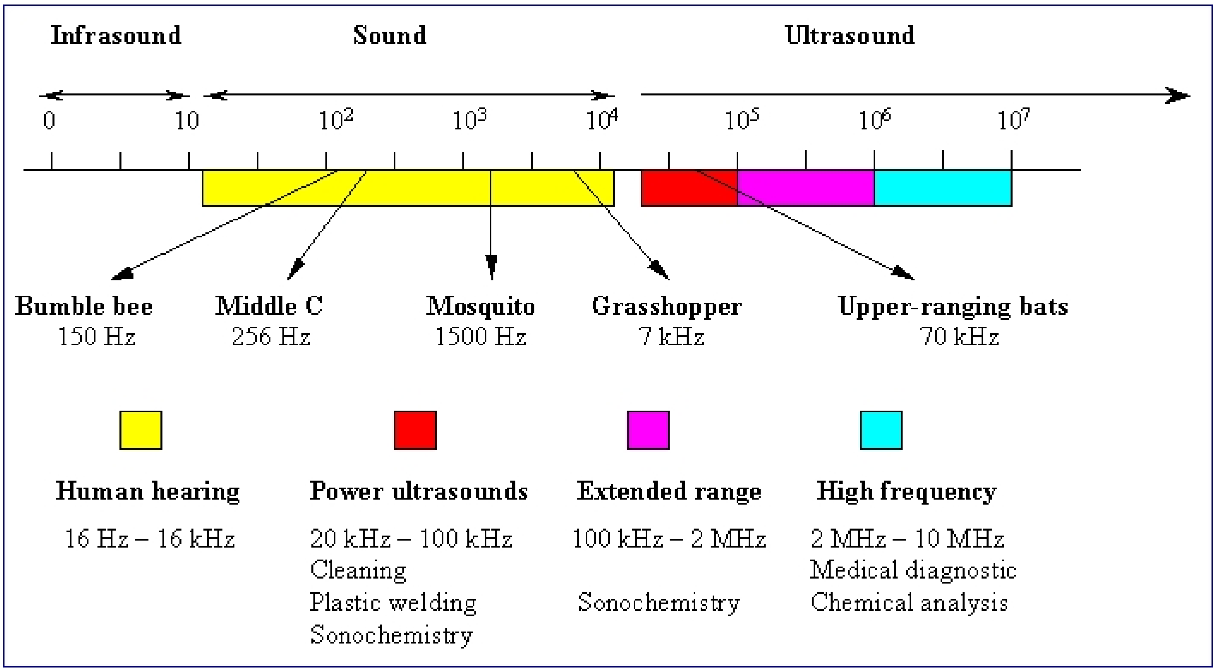
M6_on-line. Physical principles of ultrasound in medicine. Ultrasonography.

<u>Problems to be prepared</u>:

- Mechanical wave - the generation, propagation mechanism, properties, harmonic wave equation [for example, 1] – Chap. 16.
- Acoustic wave, ultrasound. The use of ultrasound in the diagnosis and therapy [1] – Chap. 17..
- Wave reflection and refraction. Ultrasound imaging - the reflection coefficient, transmission coefficient, acoustic impedance.
- The phenomena which affect the interpretation of ultrasound images: wave scattering, interference, attenuation of acoustic waves.
- The generation of ultrasound in USG units.
- A-mode, B-mode and M-mode ultrasonography.
- Resolution of the ultrasound imaging. Diffraction [1] – Chap. 35-3.
- Doppler effect [1] – Chap. 17-9.



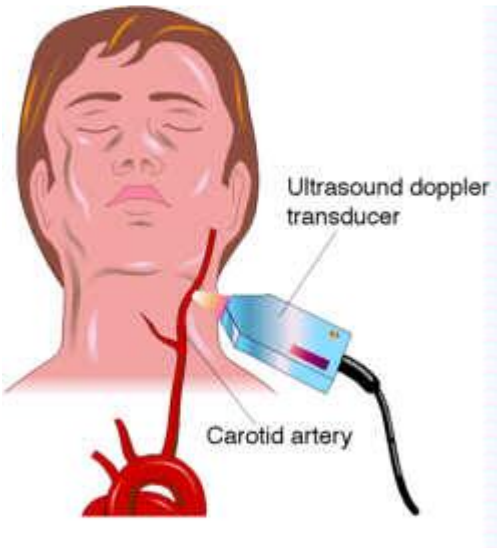
In ultrasonography, a signal generator is combined with a transducer. Piezoelectric crystals in the signal generator convert electricity into high-frequency sound waves, which are sent into tissues. The tissues scatter, reflect, and absorb the sound waves to various degrees. The sound waves that are reflected back (echoes) are converted into electric signals. A computer analyzes the signals and displays the information on a screen.

Ultrasound information can be displayed in several ways.

A-mode: This display mode is the simplest; signals are recorded as spikes on a graph. The vertical (Y) axis of the display shows the echo amplitude, and the horizontal (X) axis shows depth or distance into the patient. This type of ultrasonography is used for ophthalmologic scanning.

B-mode ultrasonography in which the strength of echoes is indicated by a proportional brightness of the displayed dots. This mode is most often used in diagnostic imaging; signals are displayed as a 2-dimensional anatomic image. B-mode is commonly used to evaluate the developing fetus and to evaluate organs, including the liver, spleen, kidneys, thyroid gland, testes, breasts, and prostate gland. B-mode ultrasonography is fast enough to show real-time motion, such as the motion of the beating heart or pulsating blood vessels. Real-time imaging provides anatomic and functional information.

M-mode: This mode is used to image moving structures; signals reflected by the moving structures are converted into waves that are displayed continuously across a vertical axis. M-mode is used primarily for assessment of fetal heartbeat and in cardiac imaging, most notably to evaluate valvular disorders.



Doppler: This type of ultrasonography is used to assess blood flow. Doppler ultrasonography uses the Doppler effect (alteration of sound frequency by reflection off a moving object). The moving objects are RBCs in blood.

Direction and velocity of blood flow can be determined by analyzing changes in the frequency of sound waves:

- If a reflected sound wave is lower in frequency than the transmitted sound wave, blood flow is away from the transducer.
- If a reflected sound wave is higher in frequency than the transmitted sound wave, blood flow is toward the transducer.
- The magnitude of the change in frequency is proportional to blood flow velocity.

Changes in frequency of the reflected sound waves are converted into images showing blood flow direction and velocity.

Description of experiment

Two-dimensional device combining two-dimensional ultrasonography and Doppler examination with a head line is used during the experiment. The purpose of this exercise is to find the blood vessels of the neck. Next students try to determinate of their velocity of blood flow using the Doppler signal analysis.

Instruction

1. Short movie will demonstrate how the USG apparatus can be operated.
2. If the received image is satisfactory, one should freeze it. After frrezing the image is the unit will automaticly analyze 6 paramiters:

   PSV – Peak Systolic Velocity,

   EDV – End Diastolic Velocities,

   TAM – Time Averaged Mean peak velocities,

   RI – Resistance Index,

   PI – Pulsatility Index,

   S/D – Peak Systolic to end Diastolic.
3. The image shoul be printed by pressing **PRINT** key.
4. The images will be provided for students during lab on-lione.
5. Using the information recorded on the device, calculate the Doppler frequency, in both systole and diastole, corresponding to the blood flow velocity in the test vessel.

$$f_d = f\frac{2v\cos\theta}{c}$$

   v – blood flow velocity (PSV and EDV),

   c - ultrasound velocity in blood - 1570 m/s,

   f – frequency of sound produced by header,

   θ - angle between direction of wave propagation and velocity of blood flow.
6. Make the 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