Medical physics module
Semester 1

Session 4

Lec.7

Sounds & Ultrasound in medicine

By: Lect. Dr. Nadia Hussein Sahib

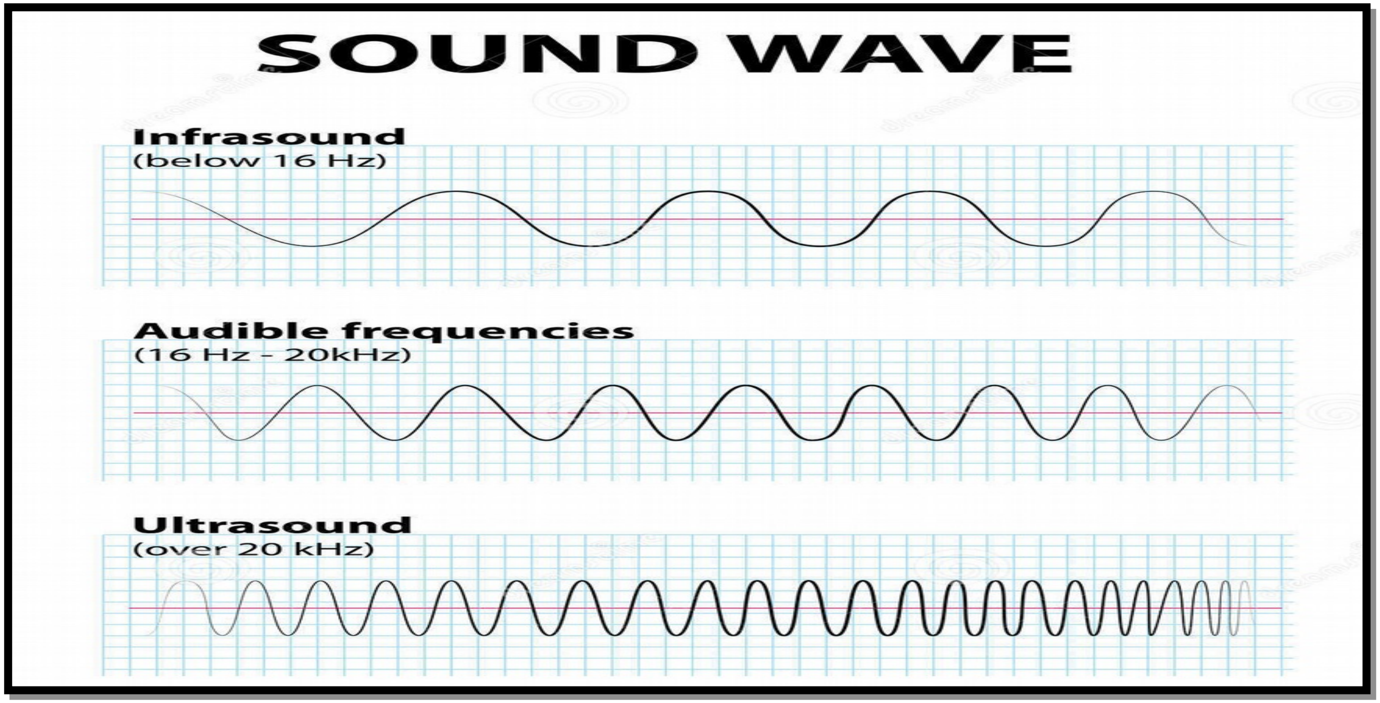
Objectives

- Definition.
- To get information about general properties of sound.
- Characteristics of human body.
- Physics of stethoscope.
- Applications of audible sound in medicine.
- Physiological effects of ultrasound in therapy.

Obj.1

Definition

- Its an audible waves of frequency between (20 Hz --- 20 KHz)



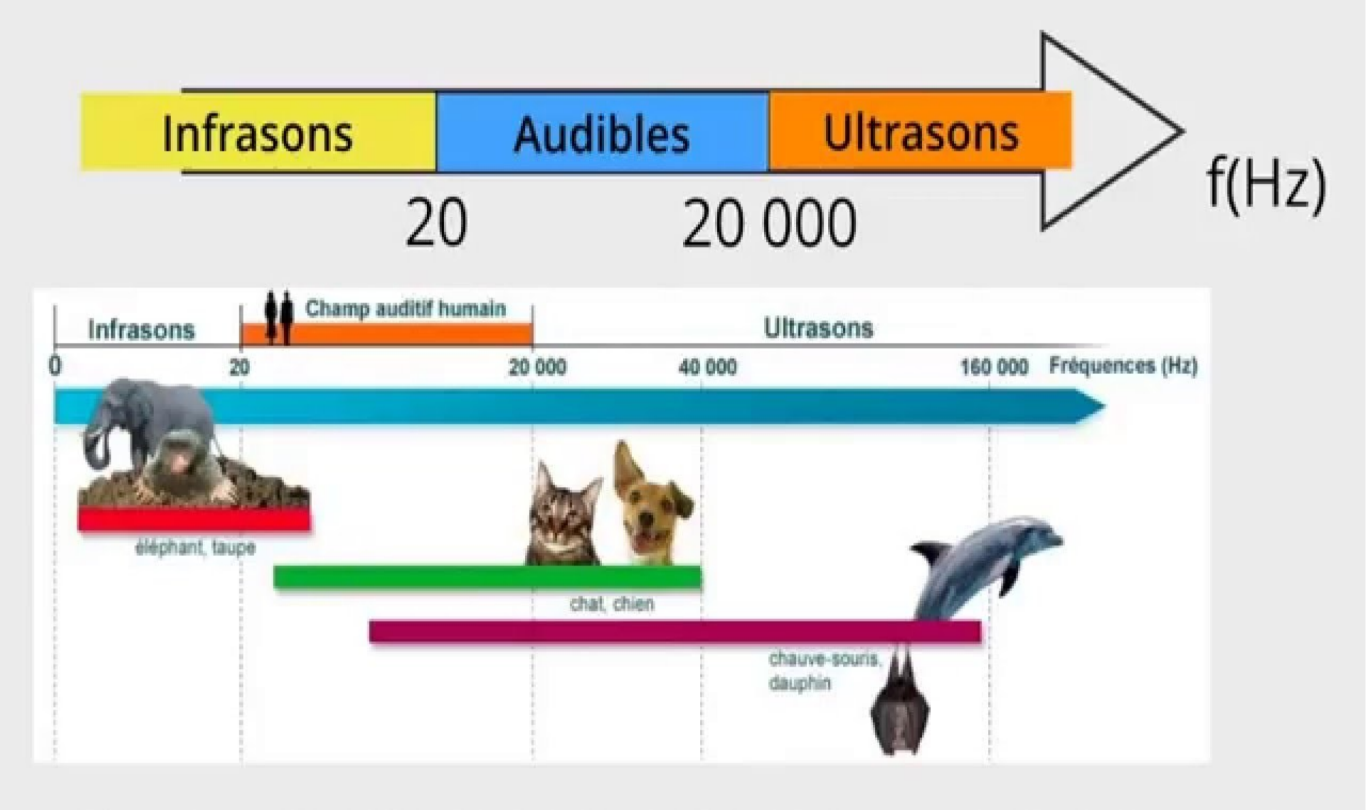
Infrasound

Refers to the sound of frequency below normal hearing range (< 20 Hz)

Ultrasound

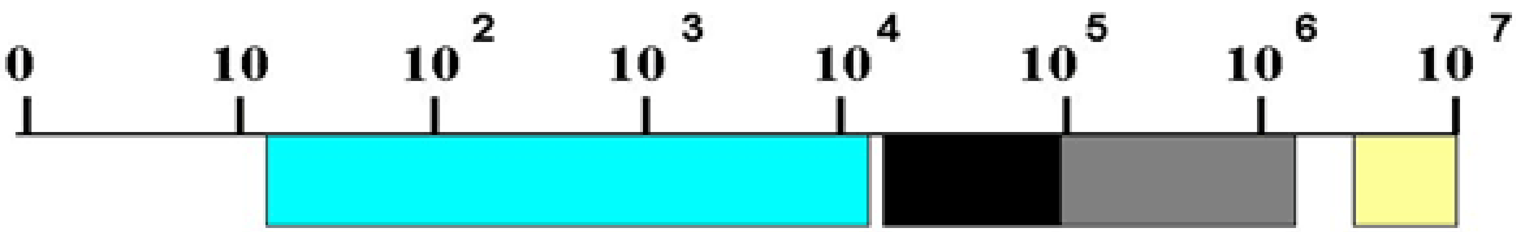
Refers to the sound of frequency above normal hearing range (20 KHz)

Infrasound & Ultrasound



- **Infrasound and Ultrasound both these sound can not be heard**

The Frequency Ranges of the Sound



Human hearing	16Hz - 18kHz
Conventional power ultrasound	20kHz - 100kHz
Extended range for sonochemistry	20kHz - 2MHz
Diagnostic ultrasound	5MHz - 10MHz

Obj.2

General properties of sound

Sound wave require medium (gas ,liquid or solid) for transmission mean matter must be present for sound to travel

Sound waves

Is mechanical wave, the vibration causes local increase and decrease in pressure relative to atmospheric pressure.

The pressure increase called compression, and decrease called rarefaction

Velocity of sound

$$V = \lambda f$$

f = frequency of vibration of the sound wave.

λ = wave length

Sound intensity

Energy carried by waves as kinetic and potential energy

Intensity (*I*) is the energy passing through

1 m^2/sec. or watts /m^2

$I = 1/2\ \varrho\ V A^2 (2 \Pi f)^2$

f = frequency ρ= density V = velocity

$Z = \varrho\ V$

$I = 1/2\ Z\ (Aw)^2$

$(2 \Pi f)$= w = angular frequency

A - maximum displacement of atoms from equilibrium state.

Z = specific acoustic impedance

$I = P_0 / 2Z$

P_0 = maximum change in pressure

Obj.3

Characteristics of human body

- Pitch, refers to the attribute of a sound sensation that
enables one to classify a node as high or low.

Loudness, the effect of intensity of the sound wave on human hearing known as loudness.

The unit of the human sound is **decibel(dB)**, it represents the ratio between two sound intensities and known as (sound intensity level)

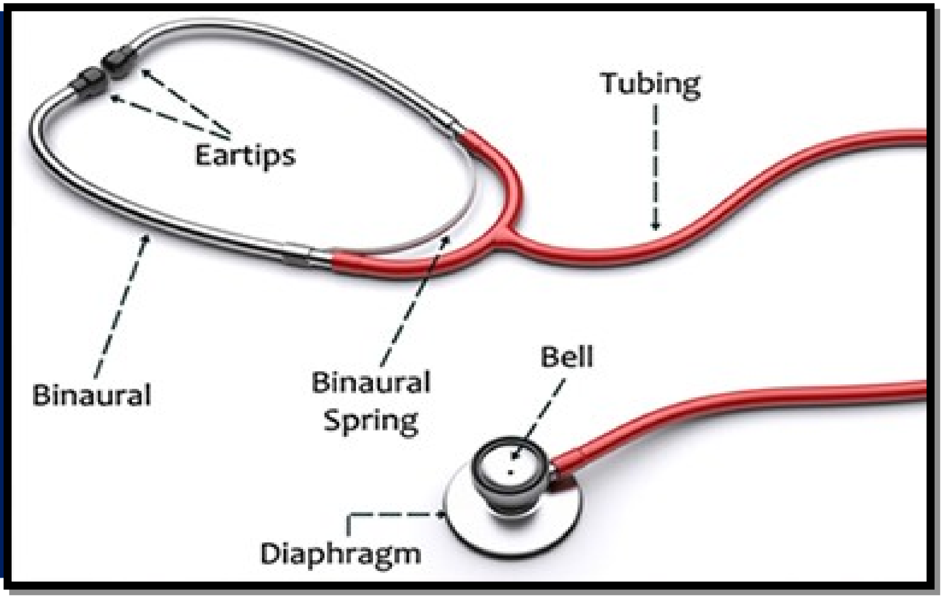
$\log I / I_{\circ}$ = intensity ratio

Obj. 4

Auscultation

Act of listening to the sound of the heart and lung with stethoscope

- ➢The main part of the stethoscope is bell, ear pieces and tube



The volume of the tube should be small, and there should be little frictional loss of sound to the walls of the tube.

If the diameter of the tube is too small frictional losses occur, and if it is too large, the moving air volume is too great: in both cases efficiency reduced.

A **good size is a tube with length of about (25 cm) and diameter of (0.3 cm).**

Obj.5
Applications of audible sound in medicine

- **The stethoscope .** **US in medicine**.

Sonar (sound wave pulse is sent out and reflected from object), it is a device that uses an US to generate an image of a particular soft tissue structure in the body.

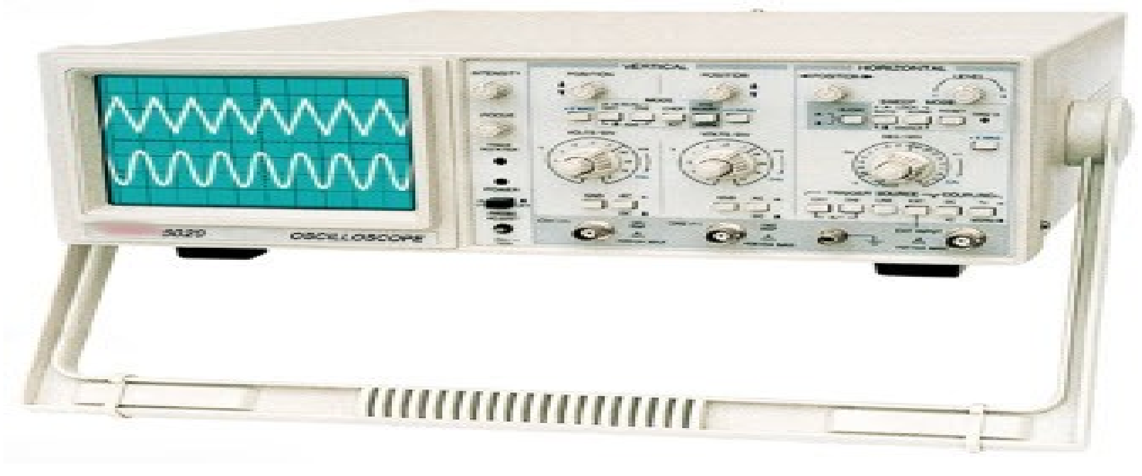
The ear gets gain in sound by equation:

(Gain) = 10 log power out / power in.

Types of US imaging

Ultrasound generator (transducer) send abeam of pulses into body ,the time required for pulses to reflect give information on the distance of various structure in the path beam (A scan).

- These detected echoes(reflected sound) converted to electrical signal and displaced as vertical deflection on oscilloscope.



Applications in medicine

1. Echoencephalography

Used in the detection of brain tumor. Pulses of ultrasound are sent into a thin region of the skull echoes from the different structures within the head.

The usual procedure is to compare the echo from the left side of the head to those from the right side and to look for a shift in the midline structure.

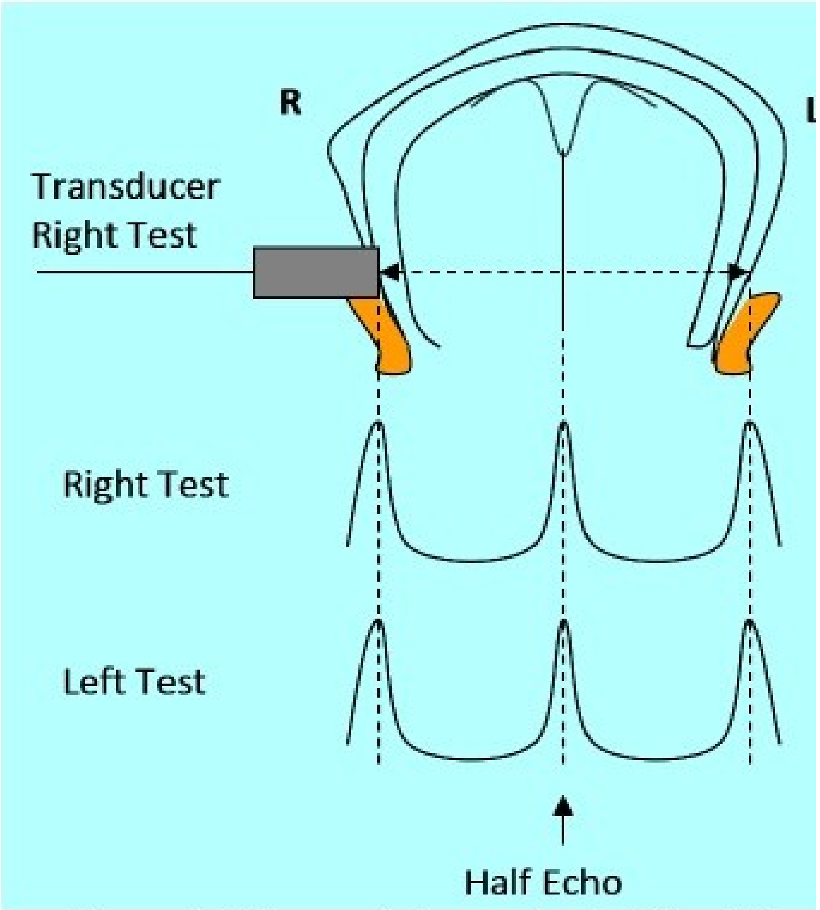


Figure 5. Echoencephalogram in a healthy skull.

2. Ophthalmology

Biometry or distance in eye

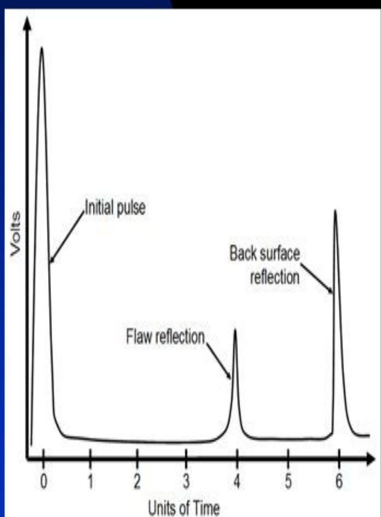
With ultrasound it is possible to measure distances in the eye such as lens thickness, depth from the cornea to the lens

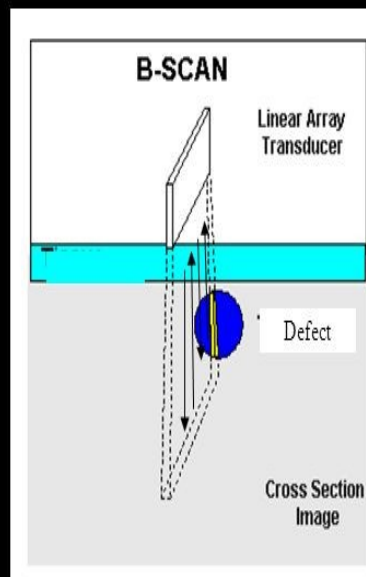
B scan

There are B scan which is used to obtain two dimensional views.

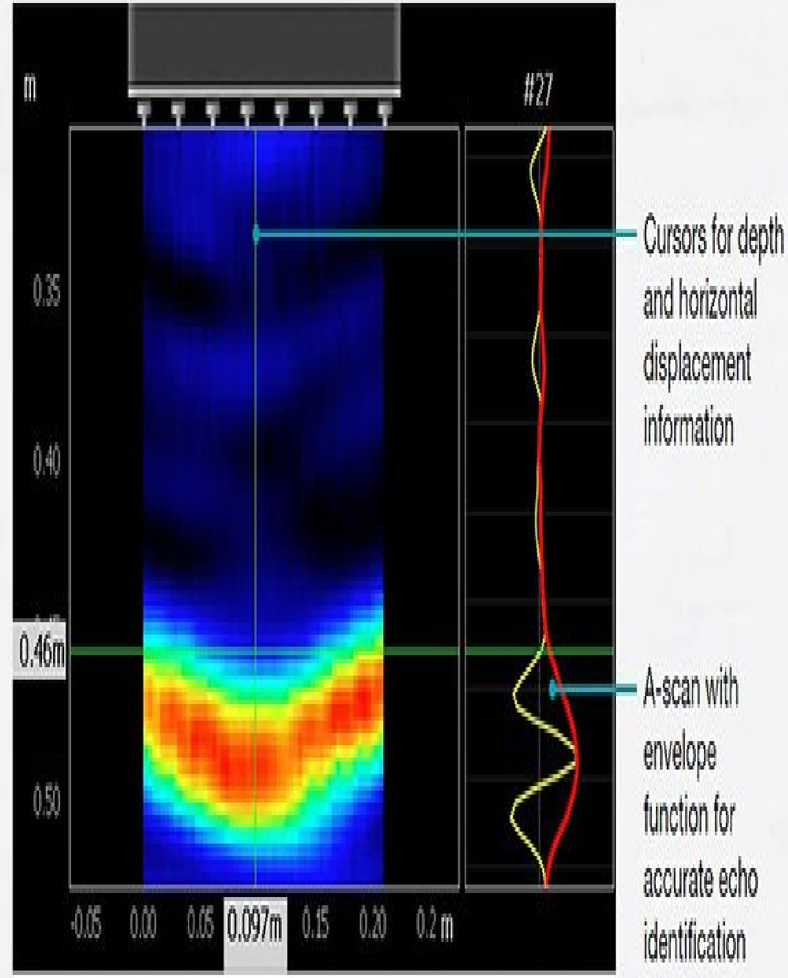
The principles are the same as for A scan except that transducer is moved.

A-scan to B-scan





Real-time B-scan



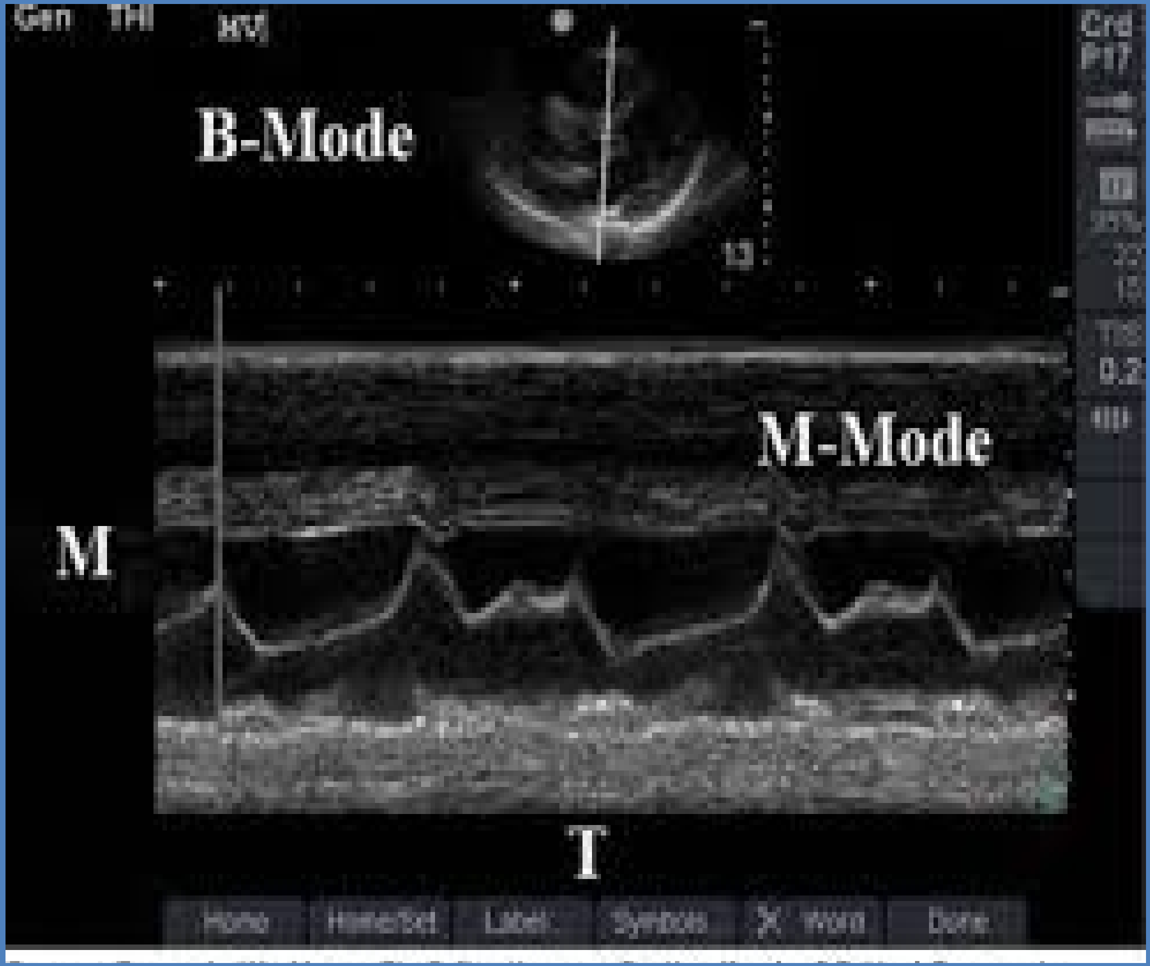
Ultrasound to measure motion

Two methods are used to obtain information about motion in the body :

M scan **(motion) used to study heart and heart valves**

Doppler technique **used to measure blood flow.**

Also used to detect motion of the fetal heart, umbilical cord .



B-Mode
M-Mode
M
T

Obj.6
Physiological effects of ultrasound in therapy

1. Low intensity US (0.01 W/cm^2), no harmful effect is observed, used for diagnostic work (sonar).
2. Continues US (1 W/cm^2), deep heating effect, and temperature raise of tissue.
3. Continues US (1 - 10 W/cm^2), sound moves through tissues, pressure differences in adjacent regions of tissues.
4. Continues and focused US (10^3 W/cm^2), selective destroying of deep tissue using a focused ultrasound beam.


Thank you