M5. The basics of biophysics of the hearing sense. Testing the human ear threshold of audibility

Topics:

- Mechanical vibrations [1] – Chap. 15.
- Mechanical waves – creation, propagation, properties and equation of harmonic wave motion [1] – Chap. 16.
- The wave interference phenomenon and the stationary wave [1] – Chap 17.
- The acoustic wave as an example of mechanical wave, acoustic wave properties, acoustic wave equation, the isophonic contours [1] – Chap. 17.
- The resonance phenomenon [1] – Chap. 15-9
- The principle of superposition for waves [1] – Chap. 16-9
- Weber-Fechner law.
- Doppler effect [1] – Chap. 17-9
- The ear and hearing. The audibility threshold and the threshold of pain.
- Objective and subjective audiometry.

Description of experiment:

The goal of the experiment is determination of the human ear threshold of audibility for acoustic waves of varying frequencies (from 250 to 8000 Hz). The thresholds of audibility might be determined with air and bone conductance audiometry.

In the air conductance audiometry the test signal is transmitted through headphones and Hughson Westlake'a test is applied. It is an automatic tonal test. The threshold of audibility is defined as 2 out of 3 correct responses to the same intensity and frequency of generated tone. In the automatic procedure the tone intensity is increased by 5 dB or decreased by 10 dB. The goal of audiometry is determination of the threshold of audibility for various frequencies. The examination might reveal hearing defect, but it can not specify its reason.

In the bone conductance audiometry the bone vibrator is used to apply test signal to either mastoid process or to a forehead of a patient. The idea is to transfer the tone directly to the inner ear and determine the threshold of audibility of the inner ear. In this test the second ear should almost always be masked.

Instruction:

1. Switch on the computer.

2. Check whether the audiometer is connected to the power supply and switch it on (switch no. 1 on Fig. 1)

3. Start OtoAcces program (icon in the upper left corner of the screen).

4. Fill in all empty red fields (name, surname etc.). Double click the audiometer usb icon (upper right corner of the screen. See Fig. 2). The diagrams of the examination record should appear on the screen (Fig. 3).

5. Start the threshold of audibility measurement (first, you should carefully read the instruction).

   - The air conductance.

     ➢ The "patient" wears anti-noise earphones (the red earphone on the right ear!!!) and holds the signal button. During the measurement the patient should not look at the audiometer screen. When the test starts the patient should push the button when she/he hears the sound.

     ➢ The person who makes the measurement should choose the Hughson Westlake's test by clicking the Auto Threshold button (no. 2 in the Fig. 1). **ATTENTION!!!** The test will start immediately after the button is pushed. The Right button, showing that the signal is applied to the right ear, should be illuminated (no. 3 in the Fig. 1). After the examination of the right ear the audiometer will automatically switch to the left ear and Left button will be illuminated (no. 4 in the Fig. 1). During the examination the frequency and intensity of applied sound is shown on the audiometer display.

     ➢ When the test is finished push the F2 button. The data will be transferred to the computer and shown on diagrams.

   - The bone conductance.

     ➢ If the same person is examined, the bone conductance data will be plotted on the same diagram as the air conductance data. Otherwise the air conductance data should be printed, first and use Esc button to go back to patient personal data screen. Then follow instructions of the pt. 4.

     ➢ Use button 5 to switch the audiometer to the bone conductance mode (Fig. 1). In this case the measurement is not automatic, so the examining person should stay focused.

       – Black buttons in the lower right corner are used for noise intensity regulation (light blue in the Fig. 1), middle buttons in the upper row regulate frequency (beige buttons in the Fig. 1) and the lower left corner buttons regulates the intensity of the

applied tone (light violet button in the Fig. 1). During the measurement the frequency might be set manually, but it is better to let the apparatus set it up automatically. After each response of the patient the button no. 6 should be pushed, so the response is stored.

- The intensity of both noise and tones should be set to 0 dB, the frequency should be automatically set to 1000 Hz.

➢ The patient wears the bone conductivity earphone. First, check the right ear. The earphone should be placed just behind the ear, so the active part should touch mastoid process. The opposite side of earphone should support on the forehead of the patient. The anti-noise earphones should protect only left ear (where noise will be applied).

➢ The examining person increases the noise intensity (with 5 dB step) until the patient hears the noise. Since now the noise level should remain fixed. Then for a given frequency increase the tone intensity (with 5 dB step) and push the tone application button. The procedure should be repeat until the patient says that she/he hears the tone. Then we push button no. 6, so the response is automatically stored and the frequency of tone should change automatically. Repeat this procedure for each displayed frequency (max. 8000 Hz).

➢ Use F2 button to download the data to the computer.

➢ Push the button no. 5 and start examination of the left ear. The left ear control will turn on. Analogously repeat the procedure described above for left ear. When finished download the data to the computer by clicking F2 button.

➢ Print diagrams and attach them to the report.

6. When finished switch of the audiometer (button no. 1), use Esc to exit diagrams screen and close the program. Leave the computer switched on.
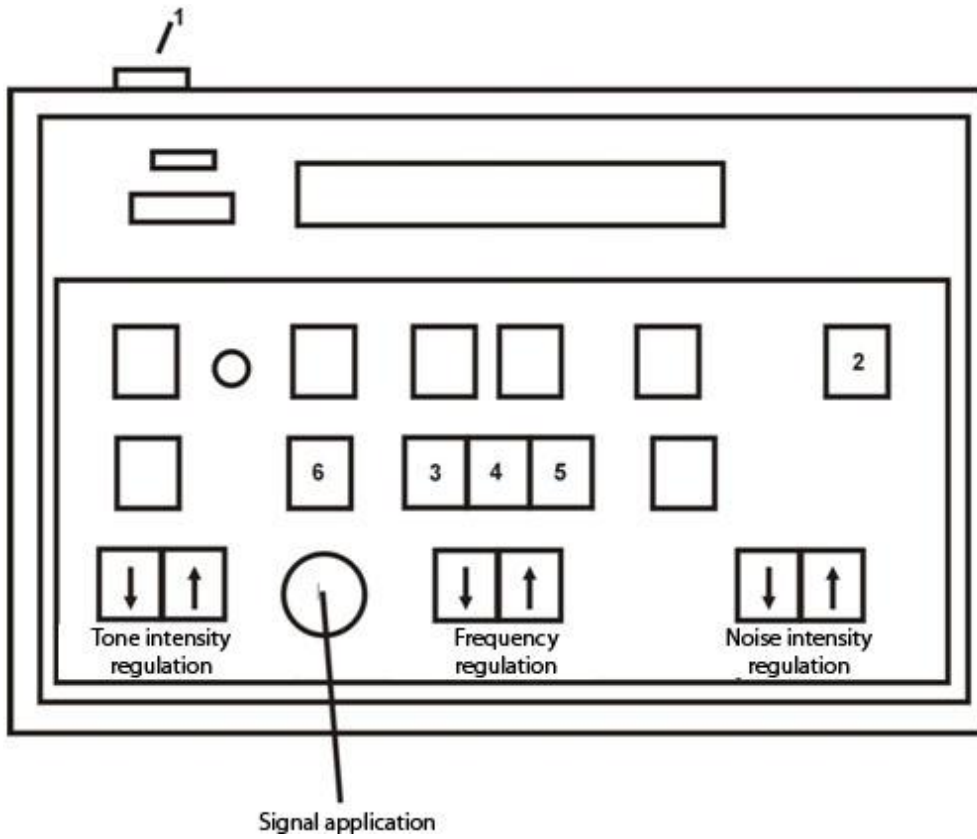
7. Discuss your results.

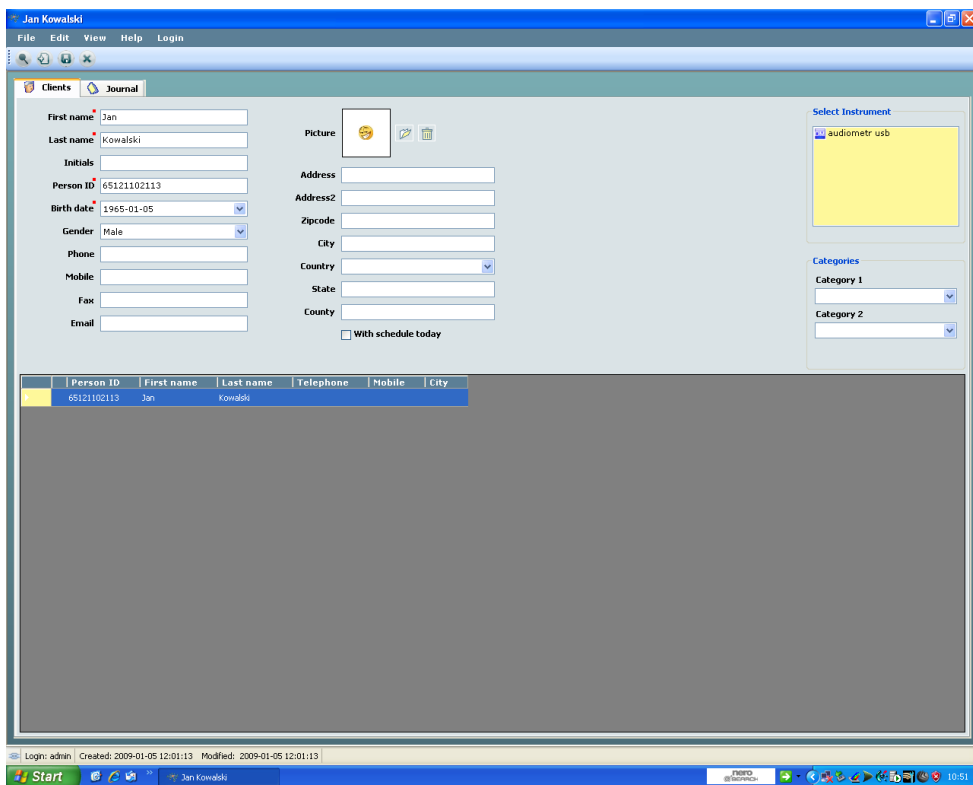Fig. 1. The scheme of audiometer keypad.

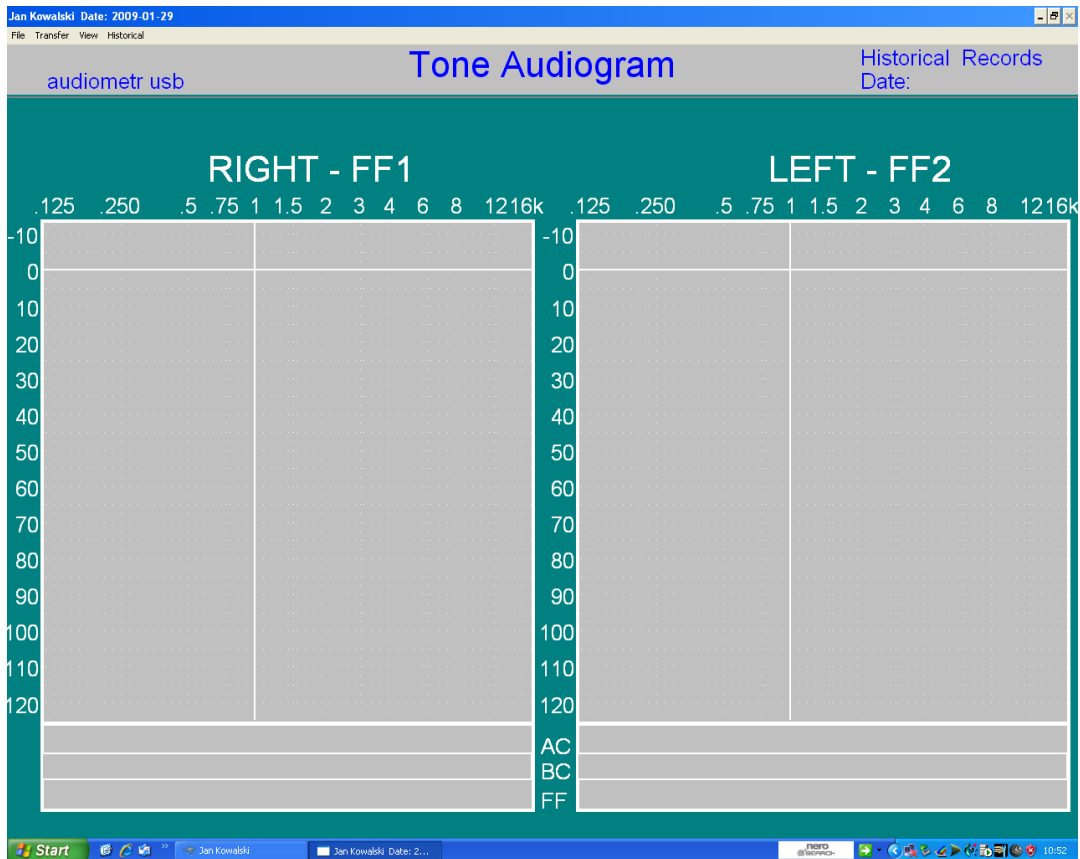Fig. 2. The screen of OtoAcces program.

Fig. 3. The diagram screen.

Conclusions

[1] Walker J., Halliday and Resnick, *Principles of physics : international student version*, 9 th ed., extended, Hoboken : John Wiley & Sons, Inc., 2011. , ISBN 978-0-470-56158-4