BSc AUDIOLOGY

AUDL1001 – SIGNALS AND SYSTEMS FOR HEARING AND SPEECH (YEAR 1)

EXAMINATION 2008

Time Allowed – 3 hours

Please answer ALL of the following questions.

The maximum marks to be awarded for each question are indicated in parentheses after the question.

1) Consider 8 harmonics of a sawtooth wave which has a fundamental period of 10 ms and a fundamental component with a level of 120 dB SPL. Give its amplitude values in a table (both in Pa and in dB SPL) and also draw its amplitude spectrum (on dB SPL and logarithmic frequency scales) *and* phase spectrum (as degrees or radians on a logarithmic frequency scale). ***(10 points)***

2) Draw 3 cycles of the sawtooth wave in Question 1, and then a full-wave and a half-wave rectified version of it. (Remember: full-wave rectification = take absolute amplitude values; half-wave rectification = set negative amplitudes to 0). Which of the three waveforms will have the highest, and which the lowest RMS energy? Why? ***(5 points)***

3) Each line of the following table indicates the spectral components in a complex periodic waveform. For each combination, calculate the fundamental frequency and fundamental period. Note that frequencies are given in hertz and periods in ms, and your answers should also be expressed in these units. ***(5 points)***

a)	frequencies	500	1000	1100
b)	periods	0.5	1	4
c)	frequencies	10	15	30
d)	periods	7	3	1
e)	frequencies	100	1010	2000

TURN OVER

4) Suppose you had a system that multiplies each input amplitude value by 2. What change in dB does this correspond to? Draw input and output waveforms for 3 cycles of an input wave which is a sinusoid of peak amplitude 2 V and frequency of 400 Hz. Given what you've been told about the response of LTI systems to sinusoids, do you think this system is LTI? Why? Is this system homogeneous (sketch the input/output function)? Time-invariant? Give reasons for your answers. Where could such a system occur in daily life? ***(10 points)***

5) It is often said that the function of the basilar membrane can be likened to that of a filter bank. Describe what a filter bank is and specify what its properties should be to most faithfully reflect the processing in the inner ear. ***(20 points)***

6) In order to reduce data, telephone systems typically band-pass filter their signals. Consider a given system that has filter cut-offs at 300 and 3500 Hz and attenuates the signal by 20 dB in its pass-band and by 50 dB outside the pass-band. It rolls off linearly in dB over 100 Hz at each side of the filter.

   a) Draw a frequency response of that filter on dB amplitude and linear frequency scales up to 5 kHz.

   b) Draw input and output spectra of the following four signals passed through this system. You are free to choose the input level in each case:

      - A sinewave at 200 Hz
      - A sinewave at 1 kHz
      - An impulse
      - A periodic train of impulses with a period of 0.002 s.

(20 points)

7) For a project you are making digital recordings using a sampling rate of 44100 samples/second and a quantization depth of 16 bits. Now you realize that your recording is too large to fit on your disc. What two things can you do in order to decrease the size of the recording, *not* using a compression technique like MP3? How may each of these affect the sound quality of the signal and what kind of errors would you possibly introduce? Make sure you explain how the dynamic range and the bandwidth of your sampled signal changes as an effect of your data reduction. ***(20 points)***

CONTINUE

8) Sketch (with linear frequency scales spanning 0-2 kHz) a low-pass filter with a cut-off at 500 Hz, a high-pass filter with a cut-off at 1000 Hz and a band-pass filter with a pass-band between 500 and 1000 Hz. The pass-band in each filter has a gain of 40 dB and the stop-band sections attenuate the signal by 40 dB. The slopes are steep.

   Now consider you play white noise at a level of 96 dB re 1 V through all the filters in a cascade (first the low-pass, then the band-pass, then the high-pass filter). Draw the input and output spectra of the white noise passing through this cascade. Does the sequence of filters have an effect on the output spectrum of the noise? Why or why not? ***(10 points)***

END OF PAPER