EEL6586 – Spring 2001
Exam 1 March 28, 2001

NAME: _____

This exam is open-book and calculator. You may use any books or papers that you like. There are four problems on this exam, you have two full class periods. State your assumptions and reasoning for each problem. Justify your steps and clearly indicate your final answers.

1	**/25**
2	**/25**
3	**/25**
4	**/25**
TOTAL	

1. (25 points)

   An infinite train of impulses is created with the following relation

$$e(n) = \sum_{k} \delta(n + kP)$$

   Assume that the sampling frequency is 10kHz.

   (a) (5 points) Determine the value of P to create a pitch frequency of 100Hz.

(b) (10 points) The infinite train of impulses is fed through an all-pole model of

$$H(z) = 1/(1 + .9z^{-1} + .81z^{-2})$$

What is the dominant formant frequency in the signal?

(c) (5 points) Is this formant frequency higher or lower than typical first formant frequencies for humans?

(d) (5 points) How will the formant frequency change if pre-emphasis is applied to the signal $(s(n) - 0.95s(n-1))$?

2. (25 points)

Assume that an infinite impulse train

$$\sum_k \delta(n + kP)$$

is filtered by a vocal-tract model given by $H(z) = 1/(1 + .9z^{-1} + .81z^{-2})$ to produce a speech signal $s(n)$.

(a) (5 points) Derive the difference equation for $s(n)$.

(b) (5 points) Compute the autocorrelation function $r(0)$ for the speech signal $s(n)$.

(c) (5 points) Compute the autocorrelation function $r(1)$ for the speech signal $s(n)$.

(d) (5 points) Compute the single LPC coefficient ($p = 1$) for this system.

(e) (5 points) How does this coefficient compare to the first coefficient when $p = 2$. Explain.

3. (25 points)

   (a) (15 points) Compute the real cepstrum of

$$H(z) = 1/(1 + .9z^{-1} + .81z^{-2})$$

   Hint: think of the relation between the complex and real cepstrum.

(b) (10 points) Sketch the real cepstrum of the speech signal s(n) created by convolving an infinite impulse train with $H(z)$. Make sure to label significant points in the sketch.

4. (25 points) Short Answer.

   (a) (5 points) Give an example of a voiced fricative and also suggest an English word that contains that voiced fricative.

   (b) (5 points) In LPC-10e, ten linear prediction coefficients are computed but they are transformed into 10 poles before they are quantized and transmitted. The decoder then transforms the poles back into LPC coefficients. Why not simply quantize and transmit the original LPC coefficients and save these extra steps?

(c) (5 points) A common algorithm for pitch determination is to perform autocorrelation on the LPC residual (error) and look for peaks. Why does this algorithm work better than performing autocorrelation on the original speech signal and looking for peaks?

(d) (5 points) Explain why humans have no problem determining the pitch of voices through the telephone, even though the cutoff frequency is larger than typical pitch frequencies.

(e) (5 points) In doing short-term speech analysis with Hamming windows, why should overlapping windows always be used?