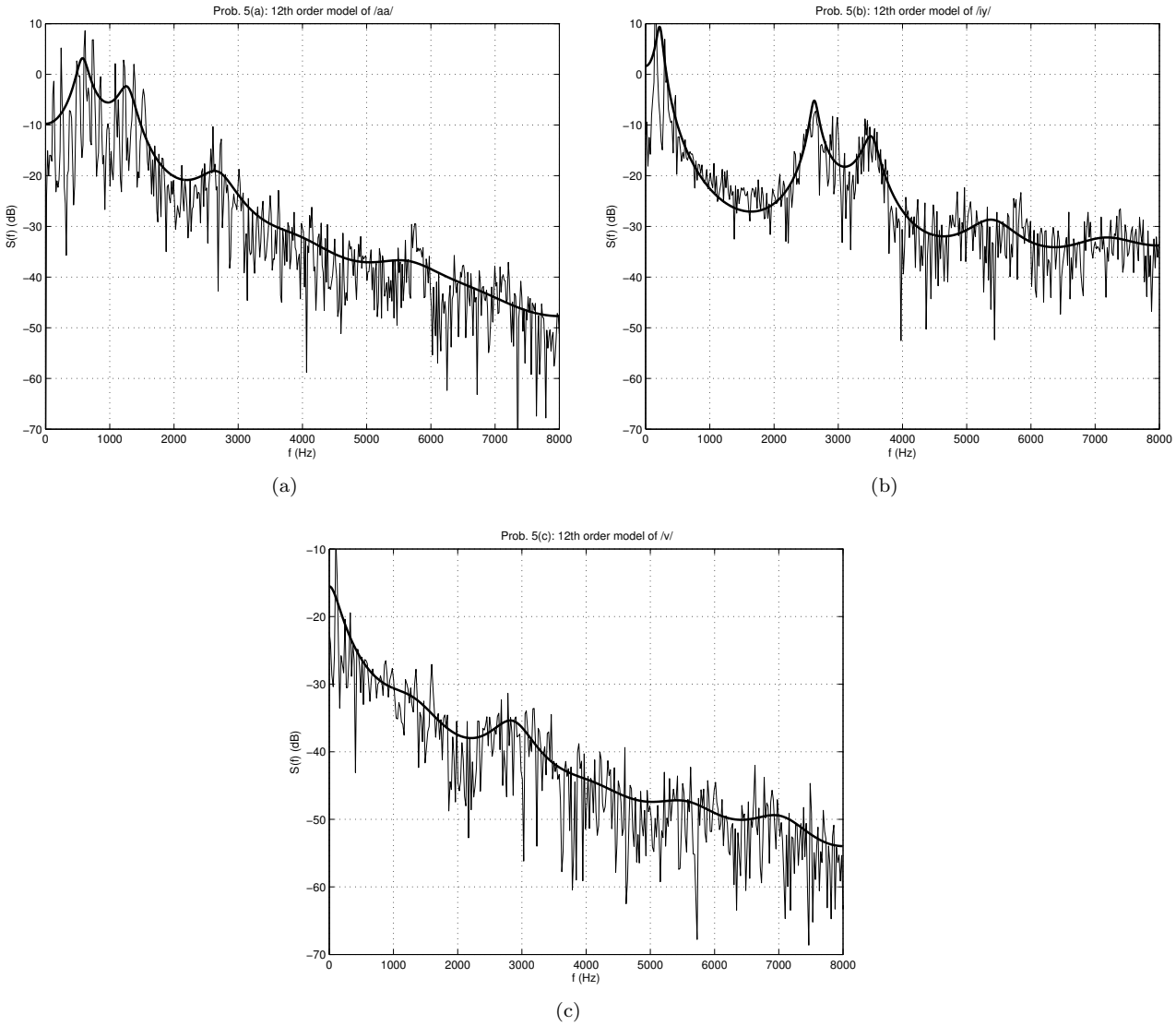



Figure 4: AR model of phonemes (a) /aa/, (b)/iy/, and (c) /v/

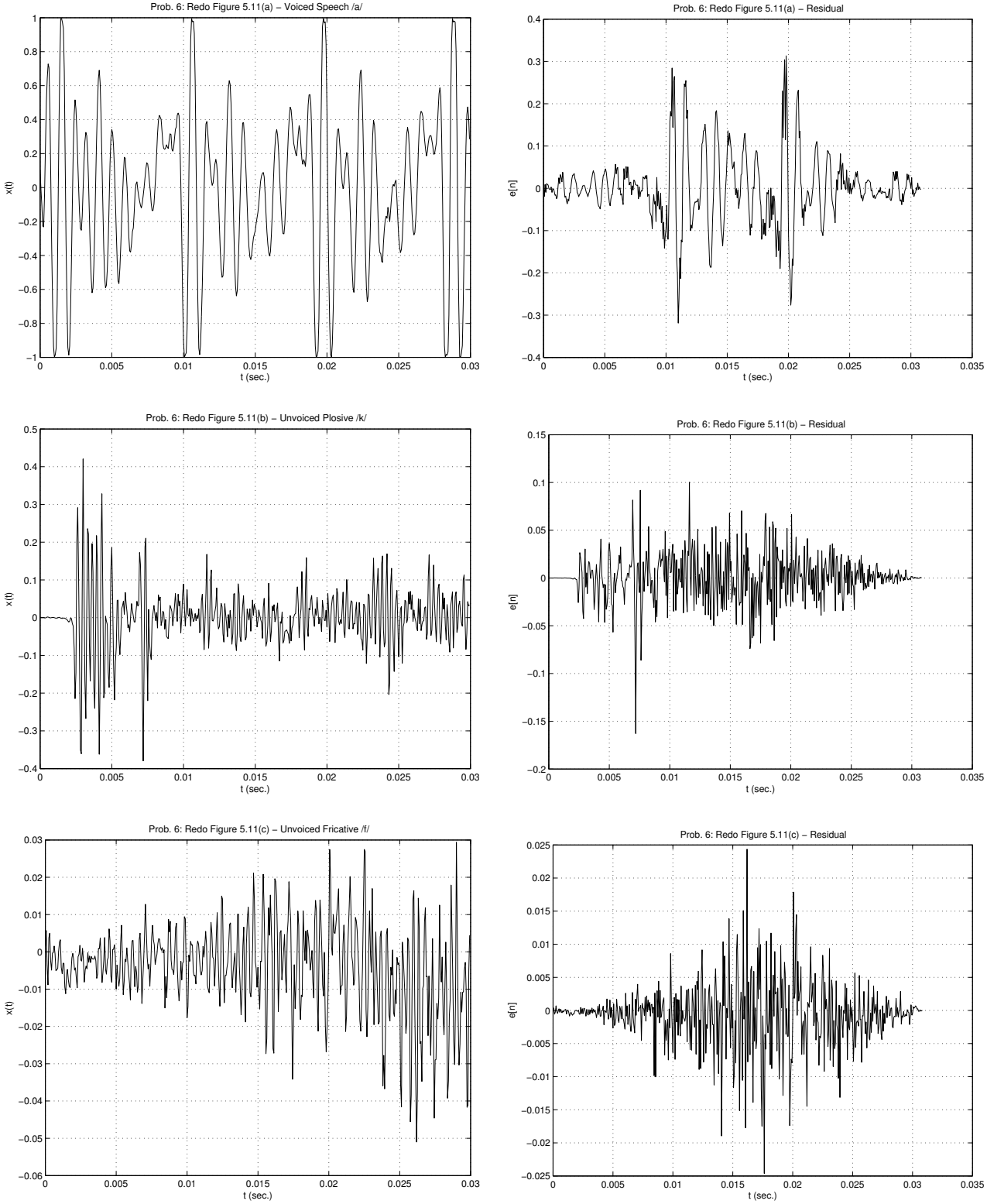



Figure 5: Redo of Figure 5.11.

# Prob. 7

Fig. 6(a)–(c) show the periodic pulse train waveform, log-magnitude spectrum, and cepstrum. We see a harmonic spectrum and pulses in the cepstrum at the pitch times. Fig. 6(d)–(e) show the all-pole filter's log-magnitude spectrum and cepstrum. The composite Fig. 6(f) shows vocal tract information (filter) in the lower part of the cepstrum and pitch information in the upper part of the cepstrum.

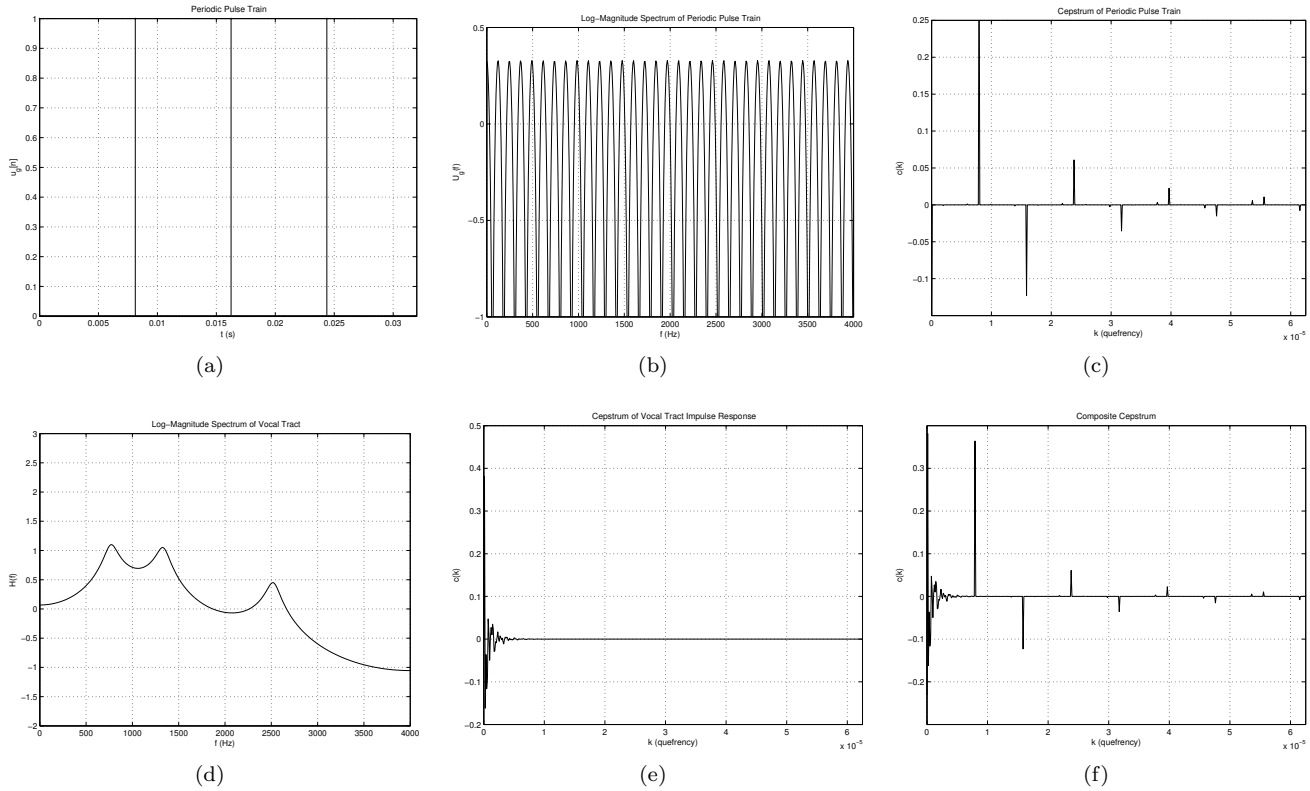



Figure 6: Periodic pulse train (a) waveform, (b) log-magnitude spectrum, and (c) cepstrum. All-pole filter (d) log-magnitude spectrum and (e) cepstrum. (f) Composite of cepstra.

# Prob. 8

Figures are shown in Fig. 7. (a) The cepstrum for the vowel /aa/ shows the classic structure with pitch information apparent at 0.008 quefrency which corresponds to fundamental $F_0 = 125$ Hz.

# Prob. 9

Figures are shown in Fig. 8.

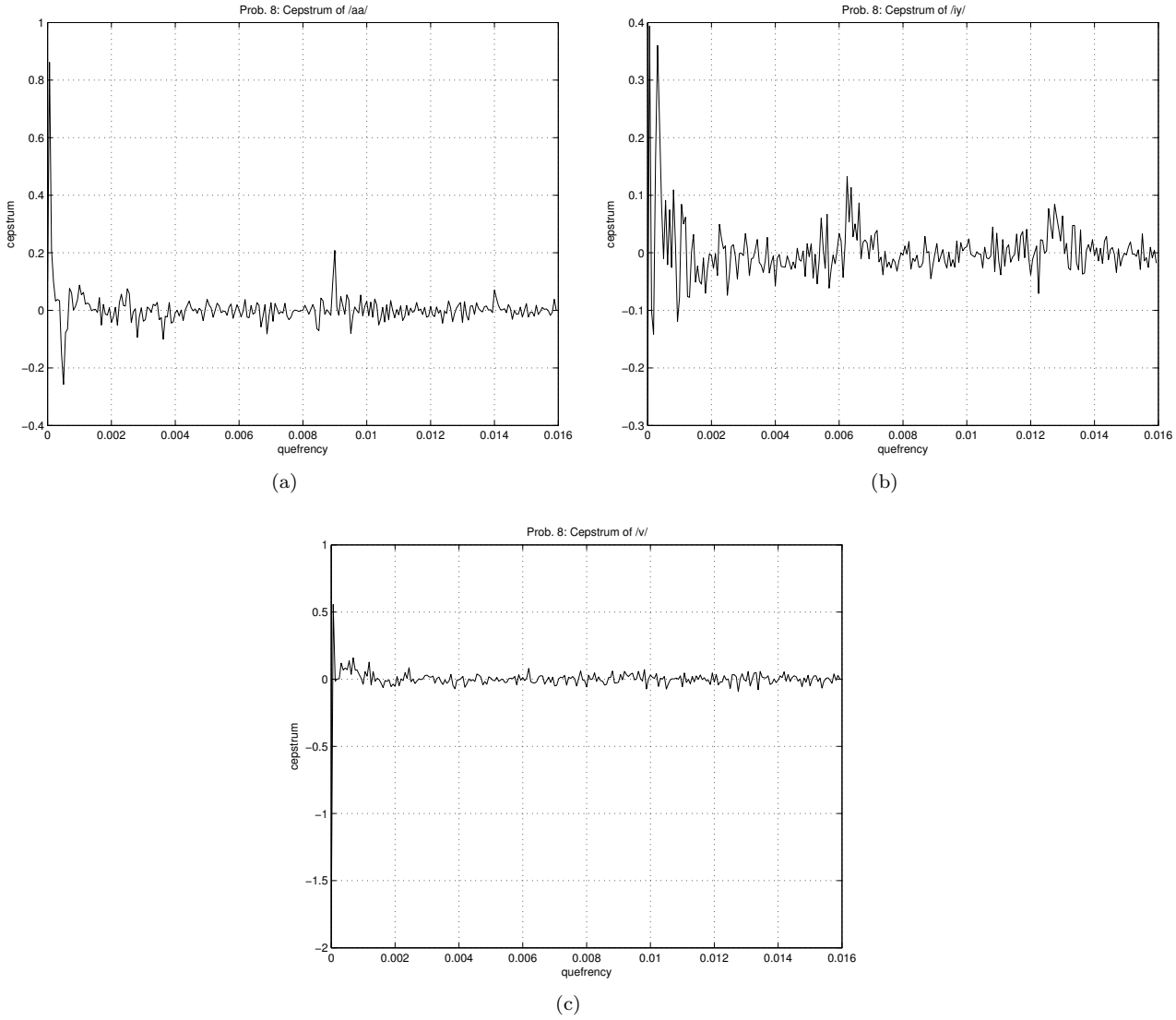



Figure 7: Cepstra of phonemes (a) /aa/, (b)/iy/, and (c) /v/

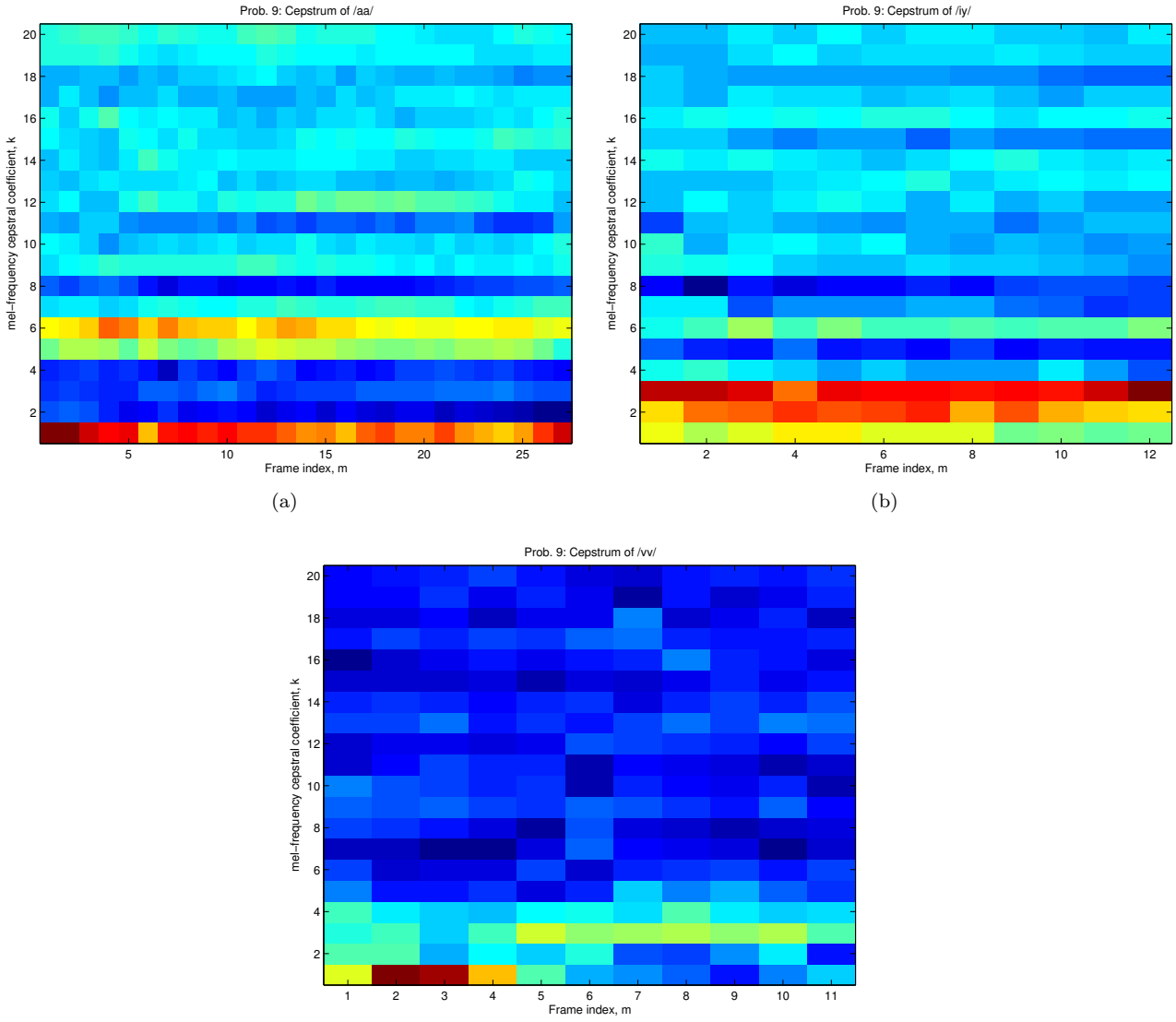



Figure 8: Mel-frequency cepstra of phonemes (a) /aa/, (b)/iy/, and (c) /v/