BSc AUDIOLOGY

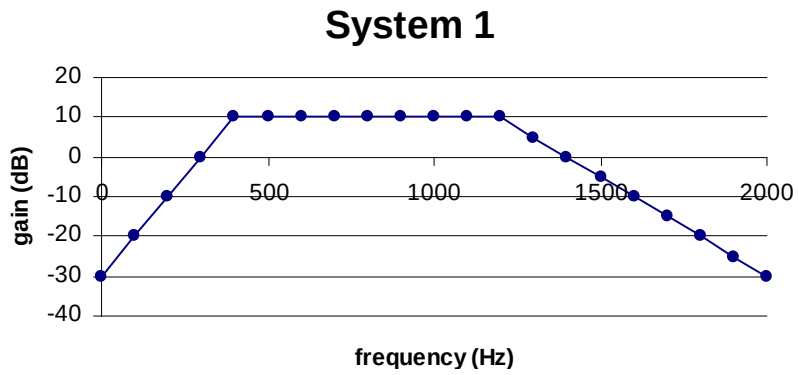
AUDL1001 – SIGNALS AND SYSTEMS FOR HEARING AND SPEECH (YEAR 1)

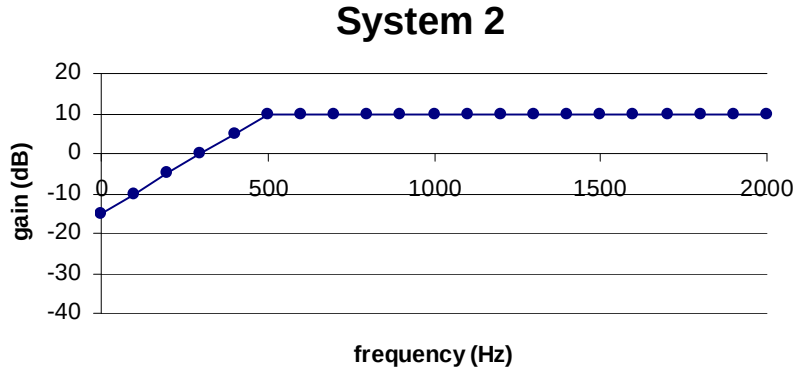
EXAMINATION 2009

Time allowed: 3 hours

Please answer ALL of the SIX questions.

1) Consider the amplitude responses of the following two systems.





CONTINUE

a) What kind of a filter does each represent?

b) Draw the amplitude response of System 2 on linear gain and linear frequency scales.

c) Now draw the amplitude response of a cascade of these two systems, System 1 followed by System 2, on dB and linear frequency scales.

d) What would be the amplitude response of the cascade if the position of the two systems were reversed? Explain your reasoning.

(**10 points total**)

2) Draw input and output spectra of the following 4 signals passed through System 1 in Question 1, over the frequency range 0-2 kHz, on dB and linear frequency scales. Ensure that your labels are accurate and that your amplitude scales are consistent across the input and output graphs.

a) A sinusoid at 300 Hz

b) White noise

c) An impulse

d) A periodic train of impulses with a period of 0.01 s

(**10 points total**)

3) Draw two cycles of a digital 50 Hz sinusoid at a peak voltage of 20 μV, sampled at 400 times per second. What processes are necessary to convert an analogue waveform to a digital waveform? What are the limitations of these processes?

(**15 points total**)

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4) Consider a periodic train of very narrow pulses at 100 Hz, whose fundamental component is at a level of 10 dB re 1 mV. This signal passes through a high-pass filter which has a passband gain of -10 dB at 400 Hz and upwards, and a low frequency slope which rolls off at 12 dB/octave from there.

   a) Draw the amplitude spectrum of the input wave on a linear amplitude scale over the frequency range 0 – 1000 Hz (use a linear frequency scale).

   b) Draw the frequency response of the system using dB gain and log frequency over the range 100 – 1000 Hz.

   c) Using dB amplitude scales, draw the amplitude spectrum of the input wave, and the output of this system to it, over the frequency range 100 – 1000 Hz.

   d) Would the input waveform be changed after passing through the system? Give reasons for your answer (you do not need to draw the output wave).

   (**20 points total**)

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 how the notion of a filter bank can be used to understand cochlear function and the relevant aspects of auditory nerve firing patterns. What properties would the filter bank need to have in order to best mimic the functioning of the inner ear?

   (**20 points total**)

CONTINUE

6) Almost all systems clip signals that are too large to be handled by them, so any system can only be considered to be linear time-invariant (LTI) over some limited range of levels. Suppose you had a system that acted as a perfect amplifier with a gain of 4. However, the magnitude of the output voltage is strictly limited to 10 V peak-to-peak (so the minimum voltage is -5 V and the maximum 5 V).

   a) Draw the frequency response of the system, on dB and linear frequency scales (0-3 kHz), assuming the input voltage to be 1 V.

   b) Draw output waveforms for 2 cycles of a 400 Hz sinusoid when:

      i) the peak voltage of the input is 1 V, and

      ii) the peak voltage of the input is 2 V.

      In terms of a general description, what kinds of output waves do you obtain in the two cases (aperiodic, simple, complex, periodic)?

   c) Make your best guess as to what the spectrum of the output to a 2 V input sinusoid at 400 Hz would look like, and draw it (using linear scales on both axes).

   d) Draw the input/output function of the system for a 400 Hz sinusoid for peak voltages ranging from 0 V to 3 V.

   e) Is the system homogeneous? Why or why not?

   f) Is the system it time-invariant? Why or why not?

   g) From what you have shown above, what are the two ways you can show that this system is not LTI for input voltages ranging from 0-3 V?

   (**25 points total**)

END OF PAPER