

**BSc Audiology
Year 1**

AUDL1001 – Signals and Systems for Hearing and Speech

2007
EXAMINATION

Time allowed: 3 hours

There is one section in this examination which contains SIX questions. Candidates should answer **ALL SIX** questions.

- Questions ONE and TWO are worth 10 marks each.
- Questions THREE to SIX are worth 20 marks each.

Candidates are reminded that it is important to demonstrate your workings: you may receive partial credit for your answer even if your final answer is wrong.

Answer Booklets

Candidates must write all answers in the Answer Booklets provided.

Candidates requiring additional answer booklets should contact an invigilator.

Any answers written on the Examination Paper will **not** be marked.

There is one section in this examination which contains SIX questions.

Candidates should answer **ALL SIX** questions.

- Questions ONE to FOUR are worth 10 marks each.
- Questions FIVE and SIX are worth 20 marks each.

Candidates are reminded that it is important to demonstrate your workings: you may receive partial credit for your answer even if your final answer is wrong.

Answer Booklets

Candidates must write all answers in the Answer Booklets provided.

Candidates requiring additional answer booklets should contact an invigilator.

Any answers written on the Examination Paper will **not** be marked.

Question 1

- a) Suppose a hearing aid amplifies the amplitude of a sound outside the ear by a factor of ten (i.e. so that the sound pressure in the ear is ten times higher than it is outside the ear).
 - i) What would be the dB SPL level inside the ear given an external sound level of 48 dB SPL?
 - ii) What are the input and output levels in Pa?
- b) Volker normally has a threshold for a 1 kHz sinusoid of 30 μPa . After visiting a disco with loud music, Volker's threshold of hearing for a 1 kHz tone is temporarily raised by 17 dB. What is his new threshold of hearing in dB SPL?
- c) The normal threshold of hearing at 125 Hz is 632.5 μPa . Stuart has a threshold that is 7 dB better than average at this frequency.
 - i) What sound pressure (in Pa or μPa) is the least intense Stuart can hear at 125 Hz?
 - ii) What is the normal average threshold in dB SPL at 125 Hz?

(10 marks)

Please turn over.

Question 2

A complex periodic waveform is made up of sinusoidal components with the following frequencies or periods. For each combination, calculate the fundamental frequency and fundamental period.

- a) frequencies = 120, 240 and 480 Hz
- b) periods = 1 ms, 3 ms, 9 ms
- c) frequencies = 150, 200 and 400 Hz
- d) periods = 7.5 ms, 5 ms, 2.5 ms
- e) frequencies = 1100, 1110 and 1500 Hz

(10 marks)

Question 3

Consider a wave which consists of the first 8 harmonics of a sawtooth wave whose fundamental period is 4 ms, and whose fundamental component has a level of 3 Pa.

- a) Draw its spectrum (on dB SPL and logarithmic frequency scales over the frequency range 125 Hz to 2 kHz).
- b) This wave is then put through a 'System X' which results in the output wave having a spectrum in which the first 4 components are at an equal amplitude of 4 Pa and the second four components at an equal amplitude of 1 Pa. Draw this spectrum on dB SPL and logarithmic frequency scales over the frequency range 125 Hz to 2 kHz.
- c) Over the same frequency range, and again using dB and logarithmic frequency scales, draw the amplitude response of 'System X'.

(20 marks)

Question 4

It is often said that the function of the basilar membrane can be likened to that of a filter bank.

- a) Describe what a filter bank is, and how the notion of a filter bank can be used to understand peripheral auditory function.
- b) What properties would the filter bank need to have in order to best mimic the functioning of the inner ear?
- c) In what ways are these properties different from the filter bank used to make ordinary spectrograms?

(20 marks)

Please turn over.

Question 5

Suppose you had a system that squares each amplitude value of a waveform.

- a) Draw input and output waveforms (3 cycles) for a sinusoid of peak amplitude 2 V and frequency of 400 Hz. What is the simplest way of knowing that this is not an LTI system?
- b) Plot the input/output function (using peak amplitude) for a 400 Hz sinusoid over the range 0-4V. Is this system homogeneous? Time-invariant? Give reasons for your answers.

(20 marks)

Question 6

In internet radio it is important to transfer the smallest amount of data possible.

- a) Calculate how much data (in kbytes/s) needs to be transmitted for a hifi signal (mono, not stereo) that is sampled at 44100 samples/second and 32 bit-quantisation.
- b) What two things can be done easily in order to bring down the amount of data?
- c) What problems do you run into when you decrease the data rate too much?

(20 marks)

END OF PAPER