SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore-35

Affiliated to The Dr.M.G.R Medical University, Chennai

DEPARTMENT OF RADIOGRAPHY AND IMAGING TECHNOLOGY
III YEAR

COURSE NAME : EQUIPMENTS OF ADVANCED IMAGING MODALITIES

TOPIC : BASIC PRINCIPLES OF ULTRASOUND

INTRODUCTION

- Sound is a mechanical and longitudinal energy wave that travels in straight line.

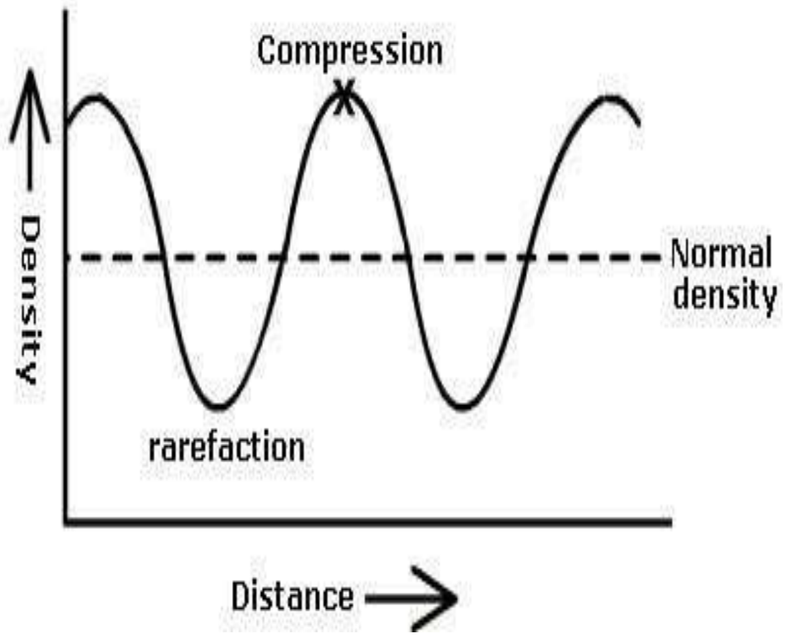
- Requires medium for propagation.

- Sound waves travels by compressing and rarefacting matter.

- Ultrasound is a sound having frequencies greater than 20,000Hz or 20KHz which cannot be detected by human ear.

- Audible sound–15 Hz to 20,000 Hz.

- Diagnostic ultrasound frequency is from 1 to 30 MHz.



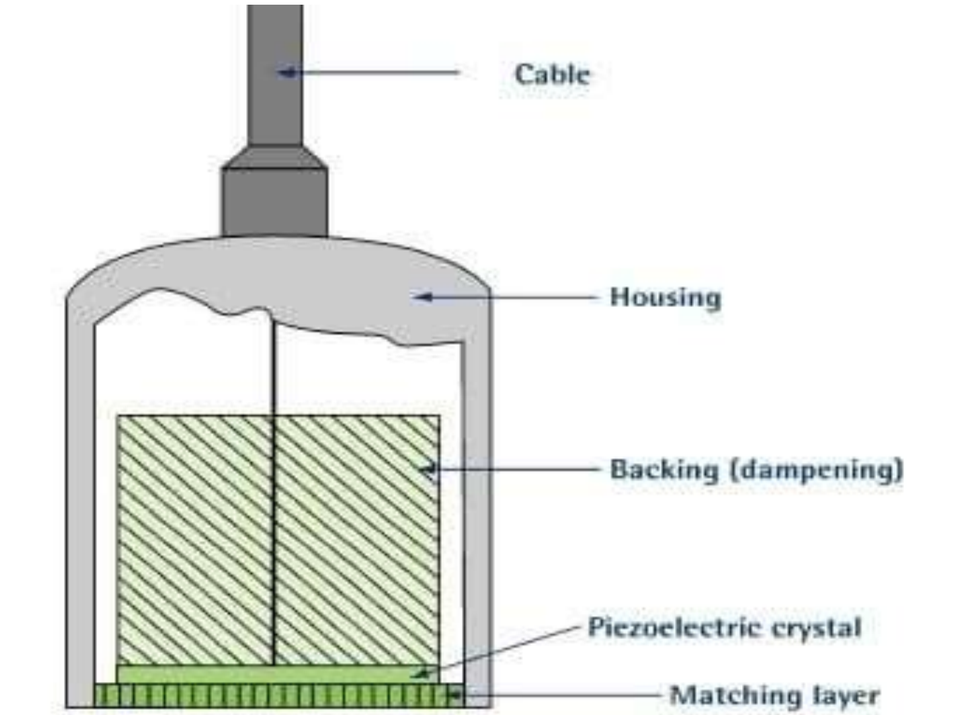
PRODUCTION OF ULTRASOUND

- Source – Transducer ,which works on the principle of piezoelectric effect.

- Transducer is a device that converts electrical energy into ultrasound energy and vice versa.

- Most important component is piezoelectric crystal which is made of quartz crystal or a synthetic ceramic such as Lead Zirconate Titanate(PZT).

COMPONENTS OF TRANSDUCER



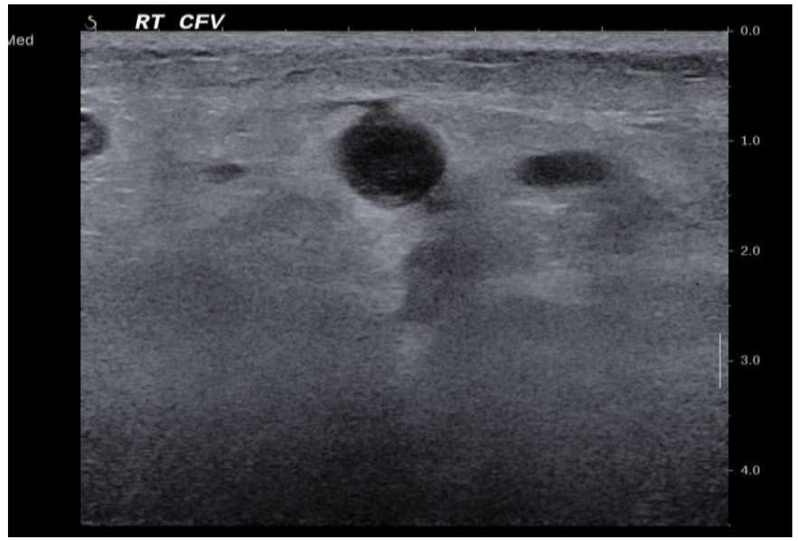
▲ Components of an ultrasound transducer.

TYPES OF TRANSDUCERS/PROBE

- Linear transducer
- Curvilinear transducer
- Phased array transducer
- Endocavitary transducer

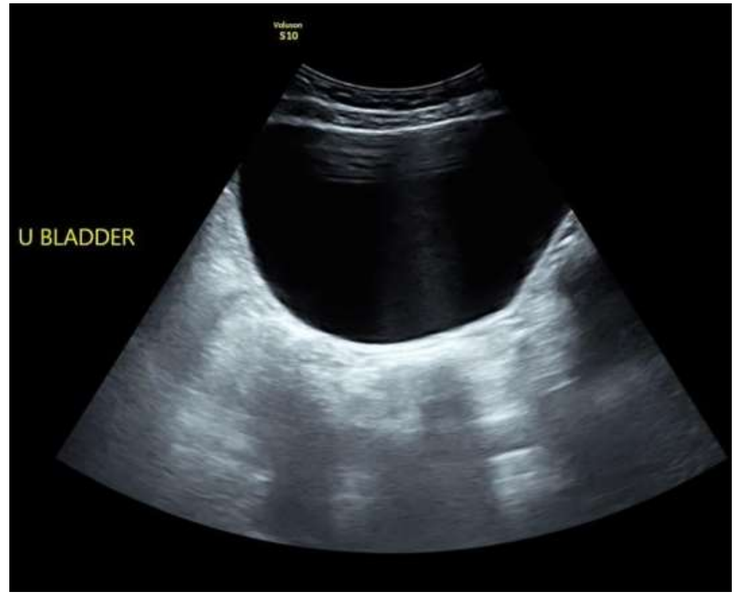
LINEAR TRANSDUCER

- Crystal arrangement – Linear
- High frequency (5 – 13 MHz
- Also called vascular probe
- FOV – Rectangular
- Footprint size – usually big
- Use – ultrasound imaging of superficial structures such as vascular accesses.



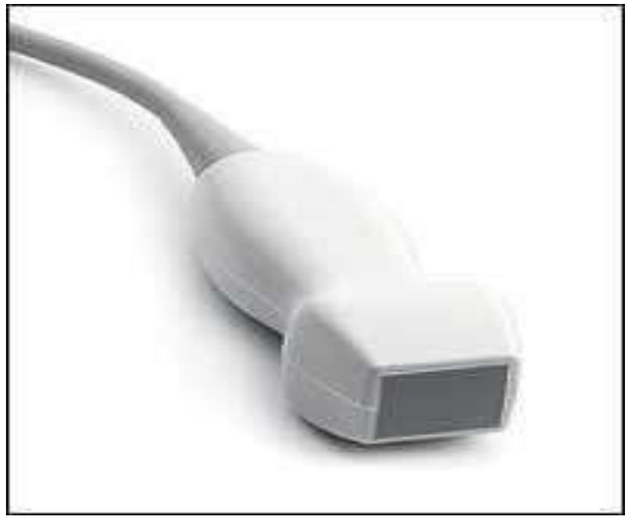
CURVILINEAR TRANSDUCER

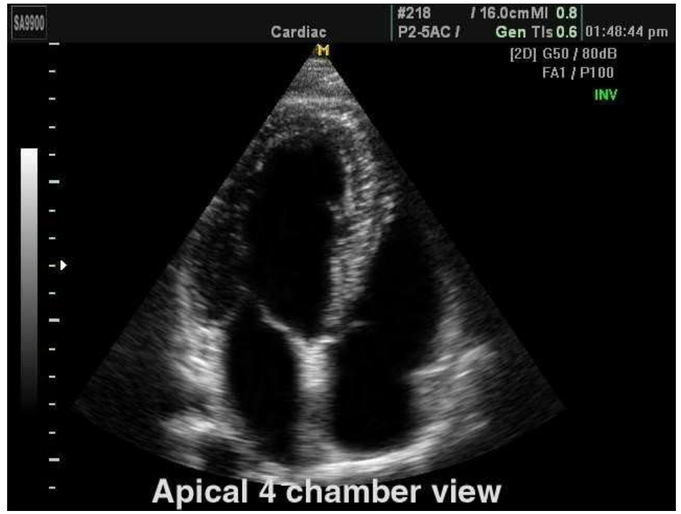
- Crystal arrangement - Curvilinear(along curved surface of the probe)
- Lower frequency (1 – 8 MHz)
- Also called convex probe
- FOV– Wider
- Footprint size – big
- Uses– scanning deeper structures (abdominal cases, pelvic imaging)



PHASED ARRAY TRANSDUCER

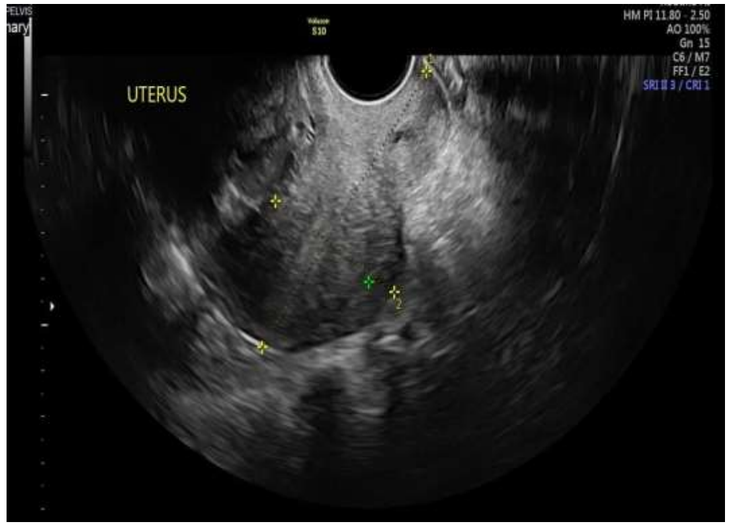
- Crystal arrangement – phased array
- Frequency : (2-8 MHz)
- FOV– almost triangular
- Footprint size – flat
- Uses – Cardiac imaging



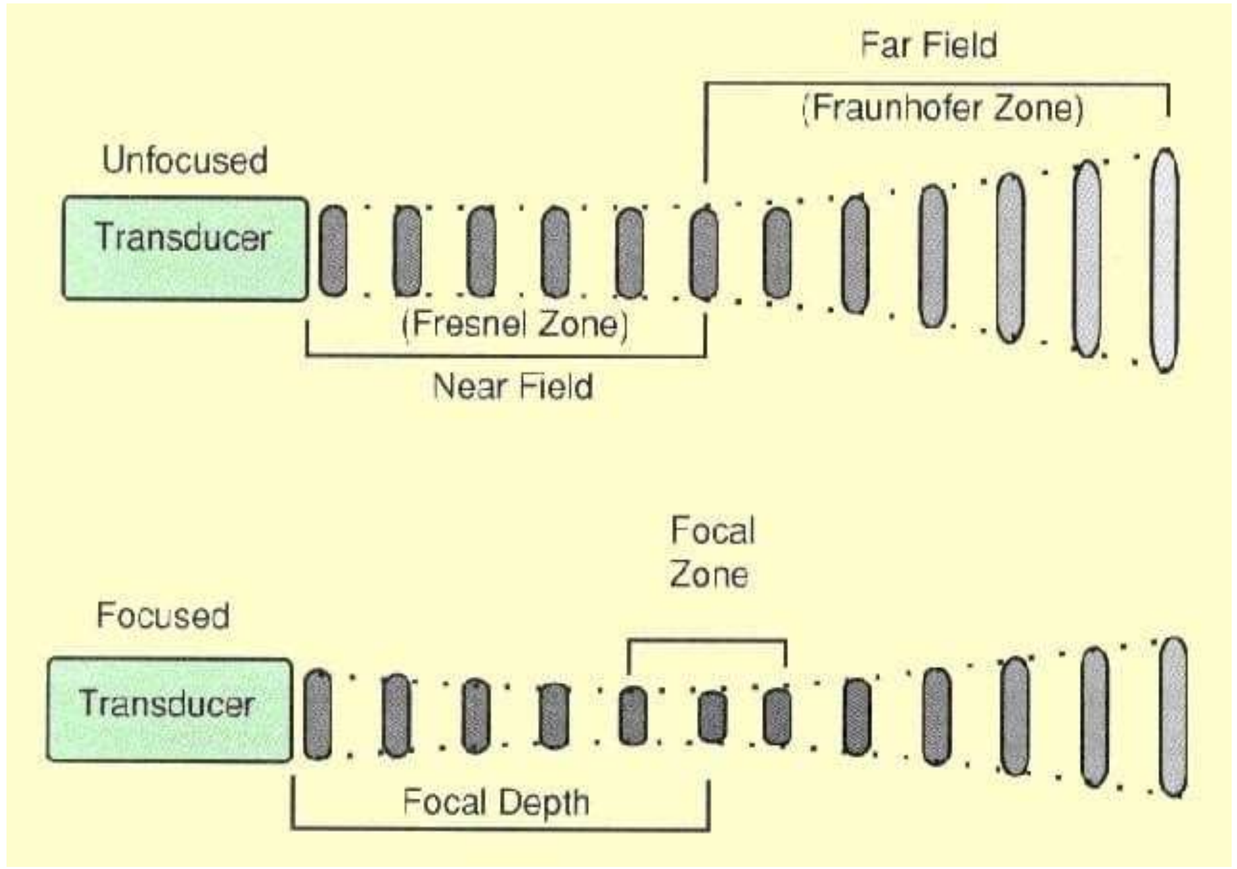


ENDOCAVITARY TRANSDUCER

- Crystal arrangement – Curved
- Higher frequency than curvilinear probes (8 – 13 MHz)
- FOV–Wider
- Footprint size – small
- Uses–TVS, mostly used in gynecological applications (early pregnancy), TRUS of prostate, prostatic cysts and seminal vesicle cyst.

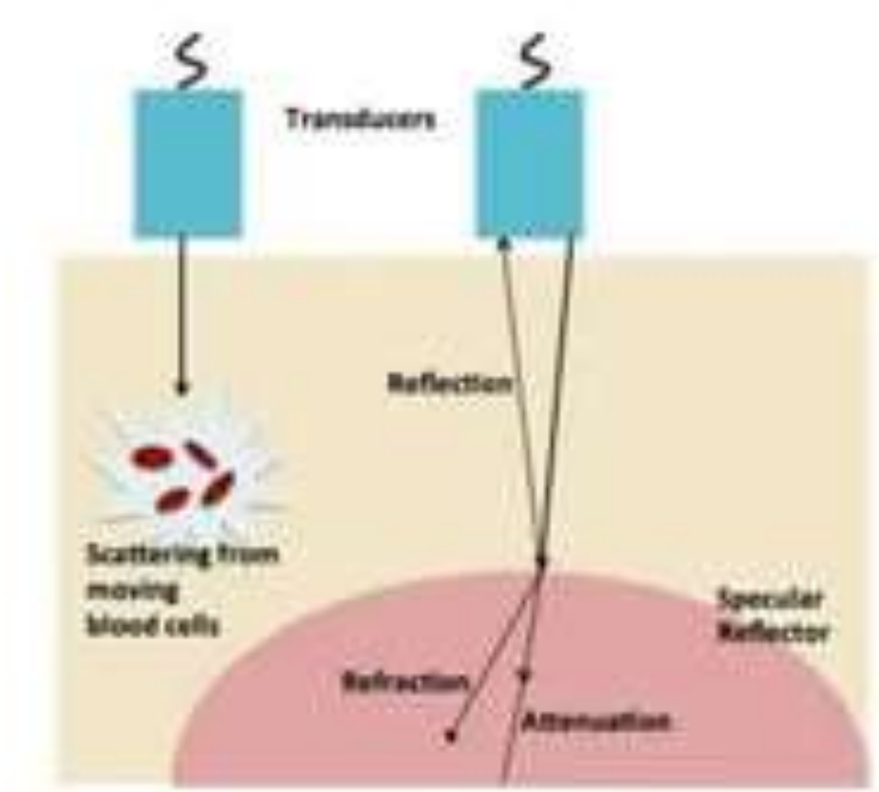


CHARACTERISTICS OF ULTRASOUND



INTERACTION OF ULTRASOUND WITH MATTER

- As incident ultrasound wave directed into the patient body, it traverses through different soft tissue interfaces, its intensity decreases.
- This decrease in intensity of incident ultrasound wave is known as attenuation.
- Hence attenuation is the progessive weakening of ultrasound waves as it traverses through the medium.



Cont.,

➢The reduction in the intensity of ultrasound waves is caused by 5 factors :

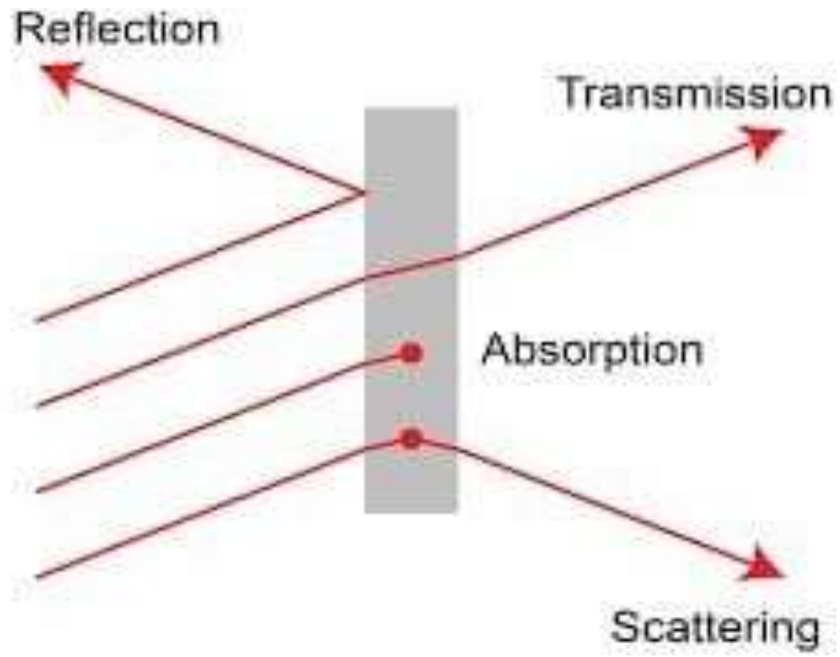
- Reflection

- Refraction

- Absorption

- Scattering

- Depth



REFLECTION

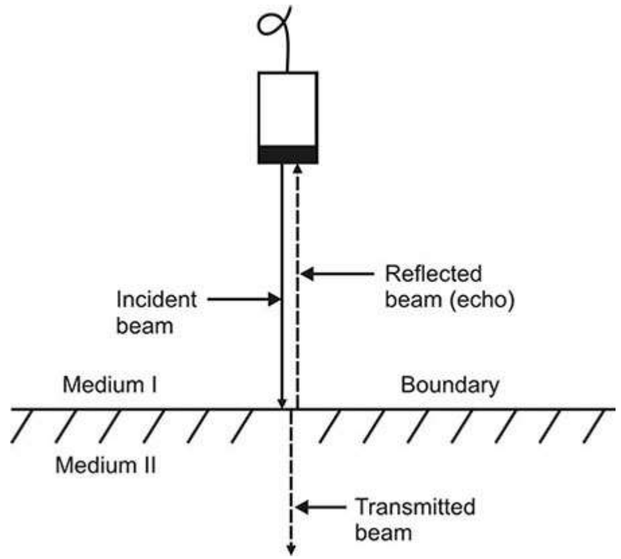
- The percentage of beam reflected at tissue.

- The percentage of beam reflected at the interfaces depends on,

  - Tissue acoustic impedance

(a soft tissue and air interface reflects major portion of US beam , 99.9% of the beam is reflected, none is available for further imaging. Transducer therefore must be directly coupled to patient skin without an air gap)

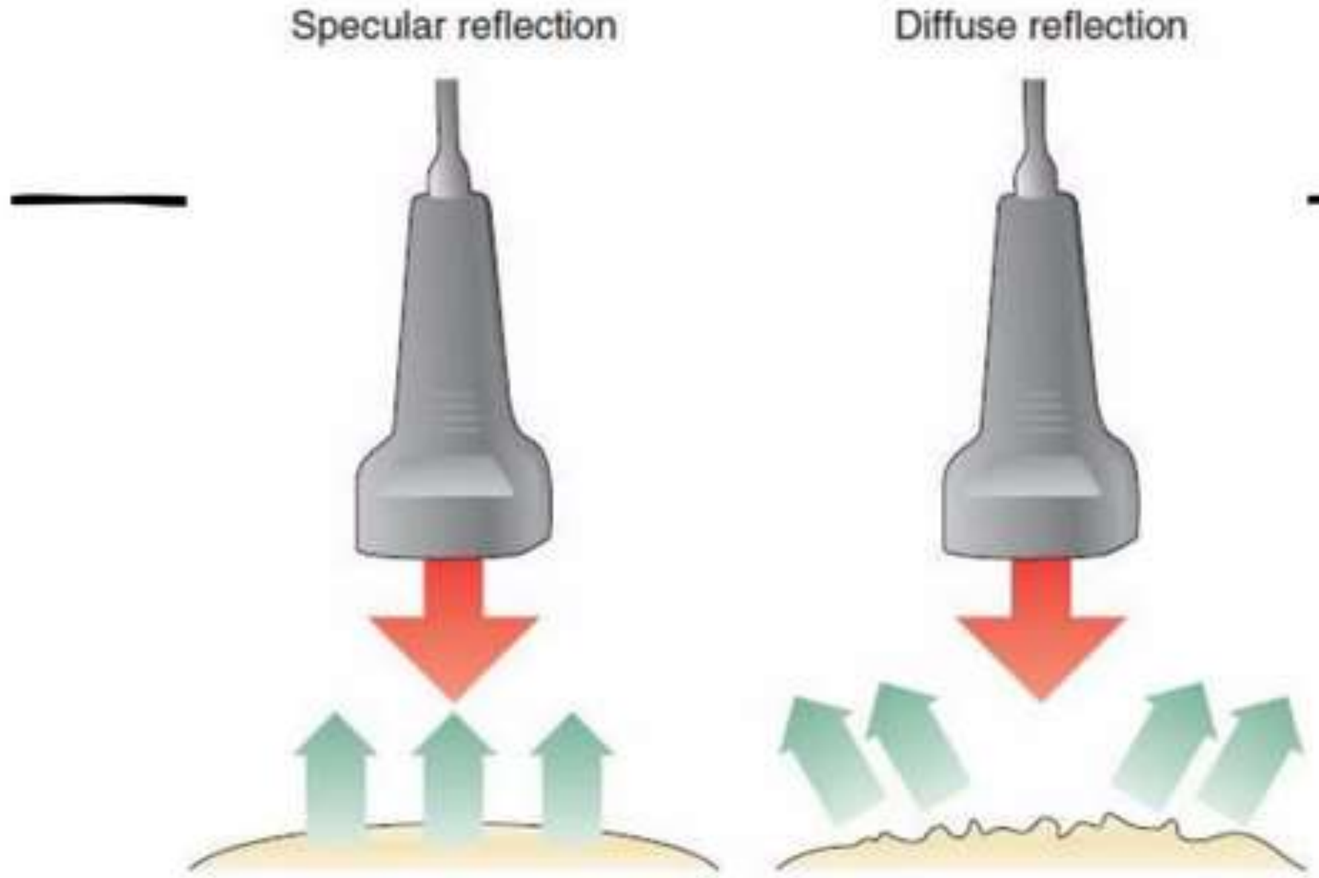
- Angle of incidence (equal to the reflection)



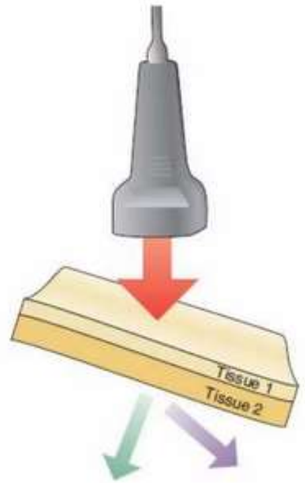
REFLECTION

Coupling agent (gel) is used as the coupling medium is to facilitate transmission of the ultrasound energy from the machine head to the tissues.

REFLECTION



REFRACTION



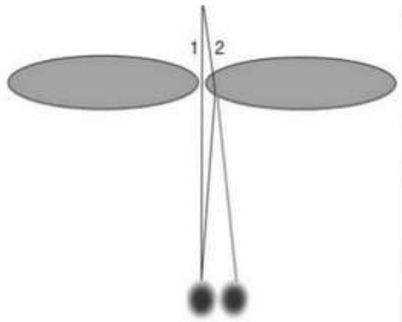
➢Bending of waves as they pass from one medium to another.

➢It occurs when sound waves meets a tissue interface boundary at an angle other than 90 degree.

➢The change of wavelength and direction of propagation of sound occurs.

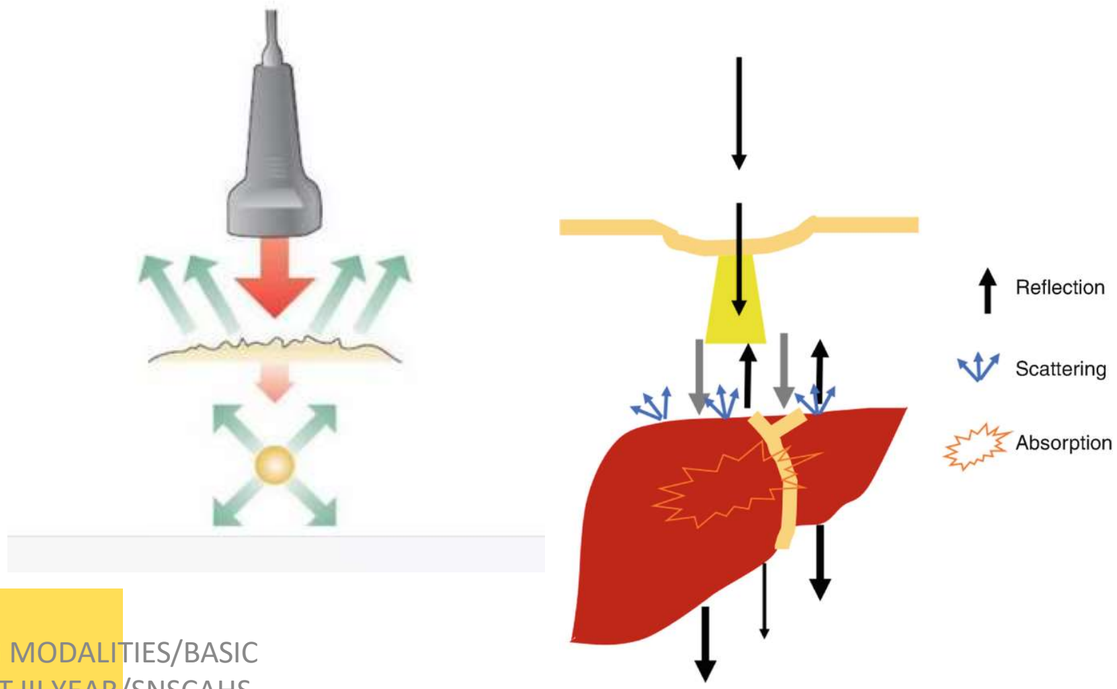
Artefacts due to refraction are,

- Loss of resolution of image
- Spatial distortion



SCATTERING

- Redirection of sound in several directions is known as scattering.
- It occur because the tissues represent a bumpy or rough surface and their sizes are smaller than the wavelength of sound waves.
- It may cause loss of intensity of ultrasound waves.



ABSORPTION

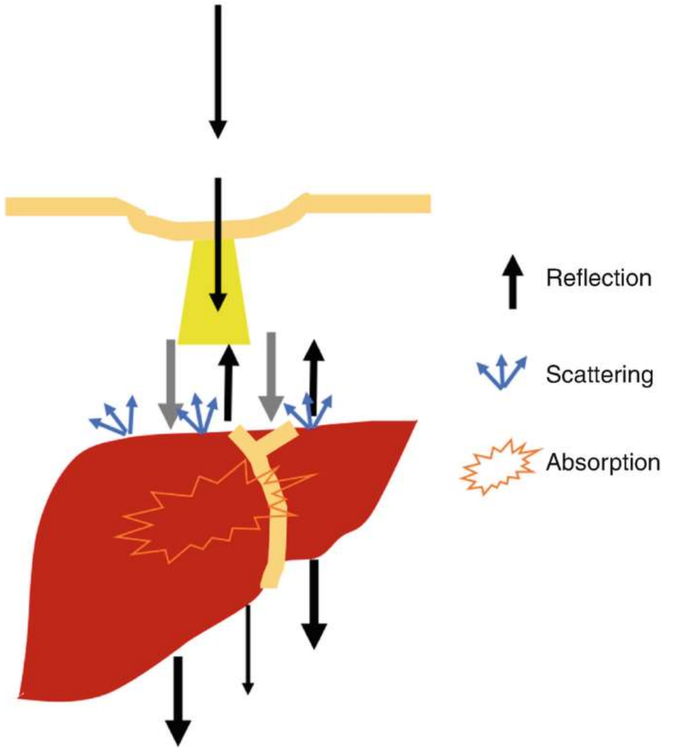
➢Absorption is the process where ultrasound energy is dissipated in the medium in the form of heat energy.

The absorption of ultrasound is related to

- frequency of transducer,
- viscosity of the medium and
- relaxation time of the medium.

➢Higher frequency– better resolution but more will be the absorption.

➢Thus to reach higher depth into tissue, lower frequency probe should be used so sound waves are less likely to be diverted.



DEPTH

➢Higher the depth more will be attenuation.

➢Attenuation reduces the intensity of ultrasound waves due to

- reflection,
- refraction
- scattering,
- frequency of transducer and
- absorption.

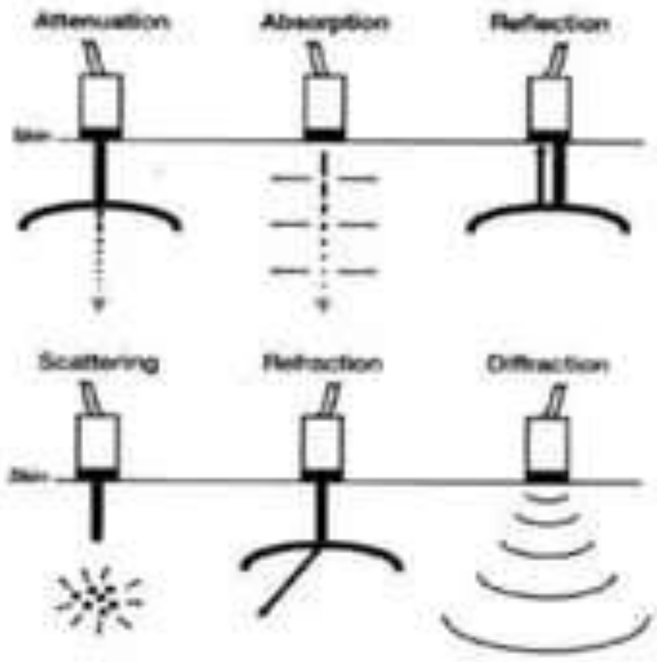


IMAGE DISPLAY

- Ultrasound images are created by using pulse echo principle.

- Transducer convert:

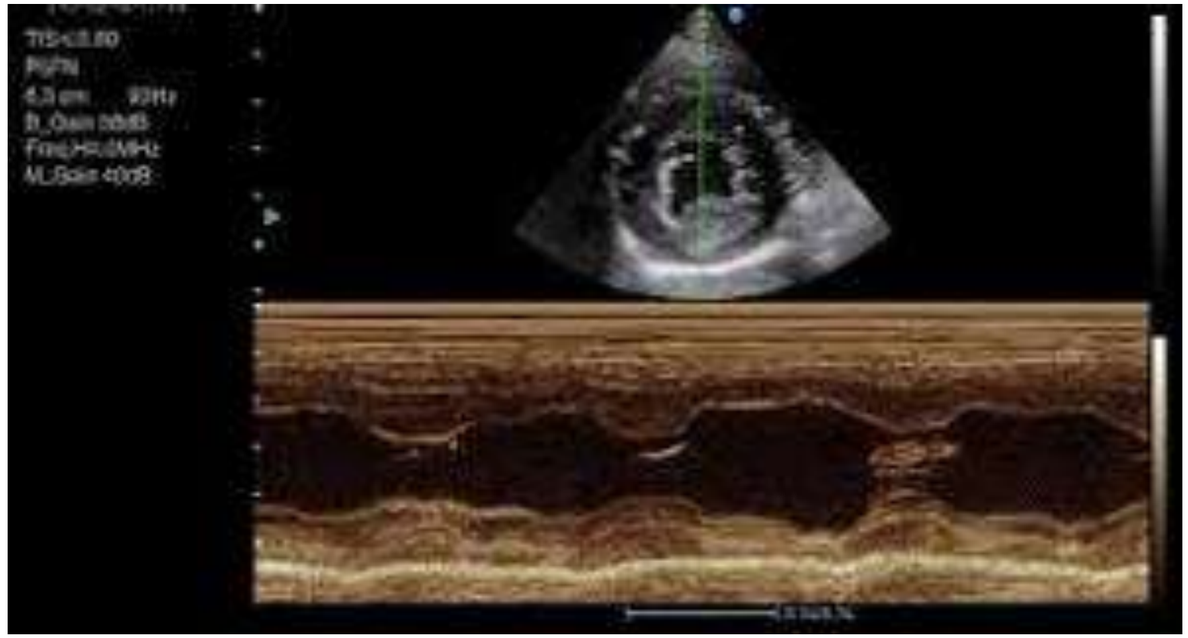
Electricity into sound – Pulse

Sound into electricity – Echo

- The depth of a relative structures is described from the delay between pulse transmission and echo reception.

IMAGING MODES

- A mode – Amplitude mode
- B mode – Brightness mode
- M mode – Motion mode



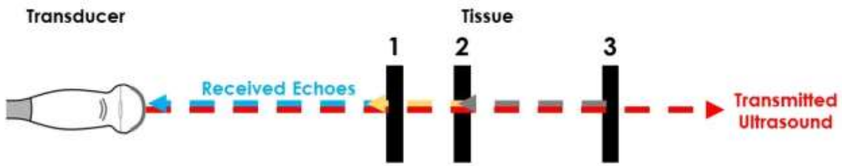
AMPLITUDE MODE

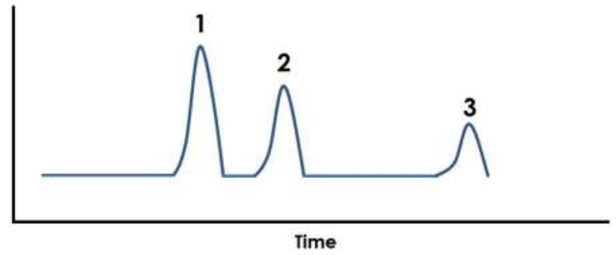
➢In A-mode,echoes are displayed as spikes projecting from a baseline as amplitude versus depth.

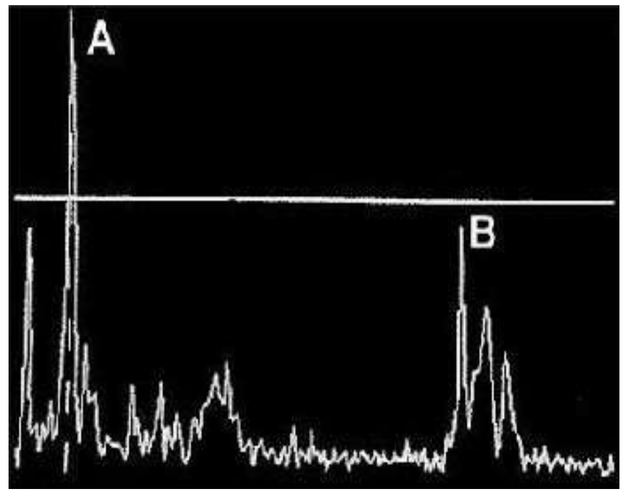
➢Spike height is proportional to echo intensity,with strong echoes producing large spikes.

➢It helps to distinguish interfaces along beam path and provides depth information.

➢A mode is used in ophthalmology and echocardiography.

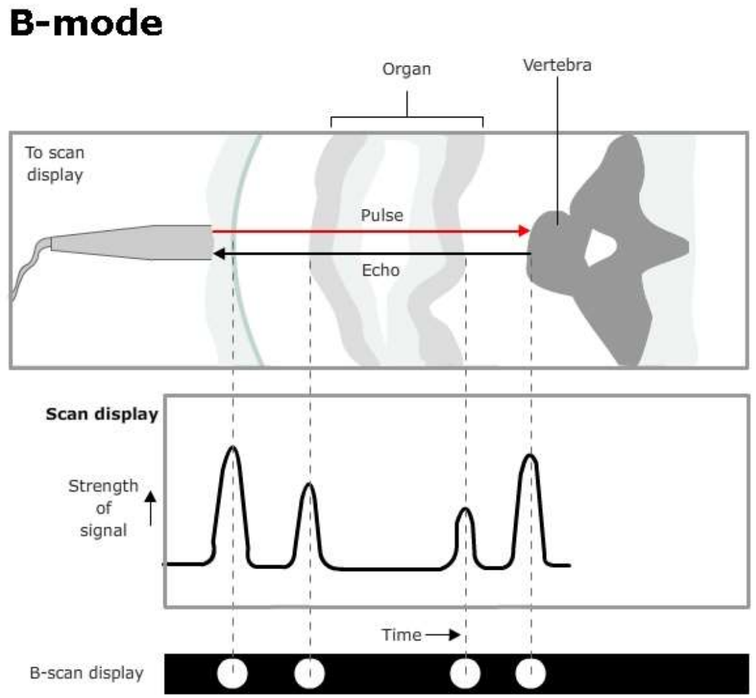






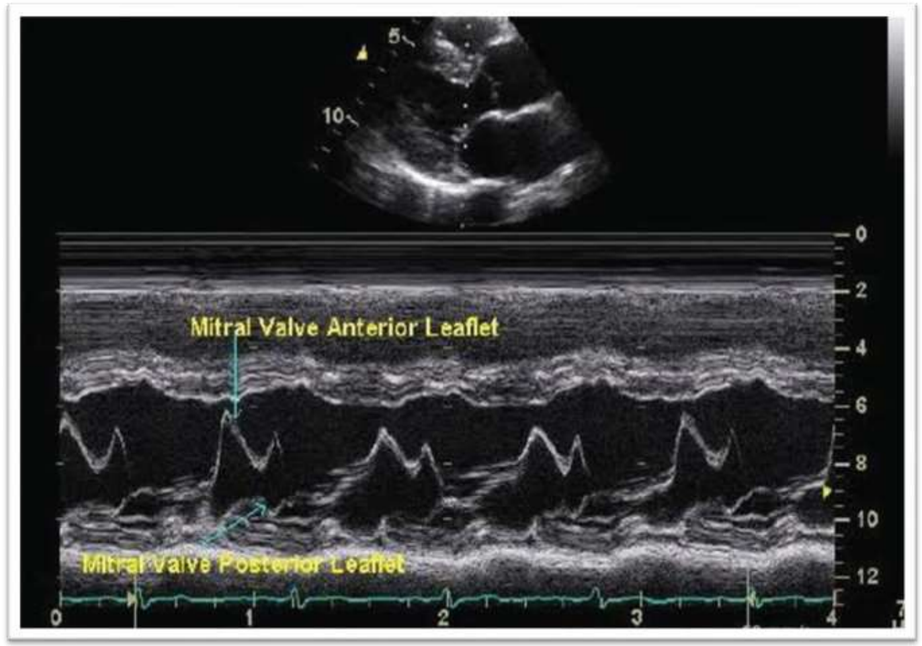
BRIGHTNESS MODE

- The B mode made the ultrasound as a diagnostic tool, especially in abdominal diseases.
- It provides a picture of a slice of tissue.
- In B mode, a two dimensional(2D) slice of anatomy of the patient is imaged.
- Imaging of organs, tissues, and fetus during pregnancy.



MOTION MODE

- In M mode, the variation of signal amplitude is converted into series of dots.
- The brightness of dot is proportional to the amplitude.
- It is recorded over a period of time and helps to see the change in position of an interface.
- It is used to evaluate cardiac value motion and cardiac anatomy. However, it has limited role in imaging, due to arrival of doppler ultrasound.



ADVANTAGE & DISADVANTAGE

ADVANTAGE :

- Non – invasive and no radiation, hence allowing pregnant women to use this imaging technique.
- Used to detect blood flow through vessels.

DISADVANTAGE :

- Air will interfere with echoes

REFERENCE

- Basic Radiological physics (2nd edition) by Kuppusamy Thayalan.