POLITEKNIK MALAYSIA

KEMENTERIAN PENGAJIAN TINGGI

KOLEJ KOMUNITI MALAYSIA

INTRODUCTION TO ULTRASOUND IMAGING

NOR KHARUL AINA BINTI MAT DIN
NURUL HUDA BINTI MOHAMD SALEH

ELECTRICAL ENGINEERING DEPARTMENT

POLITEKNIK MALAYSIA

SULTAN SALAHUDDIN ABDUL AZIZ SHAH

INTRODUCTION TO ULTRASOUND IMAGING

VOLUME 1

ELECTRICAL ENGINEERING DEPARTMENT

JABATAN PENGAJIAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENGAJIAN TINGGI

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Authors :
Nor Kharul Aina binti Mat Din
Nurul Huda binti Mohamd Saleh

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UNIT PENERBITAN
Politeknik Sultan Salahuddin Abdul Aziz Shah
Persiaran Usahawan,
Seksyen U1,
40150 Shah Alam
Selangor

Telephone No. : 03 5163 4000
Fax No. : 03 5569 1903

ABOUT

Authors

Nor Kharul Aina binti Mat Din

- Master of Technical And Vocational Education
  - Universiti Tun Hussein Onn Malaysia (UTHM)
- Bachelor of Electrical Engineering (Medical Electronics)
  - Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO)

Nurul Huda binti Mohamd Saleh

- Master of Technical And Vocational Education
  - Universiti Tun Hussein Onn Malaysia (UTHM)
- Bachelor of Electrical Engineering (Medical Electronics)
  - Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO)

ABSTRACT

This e-book consists of the basic knowledge of Ultrasounds Imaging and is arranged according to Polytechnic Syllabus. This e-book has been written for medical electronics students who would like to understand biomedical instrumentation, especially imaging equipment, and use the knowledge successfully for their own growth in industries and hospitals. The objective has been to present the matter in a simple, straight-forward, and easy form, but very accurate. This e-book is focused on ultrasound machines and consists of 7 chapters that deal with general concepts of ultrasound imaging, imaging instrumentation, and performance tests. The authors also provide a tutorial for each chapter for students' exercises. In order to facilitate easy understanding, many figures and facts were illustrated in this e-book. The authors welcome this e-book as a valuable contribution in the field of biomedical imaging which meets the expectations of the department and the students of polytechnics Malaysia in particular, or other institutions in general.

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Physics of Sound Waves

SECTION 1

Topic to be covered in this section

1. Ultrasound for therapeutic and diagnostic
2. Ultrasound as non-ionizing medical imaging
3. Definition of sound wave
4. Comparison between sound wave and ultrasound
5. Sound Wave Parameters
6. Types of basic waves
7. Properties of ultrasound waves

ULTRASOUND FOR THERAPEUTIC AND DIAGNOSTIC

THERAPEUTIC

Ultrasound machine that is used to apply massage and deep heat therapy to muscle tissue.

DIAGNOSTIC

Ultrasound machine is the medical equipment used for diagnosis and imaging internal organs non invasively by using the higher frequency in 1 MHz – 10 MHz range.

ULTRASOUND AS NON-IONIZING MEDICAL IMAGING

SOUND ENERGY & ITS EFFECT ON HUMAN TISSUE

·What happens to a sound wave as it travels via human tissues?

It must pass through the air medium and enter the skin/fat, which has a much higher density. The sound wave is completely reflected at the air-skin interface. When a coupling medium, such as a gel, is used to create a sound head-gel-skin interface, reflection is reduced to 0.1 percent; the remaining sound energy is transmitted through the skin barrier. Sound energy travels through much of the soft tissue without much absorption until it reaches tissues with high collagen (bundles of protein fibres) content, such as bone, periosteum, ligaments, capsules, fascia, tendons, and tissue interface, as shown in the absorption coefficients table (bursa).

Ultrasound at high intensity near bony areas can be detrimental to the periosteum (dense layer of connective tissue around a bone)because of high energy accumulation and heating effect on the soft tissue as sound wave hits the bone (transverse or shear wave).

ULTRASOUND AS NON-IONIZING MEDICAL IMAGING

SOUND ENERGY & EFFECT ON SOFT TISSUE

What will become of the tissues that dissolve sound energy?

Because sound energy does not emit ionising radiation, it does not pose the same risks as ionising radiation, such as cancer and chromosome breakage.

Sound energy has two physiological effects:

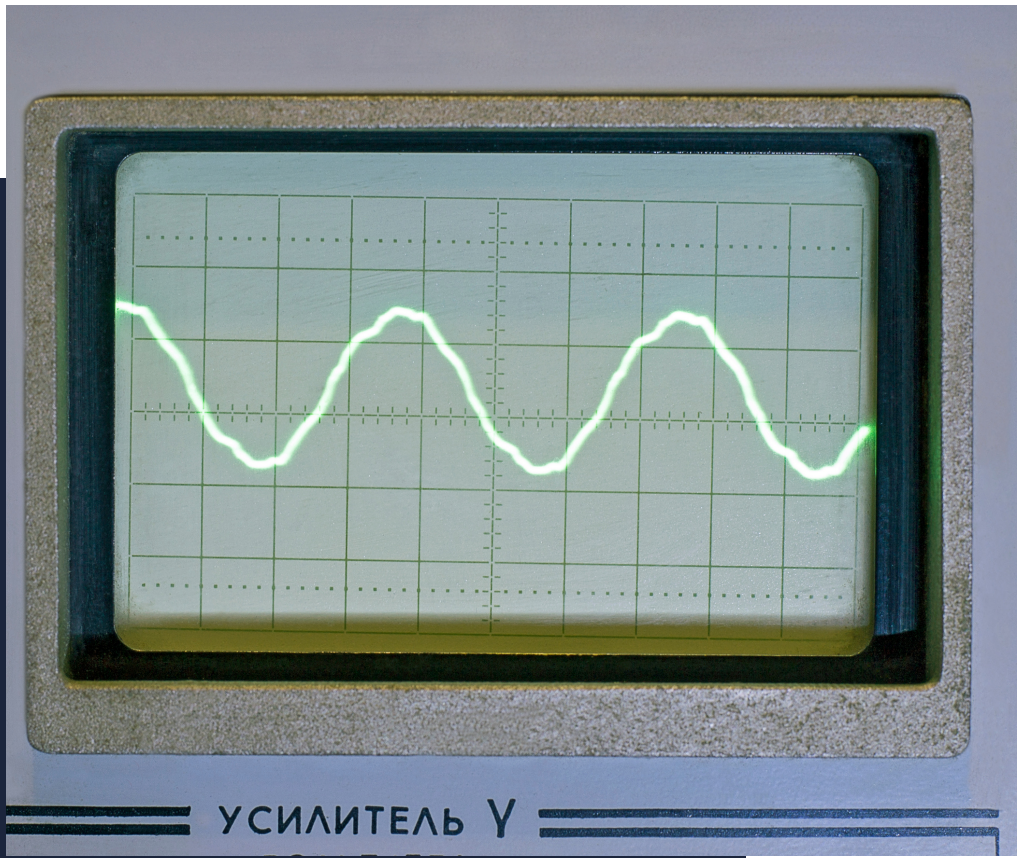
- It improves the inflammatory response and it helps with tissue repair.
- Soft tissue should be heated.

Tutorials

Why ultrasound is not good for bone imaging?
What is the best modalities for bone scanning?

DEFINITION OF WAVE

- A wave is "a disturbance or variation that transfers energy progressively from point to point in a medium.“
- The most important part of this definition is that a wave is a disturbance or variation which travels through a medium.
- The medium through which the wave travels may experience some local oscillations as the wave passes, but the particles in the medium do not travel with the wave.



DEFINITION OF SOUND WAVE

DEFINITION OF SOUND & ULTRASOUND

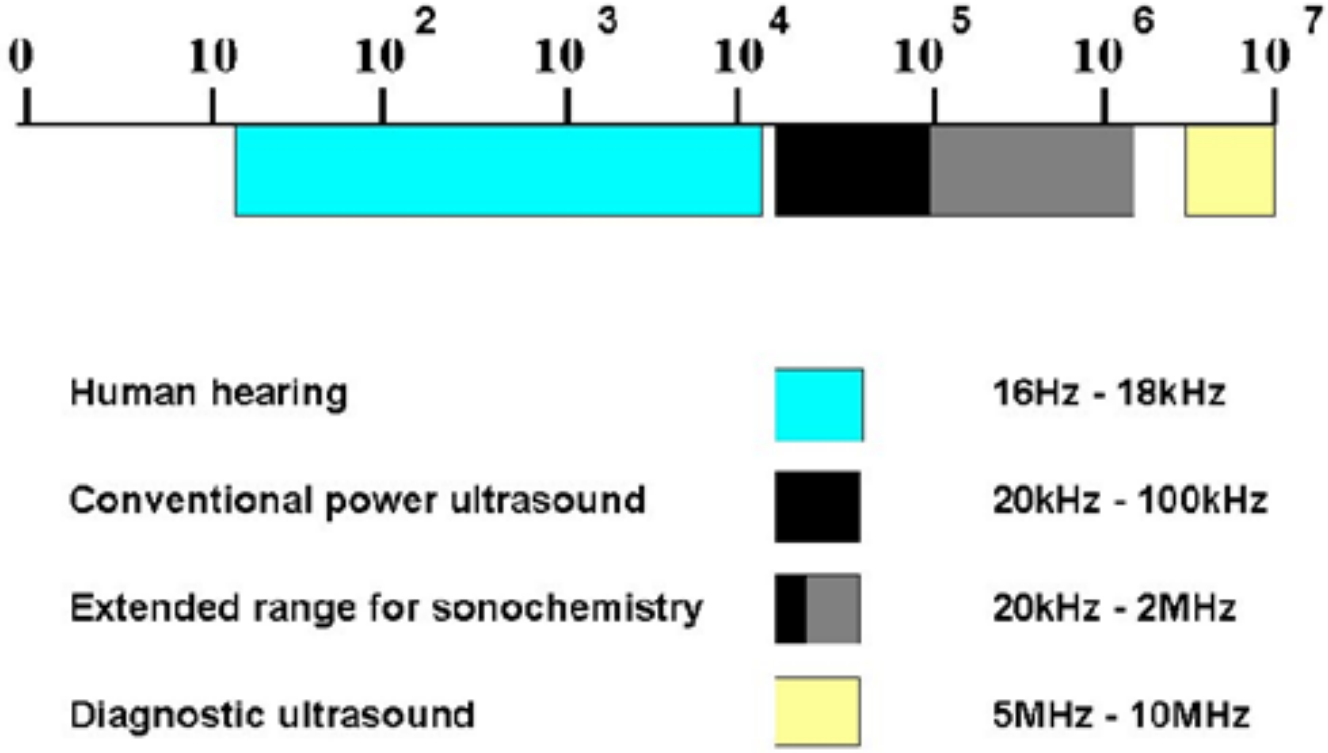
- Sound is defined as, vibrations transmitted through an elastic solid or liquid or gas, with frequencies in the approximate range of 20 to 20 000 hertz which is capable of being detected by human organs of hearing.
- Ultrasound is defined as, sound with frequency greater than 20 000 hertz.

NAVIGATING WITH ULTRASOUND

- Bats make high-pitched chirps which are too high for humans to hear. This is called ultrasound
- Like normal sound, ultrasound echoes off objects
- The bat hears the echoes and works out what caused them
- Dolphins also navigate with ultrasound
- Submarines use a similar method called sonar

COMPARISON BETWEEN SOUND WAVE AND ULTRASOUND

FREQUENCY RANGES OF SOUND



- Ultrasound is sound with a frequency greater than the upper limit of human hearing, this limit is approximately 20 kilohertz (20,000 hertz).
- It is produced by passing an alternate current through a piezoelectric crystal. This crystal contracts and spreads at around the same frequency that the polarity of the current changes. This crystal's sound field causes the molecules in the sound field to vibrate and oscillate.
- Synthetic plumbium zirconium titanium is a common crystal used in ultrasound units (PZT). The price of ultrasound depends on the quality of the crystal.
- The following factors influence crystal quality:
  - Beam nonuniformity ratio: ranges from 2 to 6 – the smaller the better.
  - Effective Radiating Area: as close to sound head area as possible
  - Therapeutic ultrasound has a frequency range of 0.7 and 5.0 MHz
- Most clinics will have sound heads with frequencies of 1 MHz and 3 MHz.

SOUND WAVE PARAMETERS

V, The velocity of sound waves is the rate at which they travel through a specific medium. The velocity is proportional to the frequency multiplied by the wavelength. Ultrasound travels at a rate of 1540 meters per second through human soft tissue. The velocity varies according to the medium.

Z, Acoustic impedance is determined by the density of the material thru which sound is propagated. The higher the impedance, the denser the material.

I, The intensity of an ultrasound beam identifies the amount of energy that flows through a unit cross-sectional area per second. The square of the pressure amplitude, particle displacement amplitude, or particle velocity amplitude determines the intensity.

- **Ultrasound Velocity (m/s)**

$$v = f\lambda$$

- **Acoustic Impedance (kg/m^2s = Rayls)**

$$Z = \rho v$$

- **Intensity (joules/cm^2 = watts/m^2)**

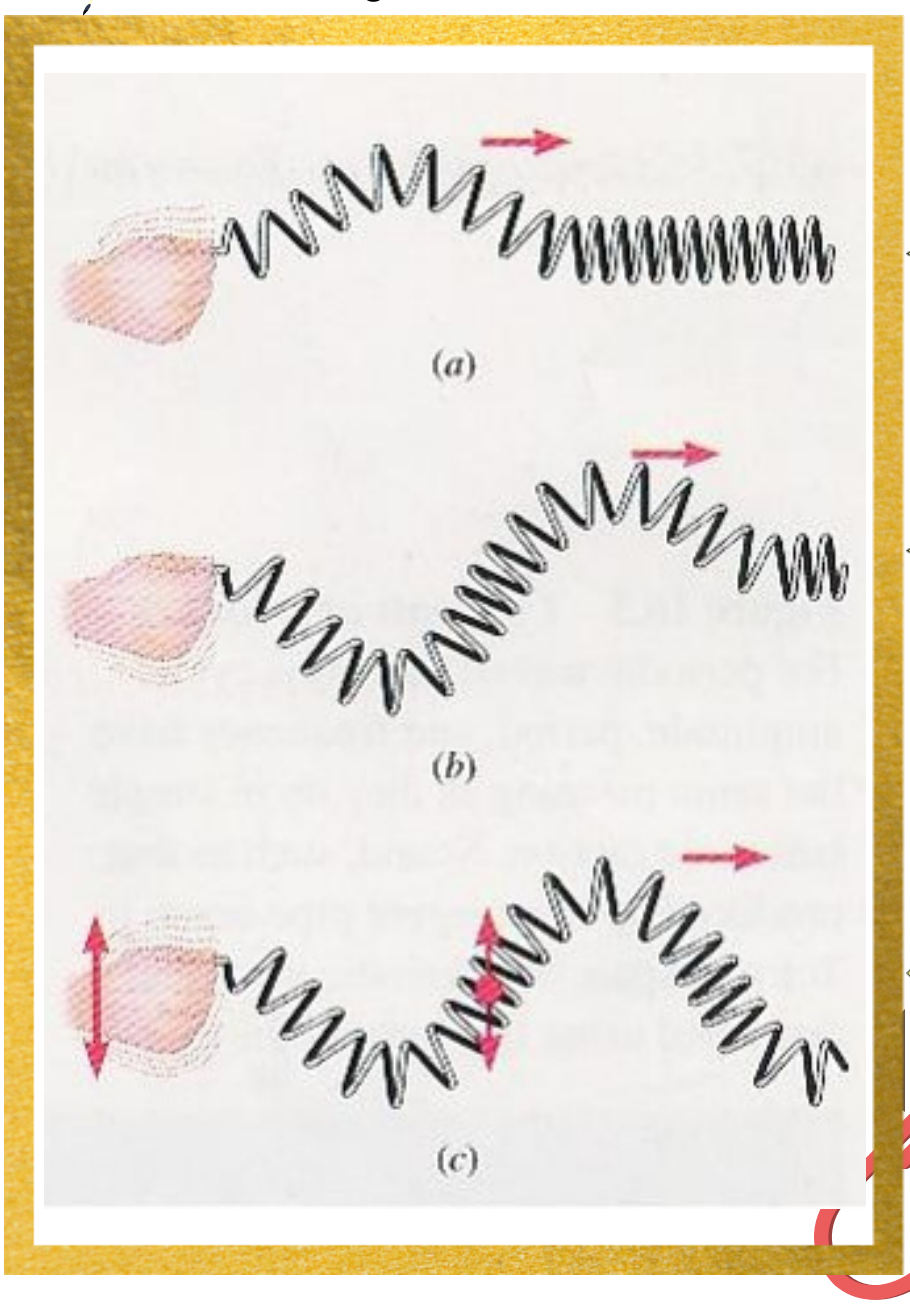
$$I \propto A^2$$

TYPES OF BASIC WAVES

TRANSVERSE WAVES

A transverse wave is one in which the disturbance is perpendicular to the direction of travel of the wave.

Examples: Radio waves, light waves, microwaves and strings of instruments such as guitars and banjos



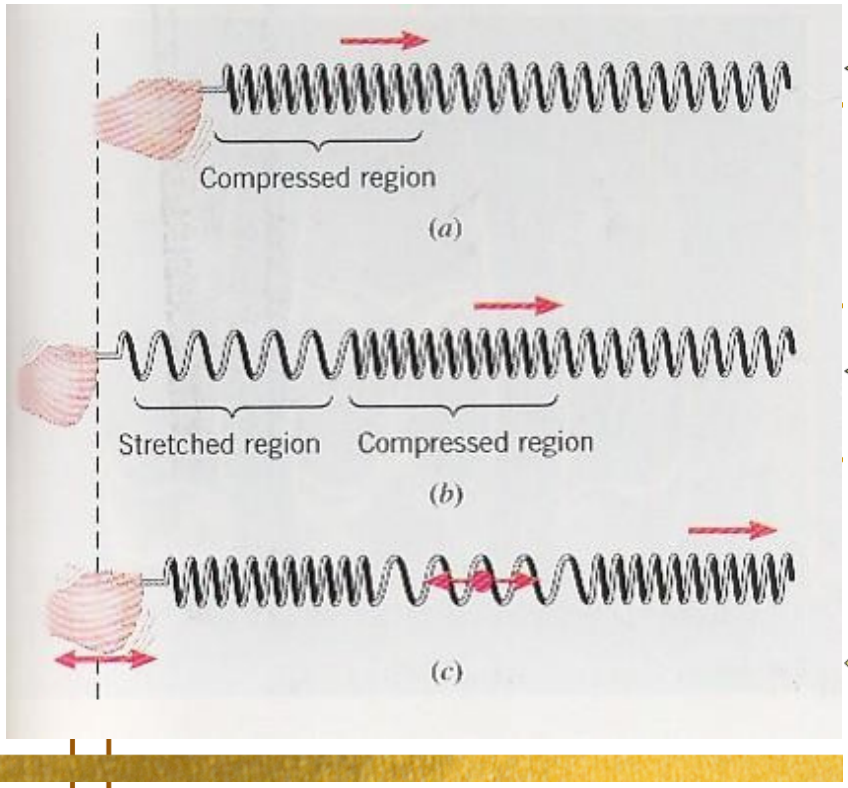
(a) An upward pulse moves to the right.

(b) a downward pulse.

(c) When the end of the Slinky is moved up and down continuously, a transverse wave is produced.

TYPES OF BASIC WAVES

" A sound wave is a longitudinal wave "



(a) A compressed region moves to the right.

(b) a stretched region.

(c) When the end of the Slinky is moved back and forth continuously, a longitudinal wave is produced.

LONGITUDINAL WAVES

A longitudinal wave is one in which the disturbance is parallel to the line of travel of the wave.

PROPERTIES OF ULTRASOUND WAVES

PROPERTIES OF ULTRASONIC WAVES

Ultrasonic waves have a frequency that is higher than what humans can hear (20 kilohertz).

Their wavelengths are shorter. As a result, they have a high penetrating power.

In the medium, ultrasonic waves travel at the speed of sound. In a denser medium, their velocity is greatest.

Ultrasonic waves cause vibrations in low viscosity liquids.

They are unable to travel in a vacuum.

They move at a constant speed in a homogeneous medium.

They are subjected to reflection, refraction, and absorption.

Ultrasonic waves are longitudinal waves that generate alternate compressions and rarefactions, similar to sound waves.

They are very high in energy. They have a high energy density and can be transmitted over long distances with minimal energy loss.

When they pass through objects, they generate a lot of heat.

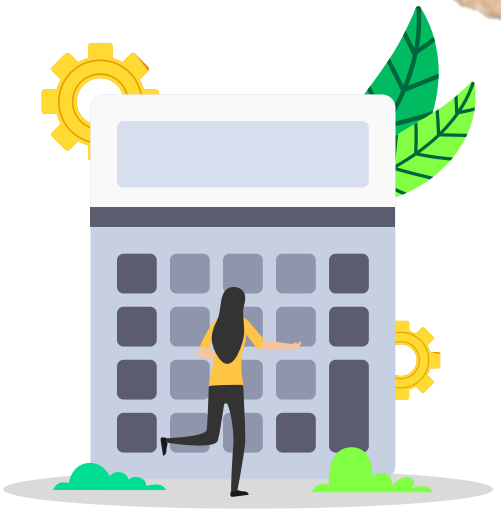
Source: https://byjus.com/jee/properties-of-ultrasonic-waves/

Physics of Ultrasound

SECTION 2

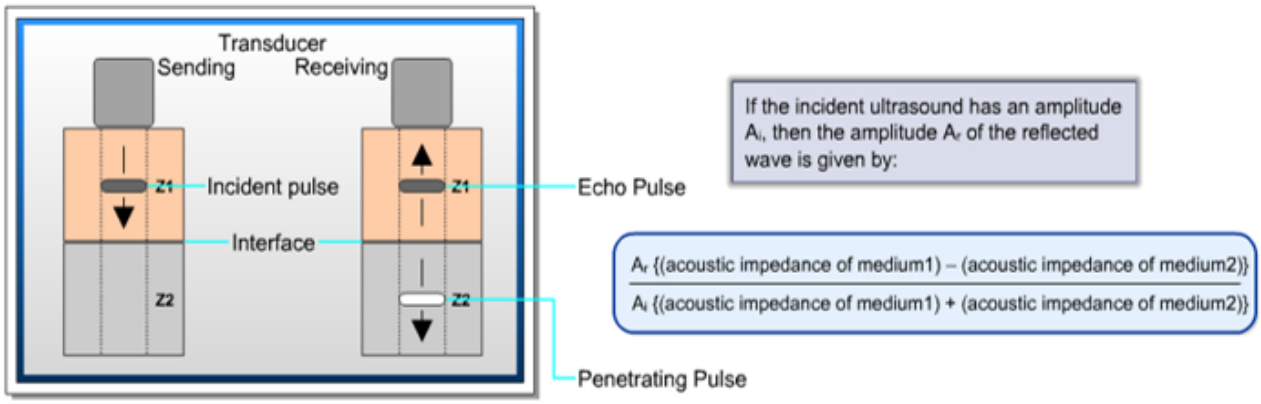
CALCULATION

- Ultrasound properties of velocity, attenuation and absorption
- Acoustic impedance, Z of a medium
- Fraction of the incident energy that is reflected and transmitted



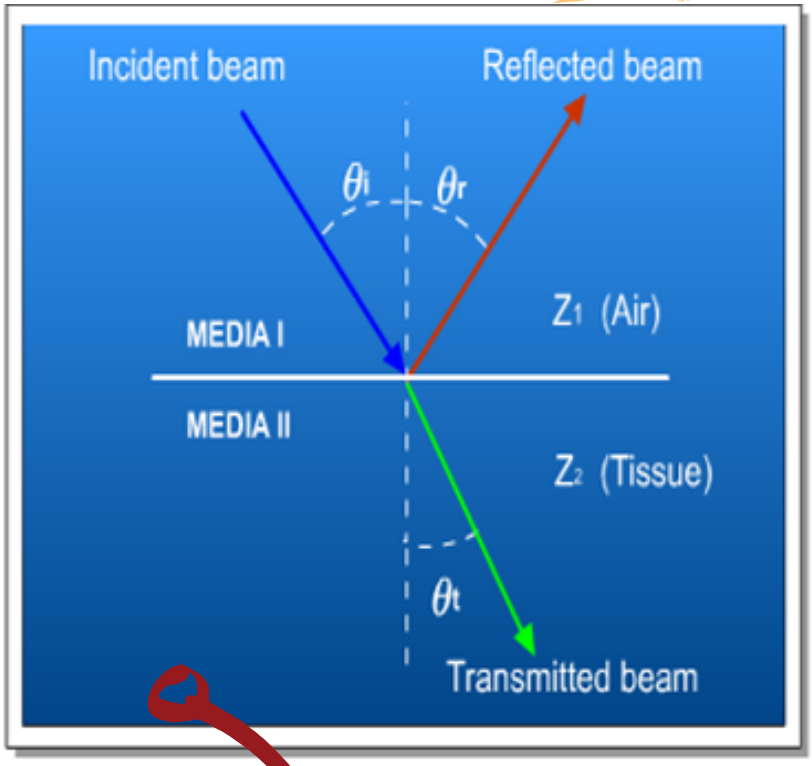
Ultrasound Reflection

- An ultrasound pulse is reflected at the interface, or border, of two different materials. The two materials must differ in terms of physical property known as acoustic impedance Z in order to form a reflection interface.
- The pulse is split into two pulses, one of which is an echo pulse that is reflected back toward the transducer and the other of which penetrates the other material.
- The intensity of the reflection or echo determines the brightness of the ultrasound image.



The Production of an Echo and Penetrating Pulse at a Tissue Interface

Percentage of Ultrasound Reflection



$$\%R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2 * 100$$

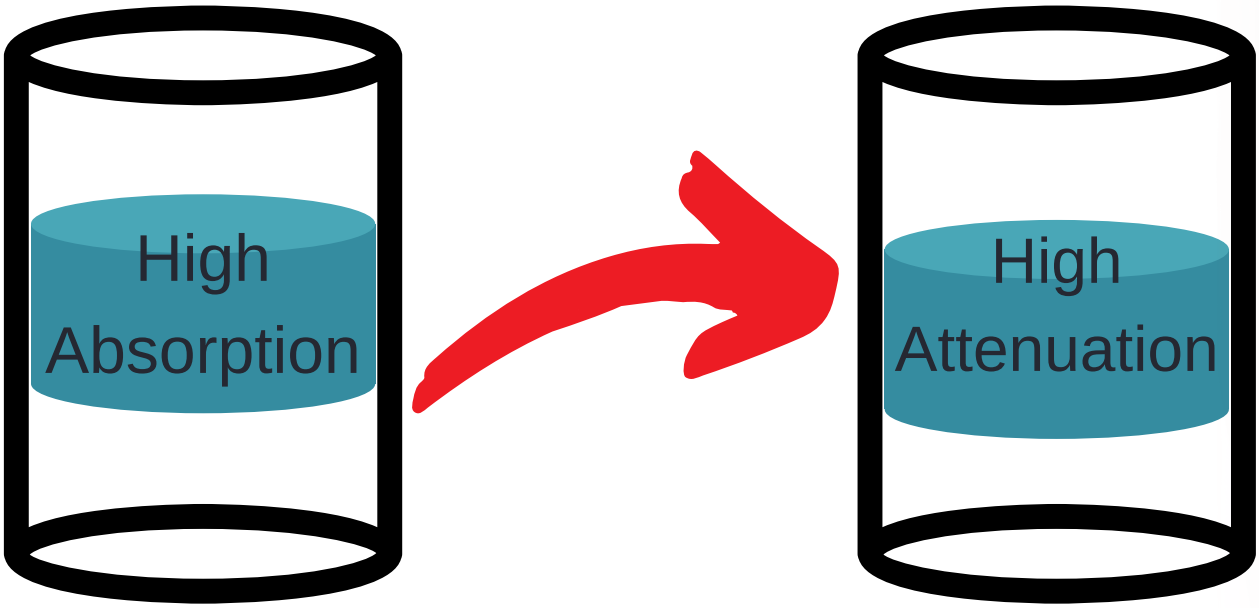
R - Percent of sound beam reflected

Z1 - Acoustic impedance of First beam

Z2 - Acoustic impedance of Second beam

Absorption and Attenuation

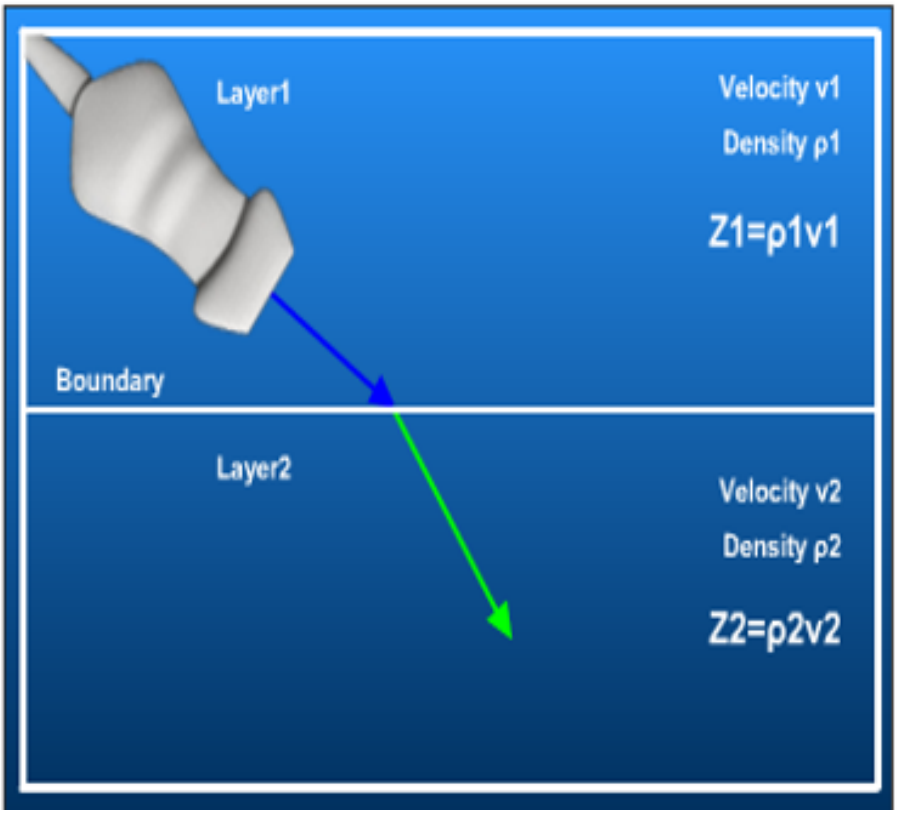
Absorption is the process whereby ultrasound wave energy is dissipated in a medium. High absorption means high attenuation, ultrasound wave cannot pass through.



This happens depends on:

- The material through which wave is passing.
- The frequency of the ultrasound.

Acoustic Impedance



- The velocity and density of a sound as it travels through any medium are determined by the medium.
- Every medium has an acoustic impedance, which is a measure of its resistance to sound passing through it.
- The formula Z=pv expresses this property.
- Where Z is the acoustic impedance, p is the medium density, and v is the wave velocity within the medium.
- Acoustic impedance causes sound waves to weaken as they move more deeply through the medium.

Velocity

- Velocity is defined as the speed at which sound waves travel through a particular medium.
- The velocity of the sound waves will be changed in a different medium due to the changes in wavelength.
- The average velocity in the human body is about 1530 m/s.

Tissue	Velocity (m/sec)
Skull, Bone	4080
Muscle	1585
Blood	1570
Kidney	1561
Liver	1549
Brain	1541
Fat	1450
Lung (air)	331

The relationship between Frequency (F), Velocity (V) and the Wavelength (λ) is given by **V= λ F**.

Resolution

- Resolution can be defined as the ability of the equipment to distinguish two separate objects.

Axial Resolution

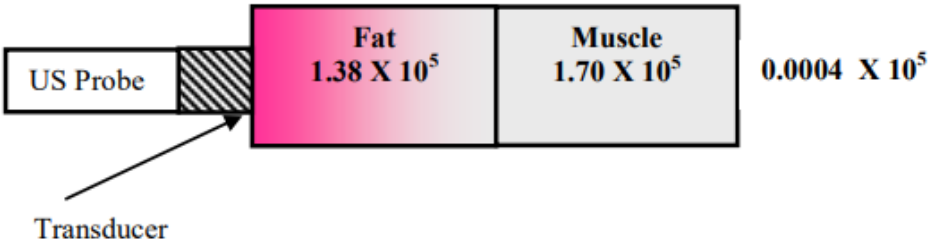
- Capability of distinguish between two separate objects which are placed together in-line in the beam (axial) direction.Axial resolution is determined by ultrasound wavelength.

Lateral Resolution

- Lateral resolution describes resolution in the lateral direction. Lateral resolution is determined by ultrasound beam.

Tutorials

(a) This question refers to the following figure.



Calculate the total percentage of ultrasound reflection coefficient α_R at transducer received from different medium? (Ignore ultrasound absorption due to its movement from various matters or medium).

Given:
The Percentage of Reflection Coefficient

$(Peratus\ Pekali\ Pantulan), \alpha_R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2 \times 100\%$

The fraction of the incident energy that is *transmitted* across an interface is described by the transmission coefficient α_T

$$where\ \alpha_T = \frac{4Z_1Z_2}{(Z_1 + Z_2)^2} \times 100\%$$

Z_1 and Z_2 are the acoustic impedances of the two media.

Table: Speed of ultrasound and acoustic impedance in some common materials. Data from Wells (1969); Goss, Johnston, Dunn (1978); and Bamber (1986). The acoustic impedance cannot calculated where the density of the material is not known.

Material	Speeds (m/s)	Acoustic impedance g/cm^{2}s
Air (NTP)	330	0.0004×10^5
Fat	1450	1.38×10^5
Kidney	1560	1.62×10^5
Muscle	1580	1.70×10^5
Soft tissue (average)	1540	1.63×10^5

Principle of Piezoelectric

SECTION 4

Piezoelectric Crystals

- By detecting reflected sound waves, the ultrasound machine creates an image of the tissues.
- As a result, the ultrasonic imaging technique is simple: sound waves are transmitted into the tissue, and the reflected waves are used to create a picture of the tissue.

1. Send ultrasound waves to the tissue
2. Analyzing reflected ultrasound waves
3. Image being created

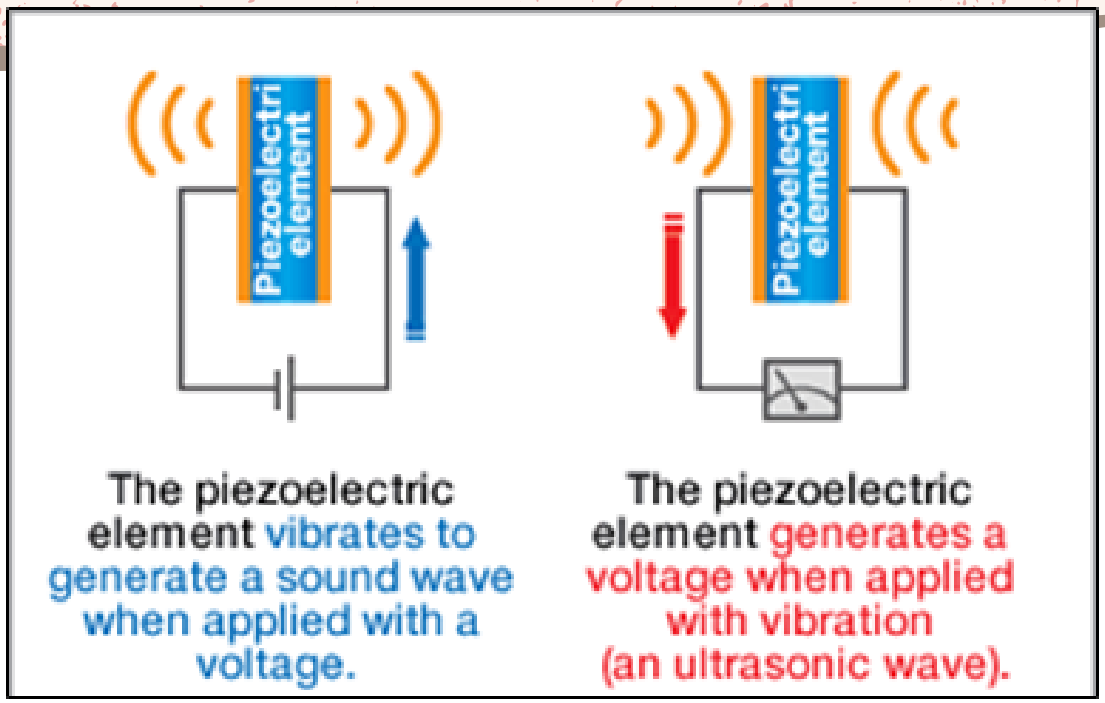
Piezoelectric Crystals

- The electromechanical properties of piezoelectric crystals set them apart. When an electric current is passed through a piezoelectric crystal, it begins to vibrate, producing sound waves with frequencies ranging from 1.5 to 8MHz.

- Using piezoelectric crystals, electric currents can thus be converted into ultrasonic waves.
- When reflected ultrasound waves hit crystals, they start to vibrate, and these mechanical vibrations are converted into electric current, which would then be shifted back to the ultrasound machine, where the electrical signal is analyzed and interpreted into a picture.

Function of Piezoelectric Element

- The piezo-electric element is an essential part of the transducer for generating ultrasonic waves. A voltage is applied to both sides of the piezoelectric electrodes. The element oscillates by dilating and contracting repeatedly, producing a sound wave. This is known as the piezoelectric effect.
- When the element is exposed to external vibration (or an ultrasonic wave), it produces a voltage. Piezoelectric ceramic (PZT: lead zirconate titanium) is the most frequently used piezoelectric element form due to its high conversion efficiency.



Ultrasound Transducer

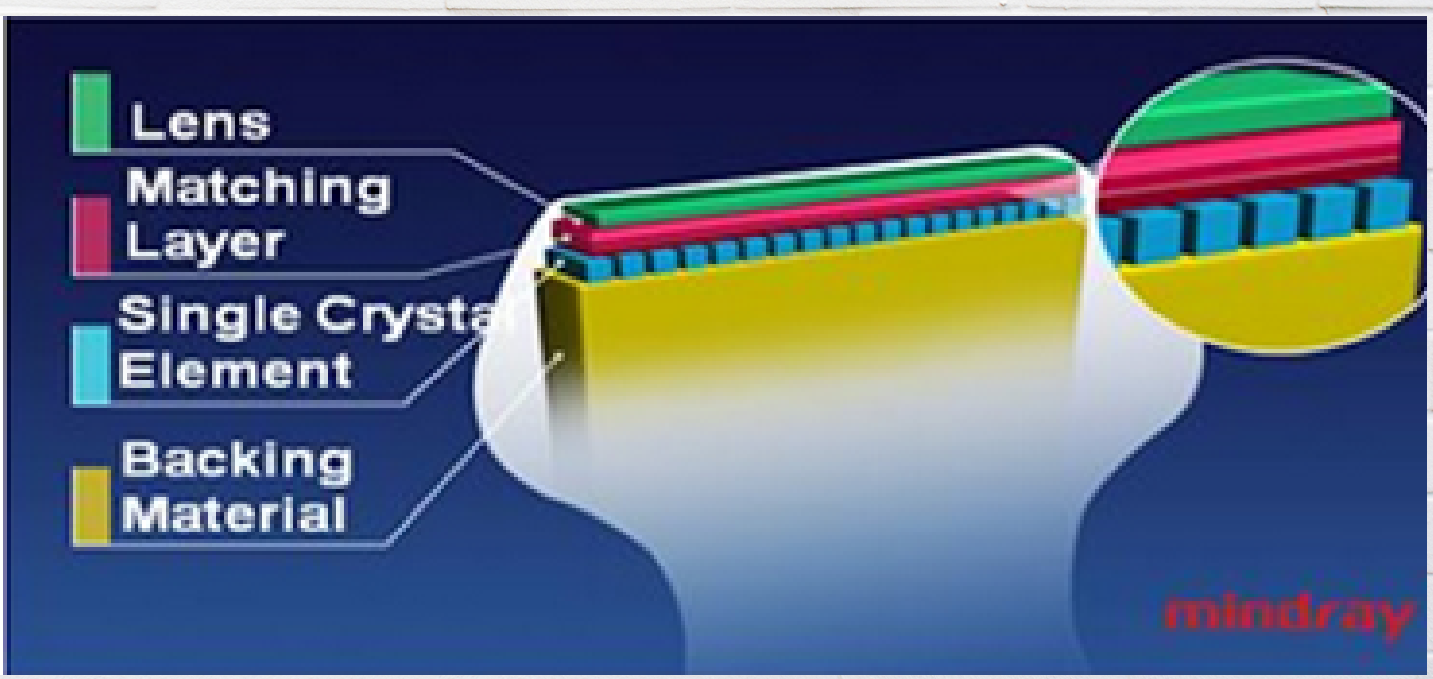
SECTION 3

WHAT IS TRANSDUCER ?

- A transducer is an electronic device that can convert one type of energy into another.
- Ultrasonic transducers convert electric signals into ultrasonic energy that can be transmitted into tissues, as well as ultrasonic energy reflected back from tissues into an electric signal.

BASIC PRINCIPLE OF TRANSDUCER

- The ultrasonic transducer is made up of several parts. The transducer is equipped with acoustic insulation to ensure that no additional acoustic waves affect it.
- Crystals enable sound waves to be sent in shorter pulses, improving resolution. Materials (corresponding layer) are placed in front of the crystals to reduce the impedance difference between the crystals and the fabric being studied.
- Without this layer, the impedance differential becomes significant, resulting in an excessive number of reflected sound waves.



BASIC PRINCIPLE OF TRANSDUCER

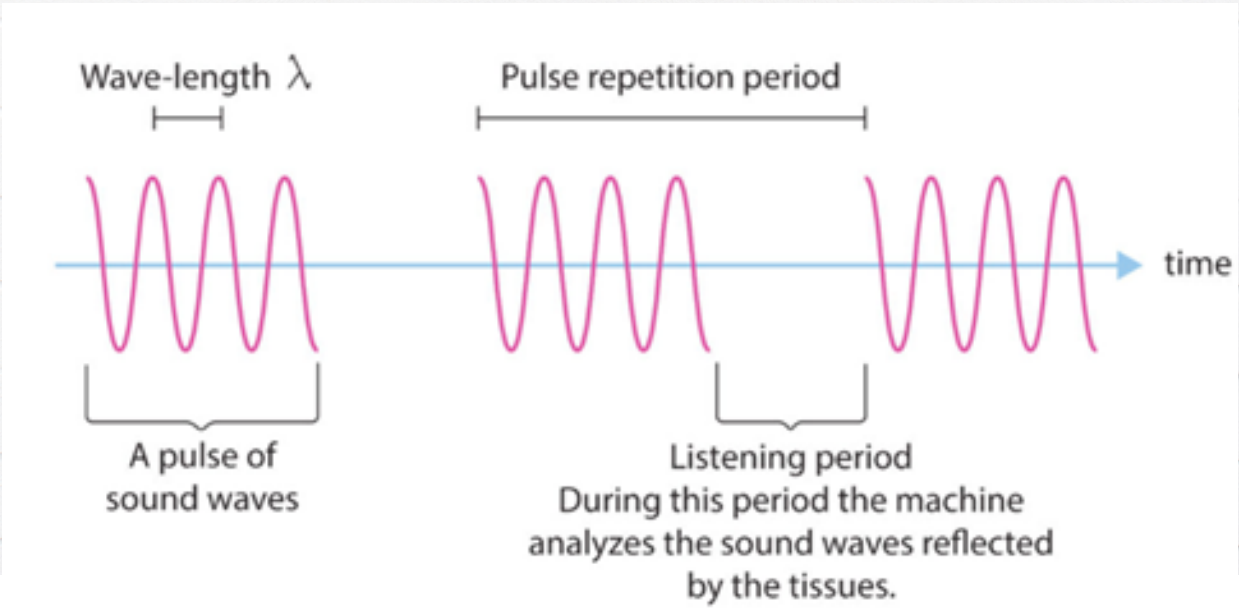
- Acoustic lens is placed in front of the transducer. This is the hard rubber that concentrates the ultrasonic waves, reducing scatter and increasing image resolution.
- Ultrasound waves in pulses are transmitted from the transducer. Each pulse is made up of a few sound waves that are broadcast every 1 to 2 milliseconds. These sound waves pass through the skin, the chest, the pericardium, the myocardium, and other organs.

- During the transition between each medium, a significant portion of all sound waves are reflected back to the transducer (tissue, blood). Once reflected sound strikes piezoelectric crystals, they produce sound and create electric currents, that are then sent to the ultrasound machine for interpretation.

- Although reflected sound waves travel at the same speed as emitted sound waves, their amplitude, frequency, and incidence angle may varies.
- By varying the amplitude, frequency, and timeframe of the reflected sound energy, the ultrasound machine projects an image of the medium (tissue).

ULTRASOUND PULSE

The ultrasound transducer produces short bursts of ultrasound waves (pulses). During brief pauses between pulses, the machine analyzes the reflected waves. As a result, the machine analyzes the sound waves reflected immediately following their emission.



The ultrasound device in the figure above sends ultrasound pulses and listens to the reflected echoes between the pulses.

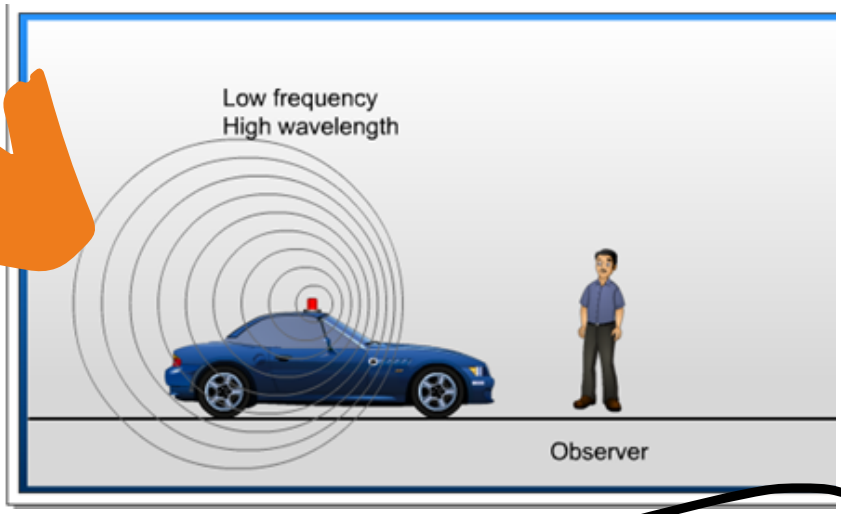
Doppler Effect

SECTION 6

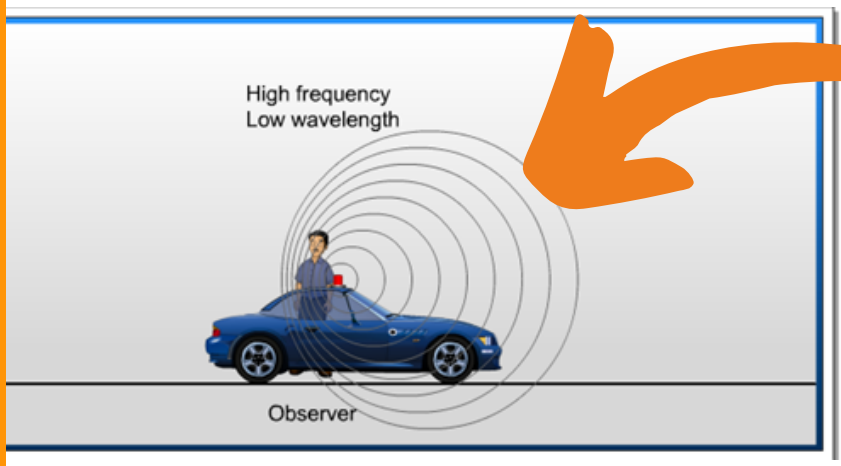
Definition of the Doppler Effect

In general, the Doppler Effect is a phenomenon observed whenever the source of waves is moving with respect to an observer.

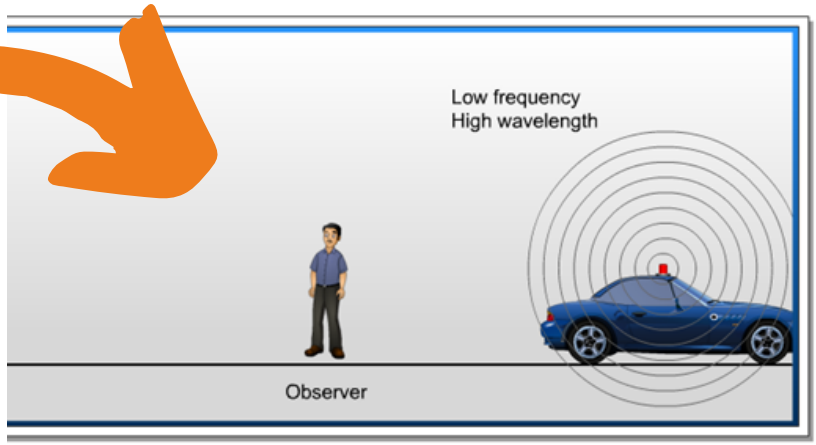
Assume that a police car or emergency vehicle was traveling towards you on the highway.



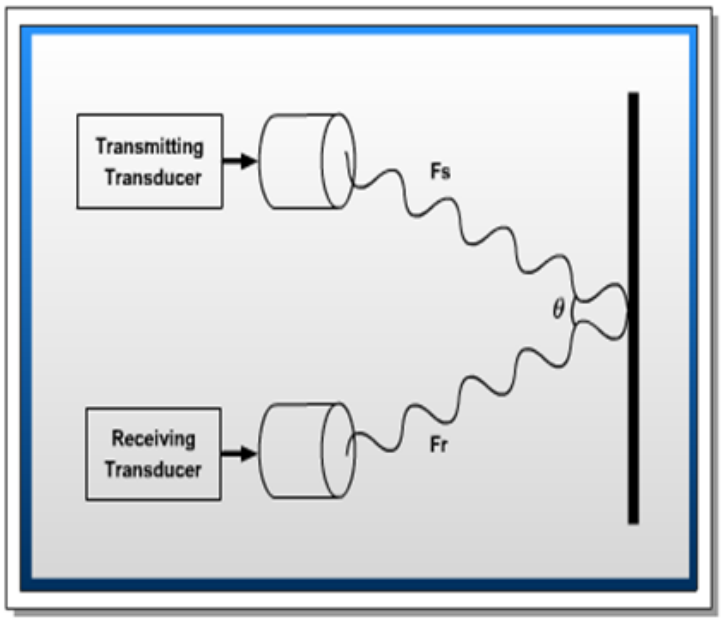
As the car approached with its siren blasting, the pitch of the siren sound (a measure of the siren's frequency) was high.



Suddenly after the car passed by, the pitch of the siren sound was low.



Doppler Effect equation



$$F_D = \frac{f_T 2\nu \cos\theta}{C}$$

F_D - Doppler frequency,

f_T - Transmitted ultrasonic frequency,

ν - Velocity of sound at the interface,

θ - Angle between the transmitted frequency and the reflected frequency,

C - Velocity of the sound in the medium.

- If a beam of ultrasound is reflected from a moving interface, the frequency of the reflected ultrasound will be different from the frequency of the incident wave.
- The difference in frequency is the Doppler shift frequency.

Doppler Principles

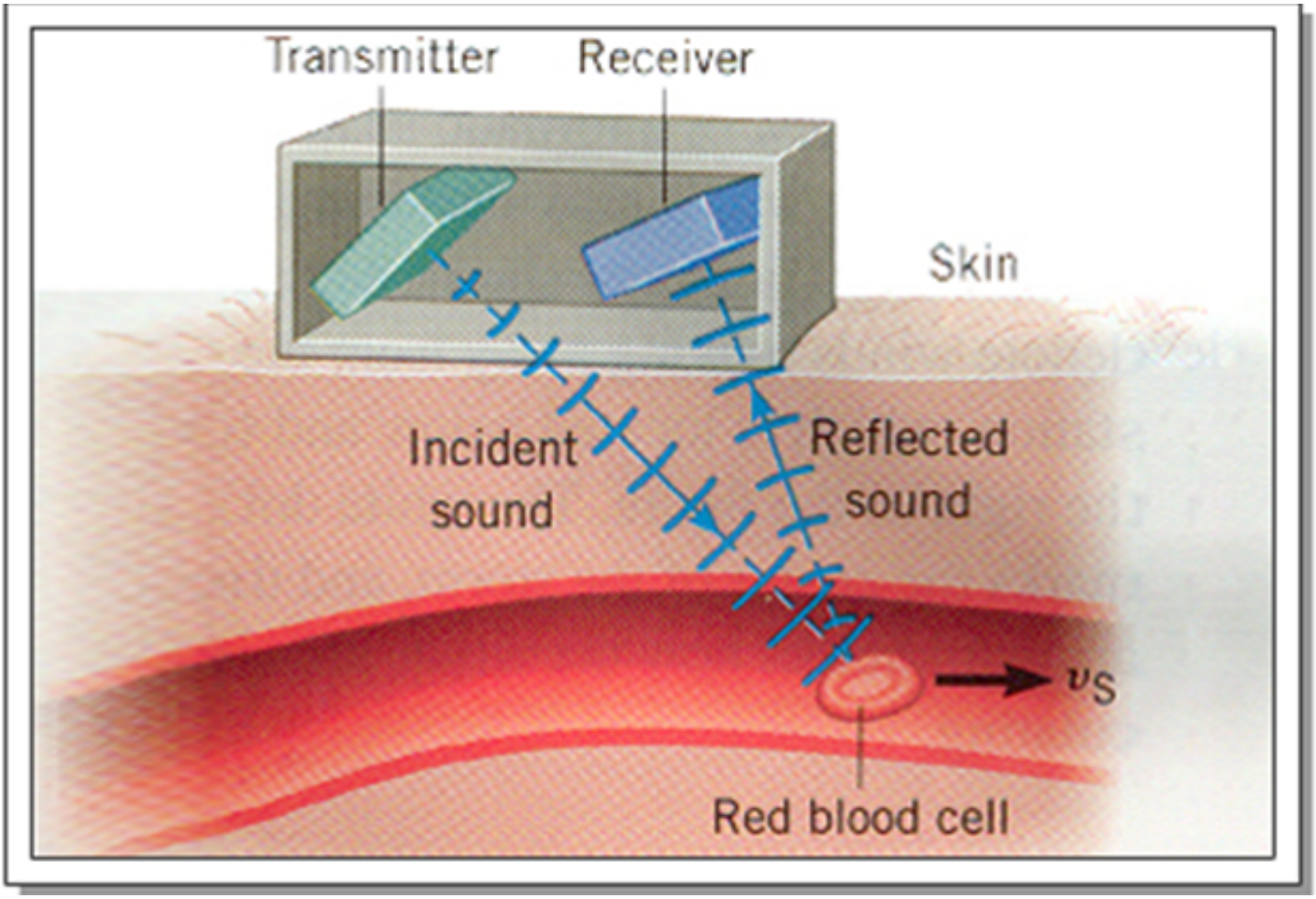
If the interface is stationary,

- then the frequency of transmitted wave and reflected wave will be the same, that is Fs = Fr. If the interface is moved away from the transducer, then frequency of transmitted wave will be more than the frequency of reflected wave, that is Fs>Fr.

If the interface is moved towards the transducer,

- then the frequency of transmission will be less than the frequency of reflected wave, that is Fs<Fr. This frequency difference is known as the Doppler shift frequency.

Blood Flow Measurement Using Doppler Effect

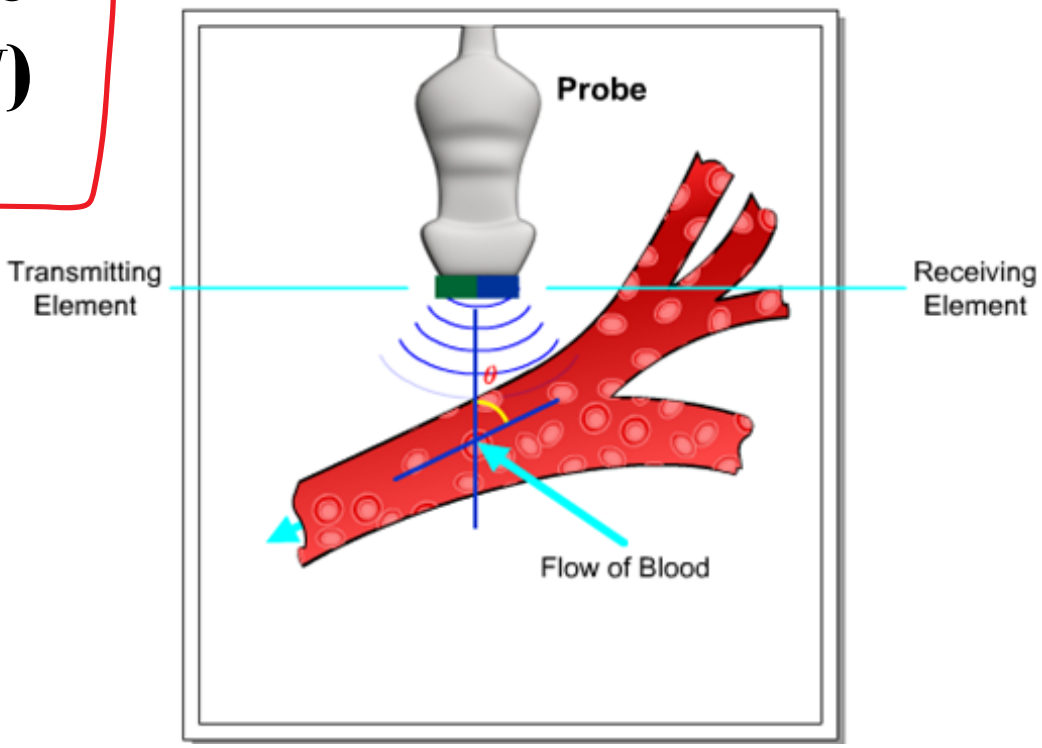


Ultrasonic Doppler systems are classified into two types:

- Continuous-Wave (CW).
- Pulsed-Wave Doppler system.

These systems are used to measure the blood flow.

Continuous-Wave (CW)

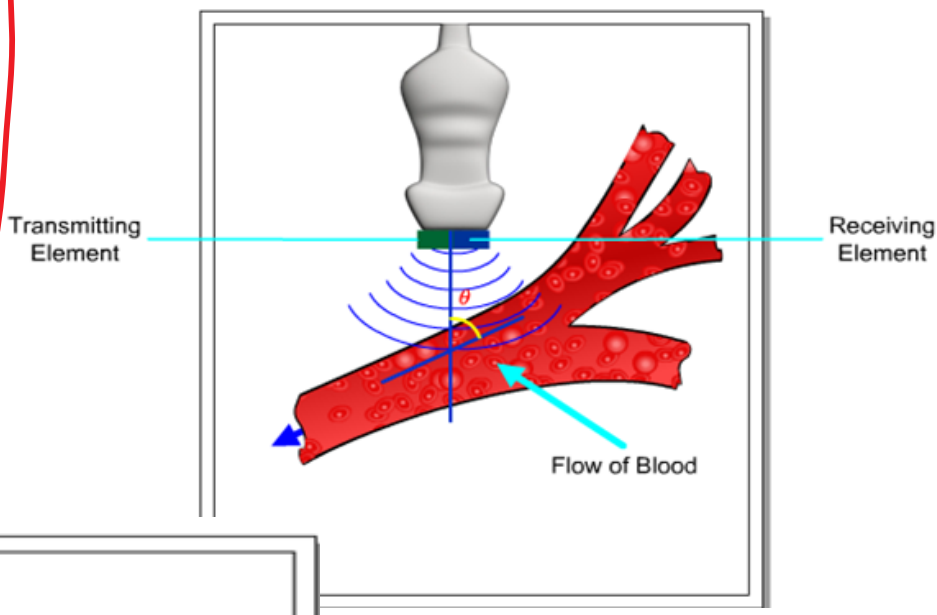


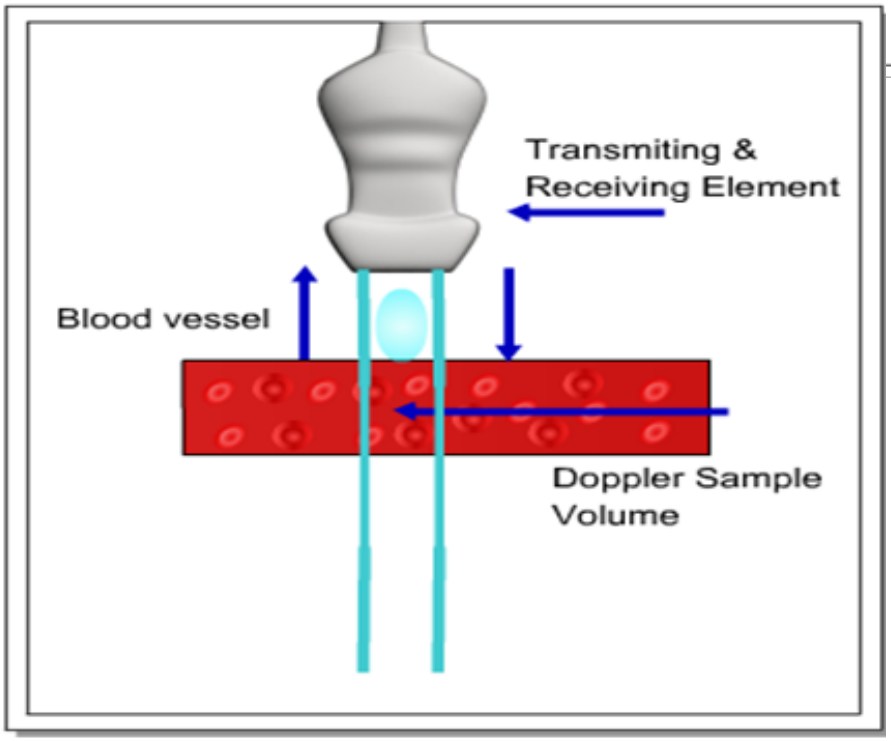
$$F_D = \frac{f_T \, 2v \cos\theta}{C}$$

Doppler shift is proportional to the frequency of the incident ultrasound as well as the velocity of the flow

Continuous-wave systems send and receive ultrasound in real time. Assume that a Doppler probe is made up of two parts, one transmitting crystal and one receiving crystal, so the ultrasonic beams are angled with the path of blood flow.

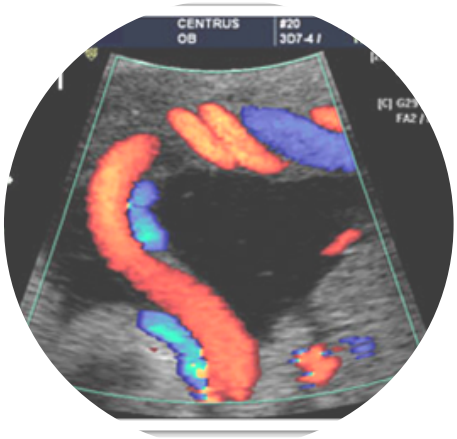
Pulsed-wave Doppler System





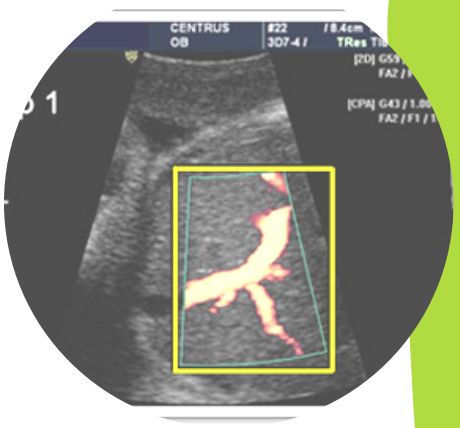
Continuous wave Doppler systems are unable to distinguish where the echoes come from. Pulsed Doppler systems produce short coherent sinusoidal bursts. The returned echoes are range gated and demodulated to obtain the Doppler shift. The range gate indicates the location from where the Doppler shift is generated.

Doppler Imaging Techniques



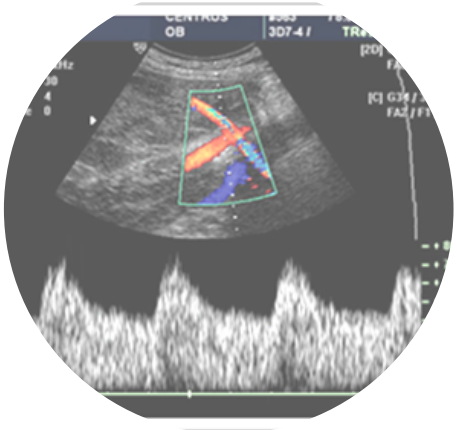
COLOR DOPPLER

Color Doppler uses a computer to convert Doppler measurement into an array of colors to visualize the speed and direction of blood flow through a blood vessel.



POWER DOPPLER

Power Doppler is a newer technique that is more sensitive than the color Doppler and it is capable of providing greater detail of blood flow, especially in vessels that are located inside organs. Power Doppler, however, does not help the radiologist determine the direction of flow.



SPECTRAL DOPPLER

Spectral Doppler displays the blood flow measurements graphically, in terms of the distance traveled per unit of time.

Ultrasound Instrumentation

SECTION 5

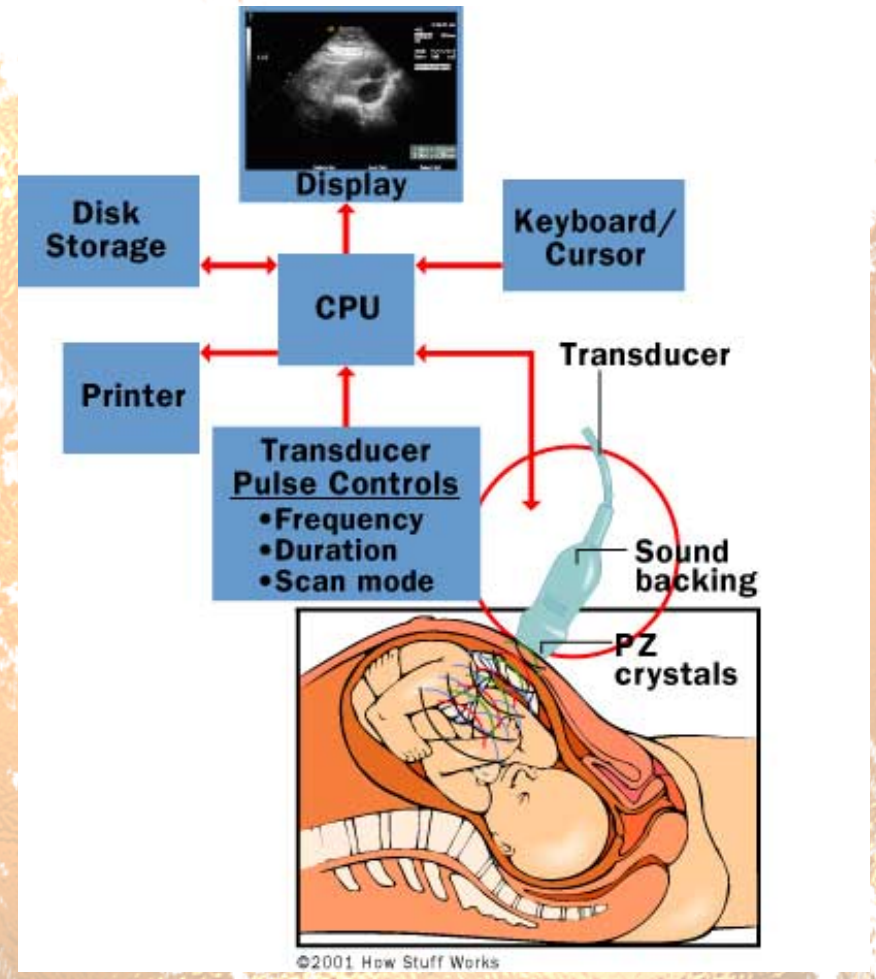


Figure:

The following components comprise a basic ultrasound machine:

- **transducer probe** - probe that sends and receives the sound waves
- **central processing unit (CPU)** - computer that does all of the calculations and contains the electrical power supplies for itself and the transducer probe
- **transducer pulse controls** - changes the amplitude, frequency and duration of the pulses emitted from the transducer probe
- **display** - displays the image from the ultrasound data processed by the CPU
- **keyboard/cursor** - inputs data and takes measurements from the display
- **disk storage device (hard, floppy, CD)** - stores the acquired images
- **printer** - prints the image from the displayed data

Transducer Probe

The main component of an ultrasound machine is the transducer probe. The transducer probe generates sound waves and detects echoes. It functions as the mouth and ears of the ultrasound machine. The piezoelectric (pressure electricity) effect, discovered by Pierre and Jacques Curie in 1880, is used by the transducer probe to generate and receive sound waves.

Central Processing Unit (CPU)

The CPU is the ultrasound machine's brain. The CPU is essentially a computer that houses the microprocessor, memory, amplifiers, and power supplies for both the microprocessor and the transducer probe. The CPU sends electrical currents to the transducer probe in order for it to emit sound waves, and it also receives electrical pulses from the probes created by the returning echoes. The CPU performs all of the calculations involved in data processing. The CPU creates the image on the monitor after processing the raw data. The processed data and/or image can also be saved to disc by the CPU.

Transducer Pulse Controls

The transducer pulse controls enable the ultrasonographer, or operator, to set and change the frequency and duration of the ultrasound pulses, as well as the machine's scan mode. The operator's commands are converted into varying electric currents that are applied to the piezoelectric crystals in the transducer probe.

Display

The display is a computer monitor that displays the processed data from the CPU. Depending on the model of the ultrasound machine, displays can be black-and-white or colour.

Keyboard/Cursor

Ultrasound machines are equipped with a keyboard and a cursor, such as a trackball. These devices allow the operator to make notes on the data and take measurements from it.

Disk Storage

Data and/or images that have been processed can be saved to disc. Hard discs, floppy discs, compact discs (CDs), and digital video discs are all examples of discs (DVDs). Ultrasound scans are typically stored on a floppy disc and archived with the patient's medical records.

Printers

Many ultrasound machines include thermal printers that can print a paper copy of the image from the screen.

Different Types of Ultrasound

So far, we've explained ultrasound as presenting a two-dimensional image, or "slice," of a three-dimensional object (fetus, organ). 3D ultrasound imaging and Doppler ultrasound are two other types of ultrasounds that are currently in use.

3D Ultrasound Imaging

Ultrasound machines capable of three-dimensional imaging have been developed in last two years. Several two-dimensional images are acquired in these machines by moving probes across the body surface or rotating inserted probes. Specialized computer software then combines two scans to create three-dimensional images.

3D imaging provides a better view of the organ being examined and is best used for:

• Early detection of cancerous and benign tumours

- Examining the prostate gland for early detection of tumours
- looking for masses in the colon and rectum
- detecting breast lesions for possible biopsies

•Visualizing a foetus to assess its development, particularly to observe abnormal development of the face and limbs

• Visualizing blood flow in various organs or a foetus

Doppler Ultrasound

The Doppler Effect encompasses Doppler ultrasound. When the object reflecting the ultrasound waves begins to move, the frequency of the echoes changes, producing a high frequency when moving toward the probe and a lower frequency when moving away from the probe. The quantity by which the frequency changes is determined by how fast the object moves. Doppler ultrasound calculates the speed of an object by measuring the change in frequency of the echoes. Doppler ultrasound has primarily been used to evaluate the rate of blood flow through the heart and major arteries.

Ultrasound Examination

- You walk into the room with an operator and the ultrasound machine for an ultrasound exam. What generally happens is as follows:You undress (Whether you wear all of your garments or just the ones that cover the region of interest).
- Any exposed regions not necessary for the test are draped with a cloth by the ultrasonographer.
- The ultrasonographer applies a mineral oil-based jelly to your skin; this jelly eliminates air between the probe and your skin, allowing sound waves to pass into your body.
- The probe is covered with a plastic cover by the ultrasonographer.
- He/she moves the probe over your skin to obtain the necessary images. Depending on the type of exam, the probe may be inserted into you.
- You may be asked to switch positions in order to get a better view of the area of interest.
- After the photos have been captured and measurements have been recorded, the data is stored on disc. A physical copy of the photographs is available upon request.
- To clean up, you are given a towelette.
- Change your clothes.

Major Uses of Ultrasound

Ultrasound is often used in numerous clinical settings, including obstetrics and gynaecology, cardiology, and cancer detection. The primary advantage of ultrasound is that it allows certain structures to be observed without the use of radiation. In addition, ultrasound is much faster than X-rays or other radiographic techniques. Here is a list of some ultrasound applications:

- **Obstetrics and Gynecology**
  - The size of the foetus is measured to determine the due date.
  - determining the fetus's position to see if it is in the normal head-down position or breech.
  - checking the placement of the placenta to see how it is developing incorrectly over the uterine opening (cervix).
  - examining the number of foetuses in the uterus.
  - determining the baby's gender (if the genital area can be clearly seen).
  - assessing the fetus's growth rate over time by taking numerous measurements.
  - detecting ectopic pregnancy, a potentially fatal condition in which the baby is implanted in the mother's Fallopian tubes rather than the uterus.
  - determining whether the baby is cushioned by an adequate amount of amniotic fluid.
  - Ultrasound has been useful in seeing and avoiding the baby during amniocentesis (sampling of the amniotic fluid with a needle for genetic testing). Years ago, doctors performed this procedure blindly; however, with the addition of ultrasound, the risks of this procedure have been dramatically reduced.
  - observing ovarian and breast tumours.

- **Cardiology**
  - seeing the inside of the heart to identify abnormal structures or functions
  - measuring blood flow through the heart and major blood vessels

- **Urology**
  - measuring blood flow through the kidney
  - seeing kidney stones
  - detecting prostate cancer early

Performance Test on the Ultrasound Machine

SECTION 7

Apparatus for Performance Test

1. Ultrasound phantom.
2. Ultrasound machine.
3. Ultrasound probe.
4. Ultrasound gel.
5. Distilled water.
6. Tissues.
7. Image quality form.
8. Ultrasound thermal paper.

To register accurate vertical distance measurements, APPLY NO PRESSURE TO THE SCANNING SURFACE!

Tissue Phantom

The International Commission on Radiation Units and Measurements (ICRU) defines a "phantom" as any structure that contains one or more tissue substitutes and is used to simulate radiation interactions in the human body.

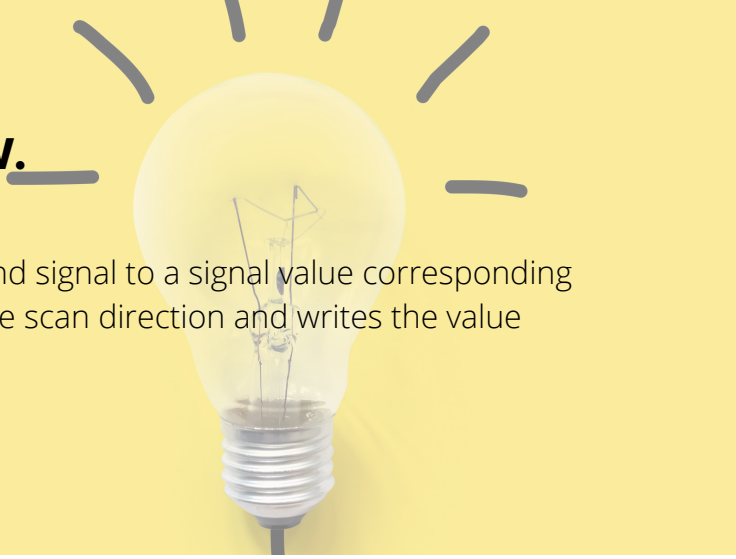
Performance Measurements

- Dead Zone
- Horizontal Distance
- Vertical Distance
- Depth of Penetration
- Image Uniformity
- Axial Resolution
- Lateral Resolution
- Anechoic Mass Resolution
- Gray Scale Contrast Resolution
- Elasticity Image Evaluation

Tissue phantom is equivalent material that has some characteristics representative of tissue.

Tutorials

ANSWER ALL THE QUESTION BELOW.



1. _____ – to converts the received ultrasound signal to a signal value corresponding to the brightness at the position according to the scan direction and writes the value into memory.
Select one:
a. memory
b. ultrasound system
c. cpu

2. Determine the frequency for ultrasound wave.
Select one:
a. 20 Hz to 20 kHz
b. greater than 20 kHz
c. below 20 Hz

3. _____ is defined as the range of weakest to strongest echo signals which can be displayed.
Select one:
a. combination focus
b. dynamic range
c. sensitivity time control

4. Differentiate between ultrasound therapeutic and ultrasound diagnostic.
Select one:
a. u/s therapeutic used for diagnostic and imaging internal organ, u/s diagnostic used for deep heat therapy and massage.
b. u/s diagnostic used for diagnostic and imaging internal organ, u/s therapeutic used for deep heat therapy and massage.
c. u/s diagnostic required less frequency compare to u/s therapeutic to operate.

5. Every medium has a property called its _____ which is a measure of its resistance to sound passing through the medium.
Select one:
a. acoustic capacitance
b. acoustic resistance
c. acoustic impedance

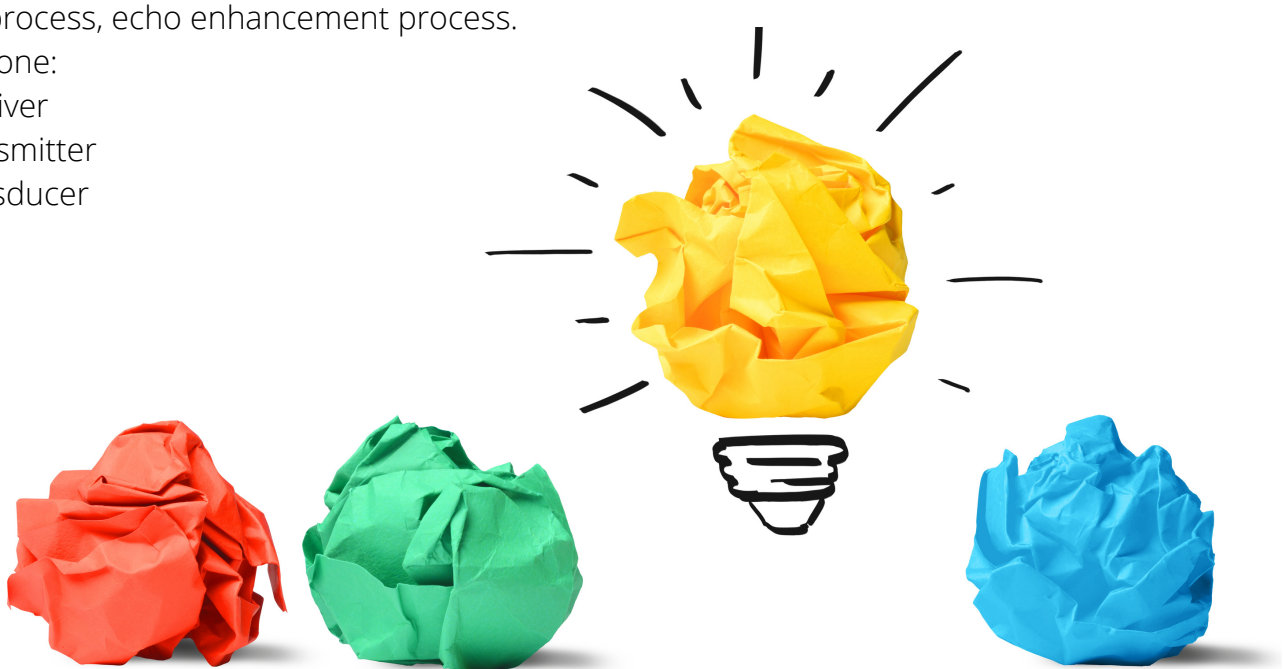
6. The basic structure of the DSC consists of _____ , _____ and _____ .
Select one:
a. echo converter, Memory and D/A converter.
b. A/D converter, Memory and D/A converter.
c. A/D converter, Memory and voltage converter.

7. The transmission delay line generates a _____ between pulses to achieve the desired focusing distance.
Select one:
a. relay time
b. delay time
c. duration time

8. Resolution can be defined as the ability of the equipment to distinguish two separate objects. State two types of resolution.
Select one:
a. wavelength resolution, beam resolution
b. axial resolution, lateral resolution
c. image resolution, beam resolution

9. The ultrasound transmission timing and reception period are determined by the _____
Select one:
a. rate pulse
b. signal pulse
c. time pulse

10. _____ to amplify the mixed echo signal from R delay line, perform dynamic range process, echo enhancement process.
Select one:
a. receiver
b. transmitter
c. transducer

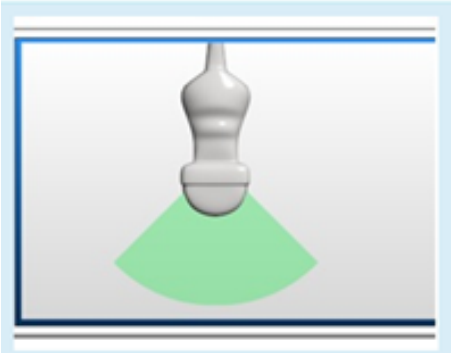


11. The _____ scanner emphasizes the movement of interfaces, including rate, amplitude and pattern of motion. It is primarily used to study moving objects like the valves and the walls of the heart.
Select one:
a. Color mode
b. B mode
c. A mode
d. M mode

12. _____ the application of medical ultrasonography to the female pelvic organs, specifically the uterus, the ovaries, the Fallopian tubes, as well as the bladder, the adnexa, and any findings in the pelvis of relevance outside of pregnancy.
Select one:
a. Gynecologic ultrasonography
b. Obstetric ultrasonography

13. A sound travelling through any medium depends on the_____ and _____ of the medium.
Select one:
a. velocity, frequency
b. velocity, density
c. velocity, impedance

14. Determine the cause that ultrasound cannot pass through the medium.
Select one:
a. high absorption and high attenuation
b. high attenuation, high energy
c. high absorption, low energy



15. State the types of scanning methods
Select one:
a. linear
b. sector
c. convex

16. Determine the function of Pre amplifier in ultrasound machine.
Select one:
a. to pre amplify the reflected echo signals received from the digital scan converter
b. to pre amplify the reflected echo signals received from the transducer
c. to pre amplify the reflected sound signals received from the transducer

17. Tissue phantom is equivalent material that has some characteristics representative of _____
Select one:
a. organ
b. muscle
c. tissue

18. Echo enhancement is to enhance the _____ of the ultrasound image.
Select one:
a. echo
b. definition
c. image

19. _____is a device used to produce the ultrasonic waves for imaging.
Select one:
a. ultrasound transducer
b. ultrasound machine
c. ultrasound wave

20. ultrasound machine consist of the following section;
Select one:
a. transducer, transmitter, receiver, digital scan converter, monitor display
b. Probe, transmitter, receiver, control panel, cpu, monitor display
c. transducer, voltage converter, digital scan converter, sound system

REFERENCES

LIST OF REFERENCES

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Website:

https://www.physics.utoronto.ca/~jharlow/teaching/phy138_0708/lec04/ultrasoundx.htm

Terbitan:

POLITEKNIK MALAYSIA
SULTAN SALAHUDDIN ABDUL AZIZ SHAH

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