Signals, systems, acoustics and the ear
Lab 1: Pure-Tone Audiometry

Introduction
Pure-tone audiometry (PTA) is probably the most common procedure used in audiological clinics. Its purpose is to measure the threshold of audibility for pure tones presented to a listener over headphones. Threshold measurements, made for a standard agreed set of frequencies, are expressed in dB HL (Hearing Level, although sometimes: dB ISO) and plotted on a graph called a *pure-tone audiogram*. In the clinic, a calibrated audiometer is used to present the correct intensity for each tone such that 'normal hearing' (as described in 1964 by the ISO) registers as 0 dB HL. In this experiment you will take the roles of patient and audiologist in a pure-tone audiometric procedure using basic equipment.

Learning Objectives
- to understand the relationship between dB SPL and dB HL units of intensity/pressure
- to convert measurements of pressure in Pa to dB SPL, and v.v.
- to demonstrate a particular method of threshold measurement ('10 down, 5 up')
- to illustrate the principles underlying the determination of a pure-tone audiogram using the simplest equipment possible

Apparatus
The apparatus consists of a sine-wave oscillator connected to headphones through an attenuator box. The apparatus has been set up in the sound-proof cubicles in the basement suite. The apparatus has been calibrated so that the sound pressure level at the right headphone for an attenuation of 0 dB is known. **YOU SHOULD NOT ADJUST THE OUTPUT LEVEL OF THE OSCILLATOR.**

Method
You should work in pairs, one taking the role of patient and one of audiologist, then swapping roles to repeat. The 'patient' should raise a finger to indicate that s/he has heard a tone.

Setup procedure:
1. Set the oscillator to the frequency under test, and the attenuator to 0 dB. Use the push button on the attenuator box to present a tone at the headphones.
2. Ensure the subject can hear the tone in the right ear only. Once the test is underway, please do not touch or adjust the headphones or watch the 'audiologist'.

Measurement procedure ('10 down 5 up'):
1. Using the attenuator, decrease the level of the tone by 10 dB (2 clicks clockwise), and present the tone using the push button (for about 1 second). Repeat until the subject ceases to respond. The presentation level is now below the subject's threshold.
2. Increase the level of the tone by 5 dB (1 click) and present tone. Repeat until the subject responds again. The presentation level is now at or above threshold.
3. Decrease the level of the tone in steps of 10 dB until the subject ceases to respond.
4. Repeat steps 2 and 3 until you find the threshold level (lowest attenuator setting that the 'patient' indicates hearing a tone twice out of 2, 3 or 4 ascending trials) .
5. Record the dB setting from the attenuator.

Observations

1. Using the measurement procedure, test the frequencies in the table below, entering the final attenuator values in row 2.

2. Convert your attenuator readings into dB SPL **using the calibration reading for your equipment**:

Threshold @ f Hz (dB SPL) = Calibration level @ f Hz (dB SPL) – Attenuator reading @ f Hz (dB).

Where 'f' = 125, 500, etc. Plot a graph of your thresholds in dB SPL against log frequency on the top of the next sheet.

3. Convert your threshold levels in dB SPL to Hearing Level in dB HL:

Threshold @ f Hz (dB HL) = Threshold @ f Hz (dB SPL) - Average Threshold level @ f Hz (dB SPL).

If your threshold level is more intense (worse) than average you should get a positive number. If your threshold level is less intense (better) than average you should get a negative number.

4. Plot your Hearing Levels on the standard audiogram form supplied on the next sheet.

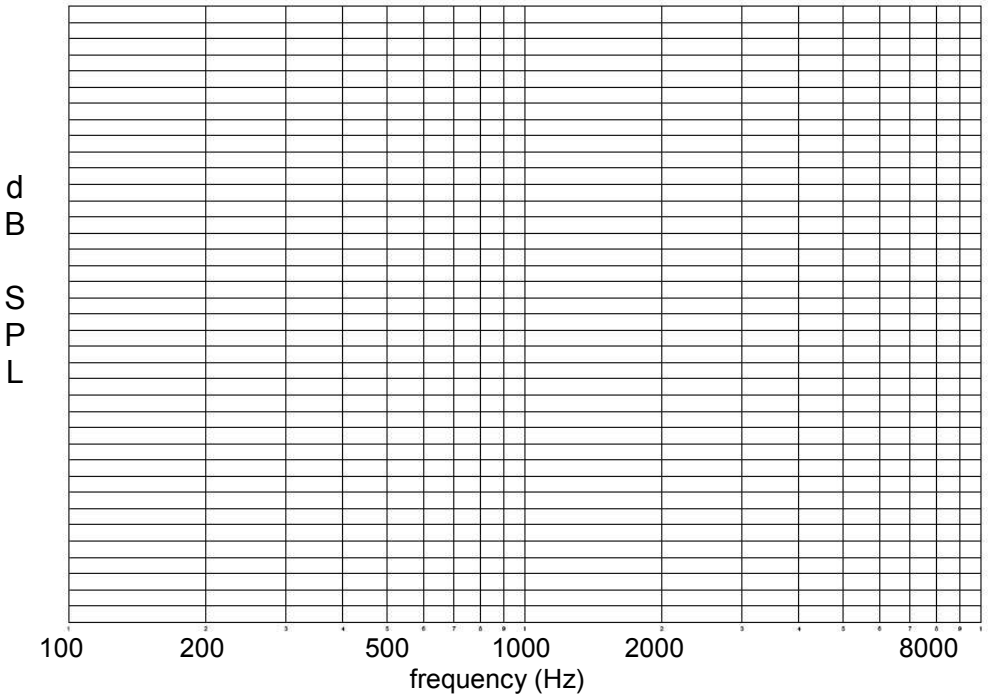
5. For all frequencies, convert the normal thresholds (*e.g.*, 30 dB SPL at 125 Hz) into μPa (micro-pascals – row 8). Also convert your own thresholds from dB SPL into μPa (row 9). Then calculate from these two values the dB value of your own threshold referred to the average normal threshold: *= 20 log ((own threshold in μPa [row 9])/(normal threshold in μPa[row 8]))* What is the relationship between these values and your thresholds in dB HL?

6. **In the interests of time, do only the 3 circled frequencies!**

1	*frequency*	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
2	*threshold attenuator reading*							
3	*dB SPL at 0 dB attenuation (calibration factors specific to your cubicle)*							
4	*threshold dB SPL (row 3 – row 2)*							
5	*average normal threshold (dB SPL)*	**30**	**19**	**12**	**9**	**9**	**9**	**10**
6	*threshold dB HL (row 4 – row 5)*							
7								
8	*average normal threshold in μPa (converted from row 5)*							
9	*threshold in μPa (converted from row 4)*							
10	*threshold (dB re average normal threshold, calculated from rows 8 and 9)*							

A WORD OF WARNING

We have tried to make this experiment realistic, but the apparatus is designed to explain audiometry rather than give accurate results. Since the testing conditions are less than perfect, our equipment and calibration methods non-standard, and your partner probably not a trained audiologist, **you should not take the results to be a reliable indicator of your hearing**. If you are concerned about your hearing you should arrange to visit the audiology department of your local hospital.



On the y axis, each grid line represents 1 dB, so choose a sensible starting point, and mark off 5 dB intervals to make your plotting easier.