CLINICAL APPLICATIONS OF ULTRASOUND

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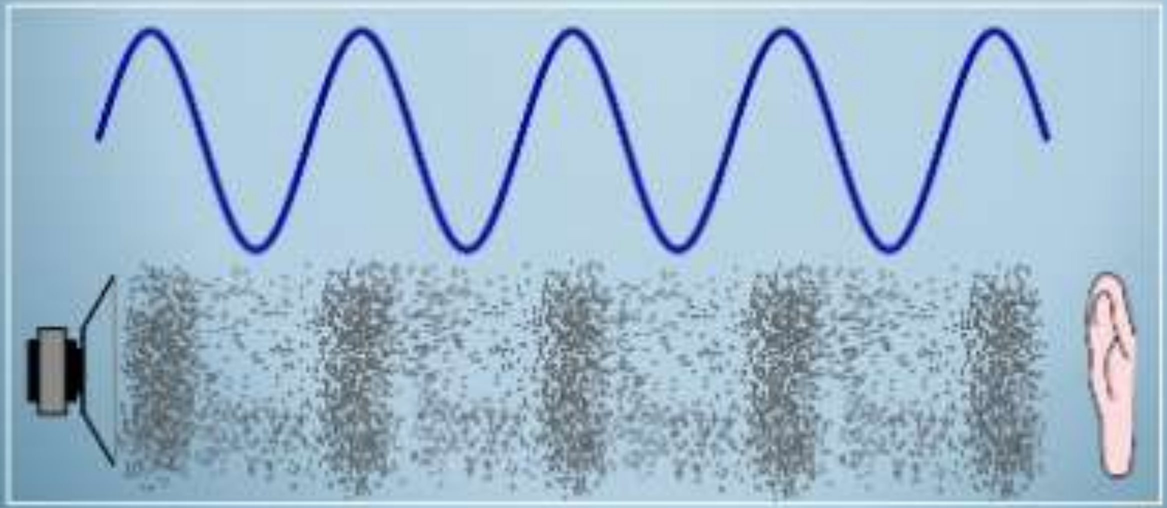
What is Sound ?

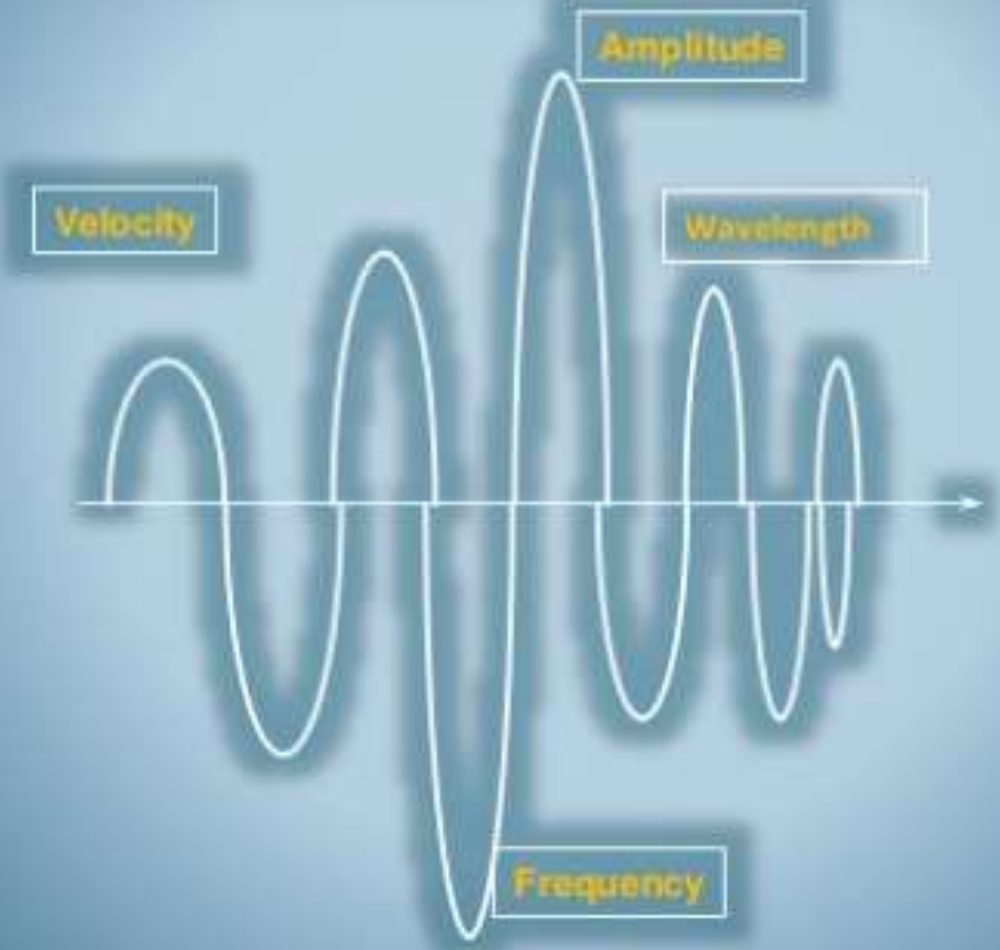
- Mechanical and Longitudinal waves wave that can transfer a distance using a media.
- Cannot travel through Vacuum.



What is Ultrasound?

- Ultrasound is a mechanical, longitudinal wave with a frequency exceeding the upper limit of human hearing, which is 20,000 Hz or 20 kHz.
- Typically at 2 - 20 Mhz.
- Average speed of ultrasound in body is 1540m/sec

Basic Ultrasound Physics

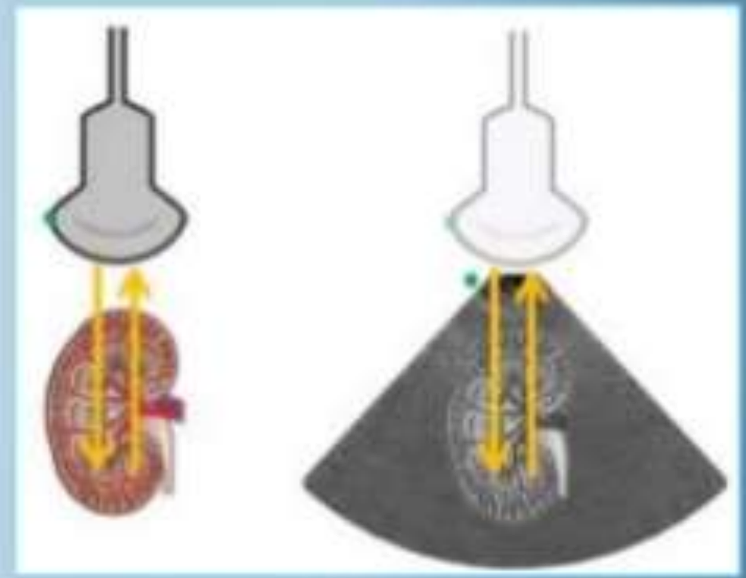


Velocity

Near Field Imaging

Tissues closer appear on top and faster the waves return

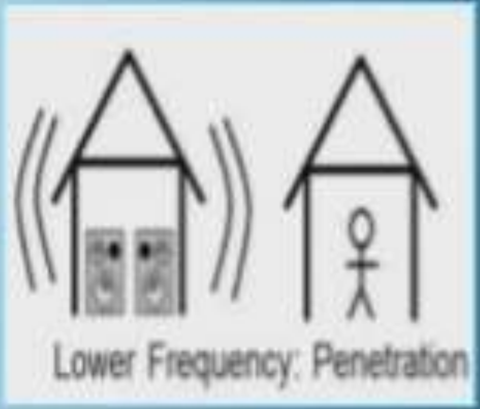
Far Field Imaging



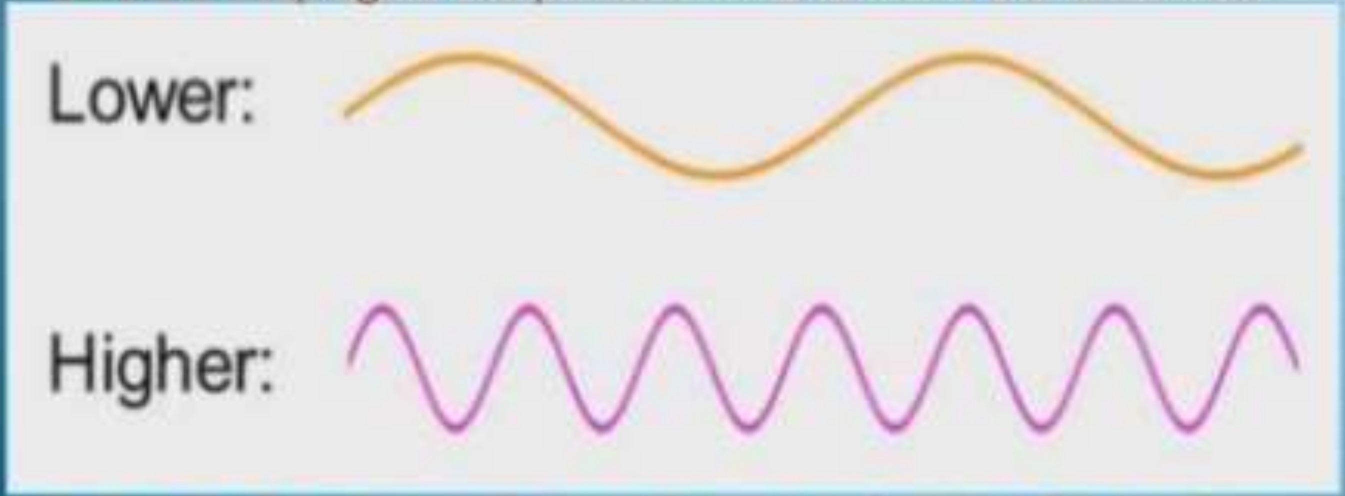
Tissues further appear at the bottom & slower the waves return

Frequency

- Number of cycles per second
- Units are Hertz
- Ultrasound imaging frequency range 2-20Mhz



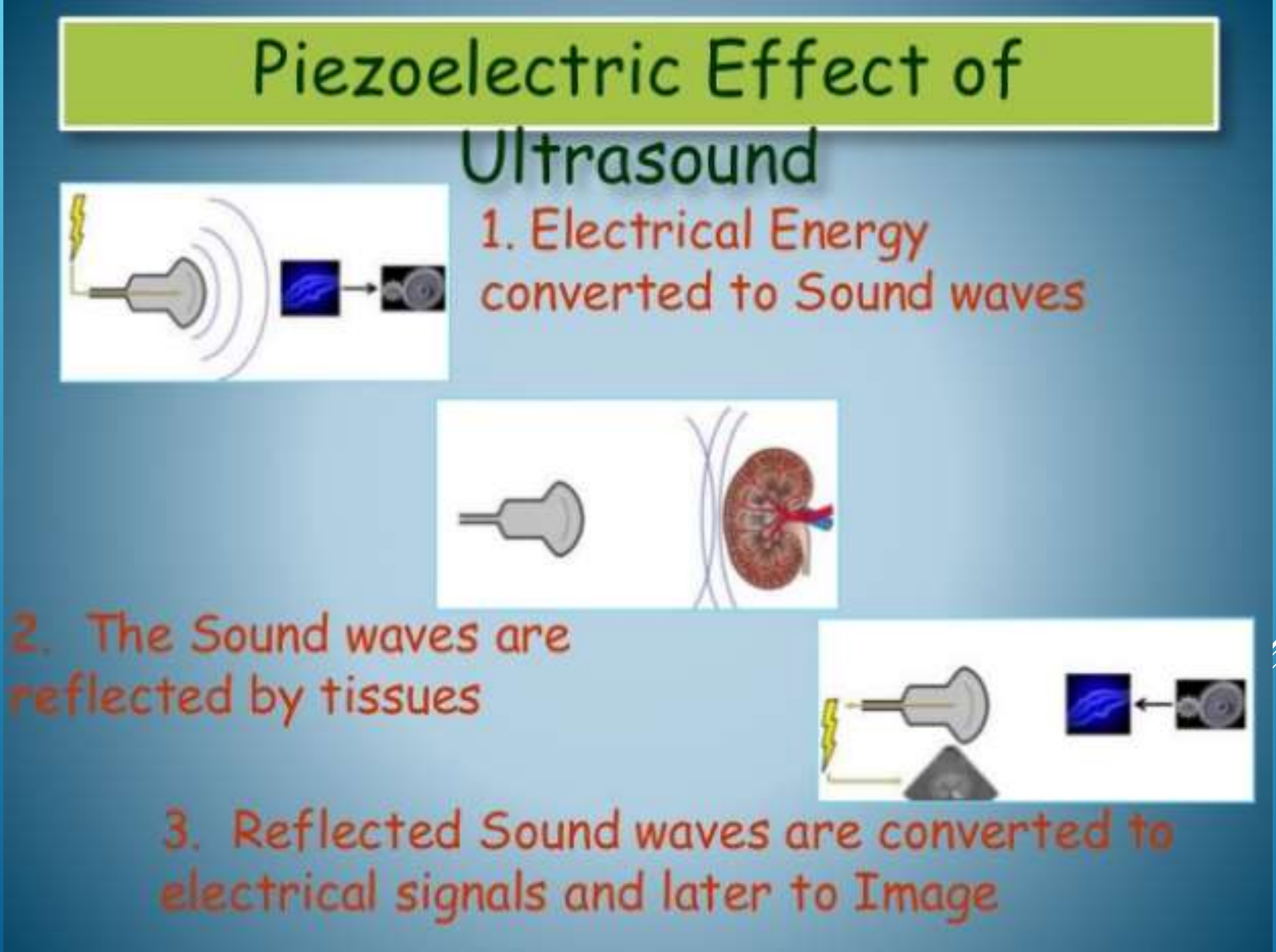
Low the freq higher the penetration and lower the resolution



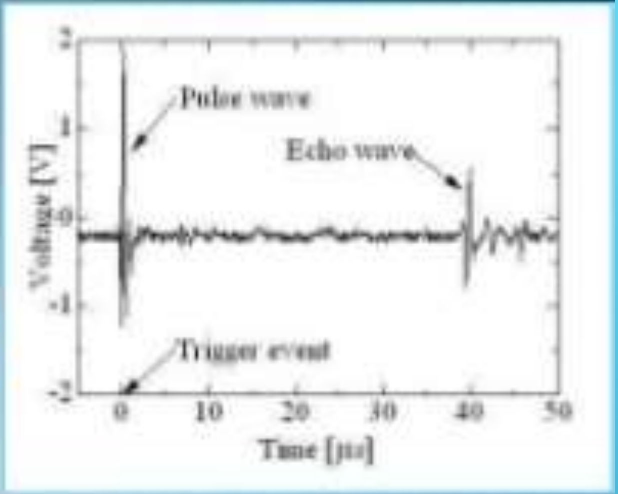
Higher the freq Lower the penetration and Higher the resolution

How Ultrasound Works

????


Piezoelectric Effect of Ultrasound
1. Electrical Energy converted to Sound waves
2. The Sound waves are reflected by tissues
3. Reflected Sound waves are converted to electrical signals and later to Image

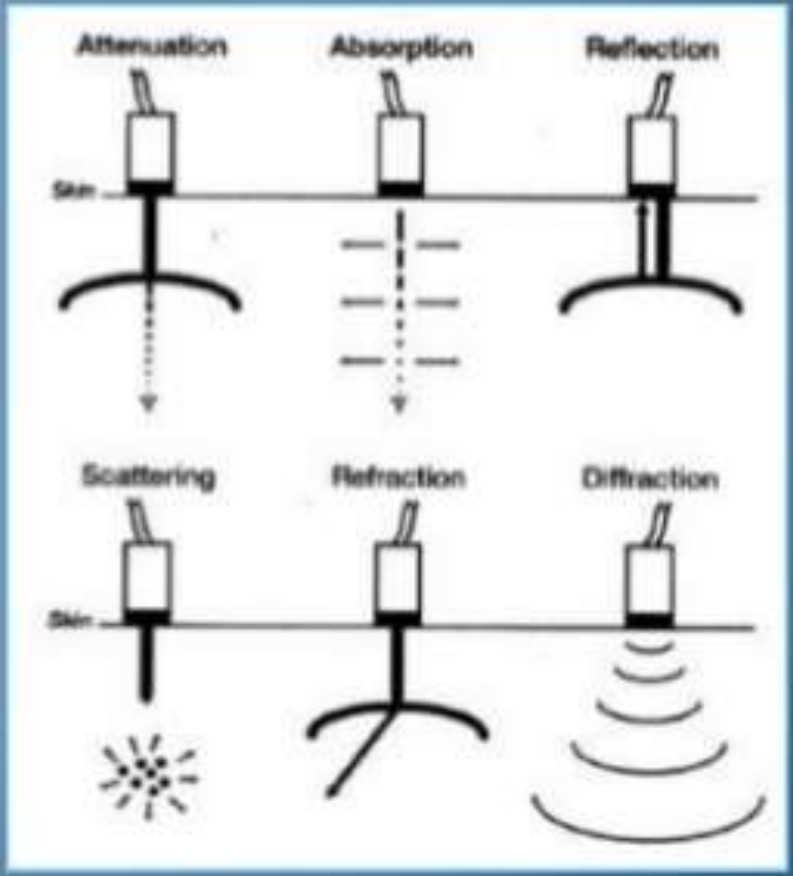
Pulse-Echo Method



- Ultrasound transducer produces "pulses" of ultrasound waves
- These waves travel within the body and interact with various tissues
- The reflected waves return to the transducer and are processed by the ultrasound machine
- An image which represents these reflections is formed on the monitor

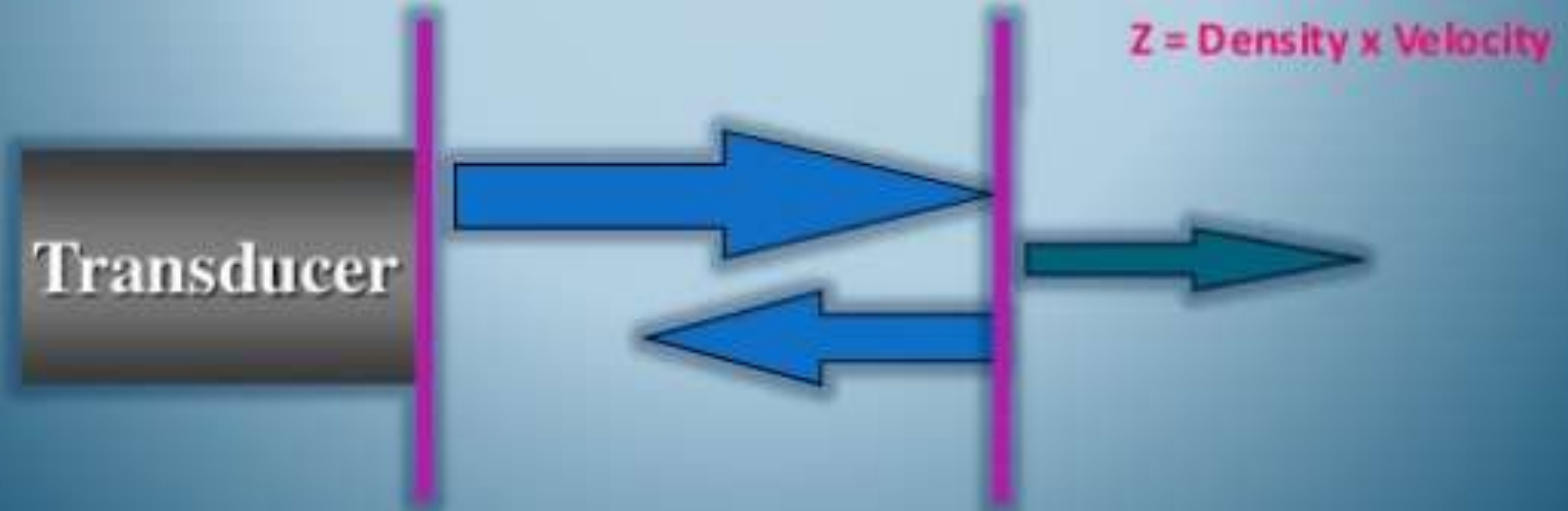
Interactions of Ultrasound with tissue

- Reflection
- Transmission
- Attenuation
- Scattering



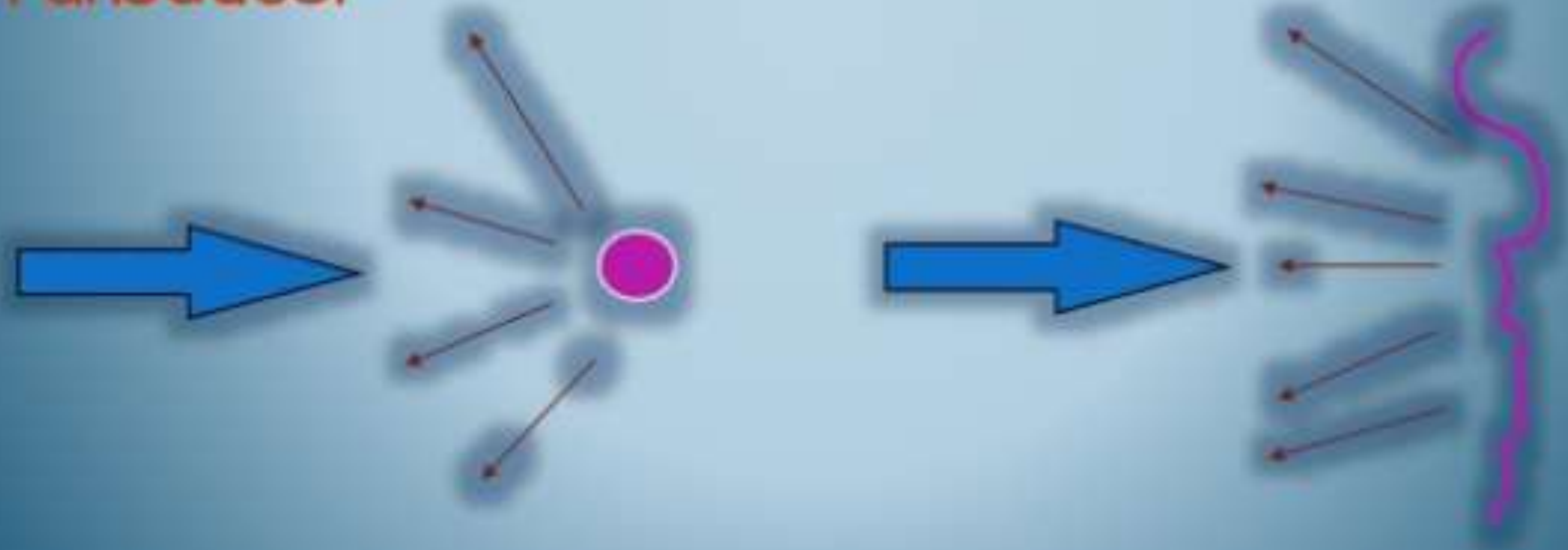
Reflection

- Occurs at a boundary between 2 adjacent tissues or media
- The amount of reflection depends on differences in acoustic impedance (z) between media
- The ultrasound image is formed from reflected echoes



Scattering

- Redirection of sound in several directions
- Caused by interaction with small reflector or rough surface
- Only portion of sound wave returns to transducer

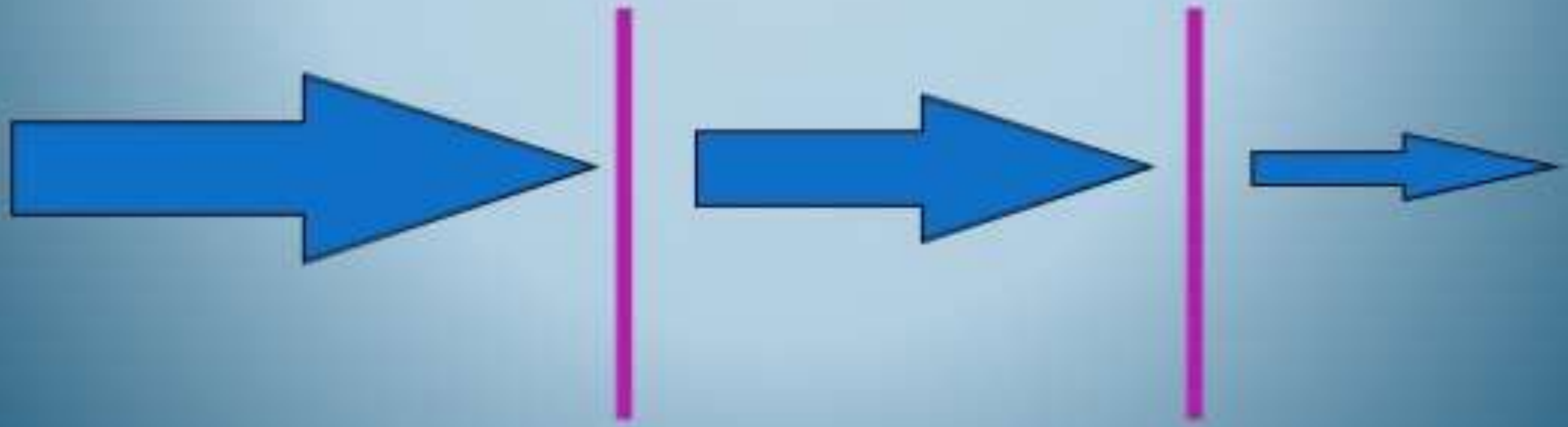


Transmission

- Not all the sound wave is reflected, some continues deeper into the body
- These waves will reflect from deeper tissue structures

Attenuation

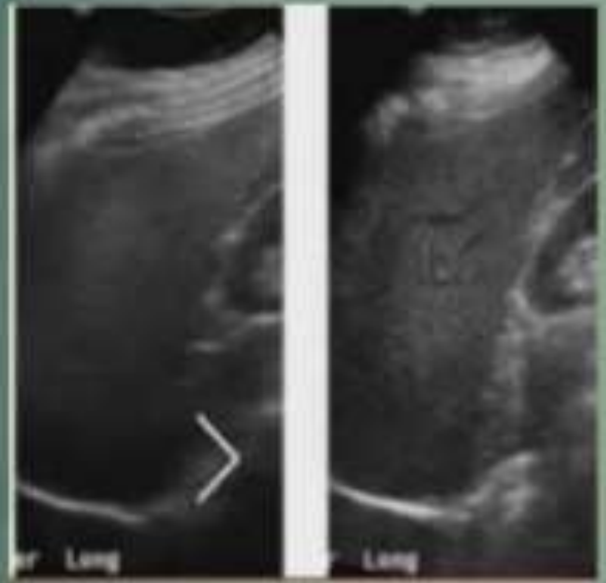
- The deeper the wave travels in the body, the weaker it becomes
- The amplitude of the wave decreases with increasing depth



Attenuation

Absorption

The Longer it travels the more less Resolution



High Freq Low Freq

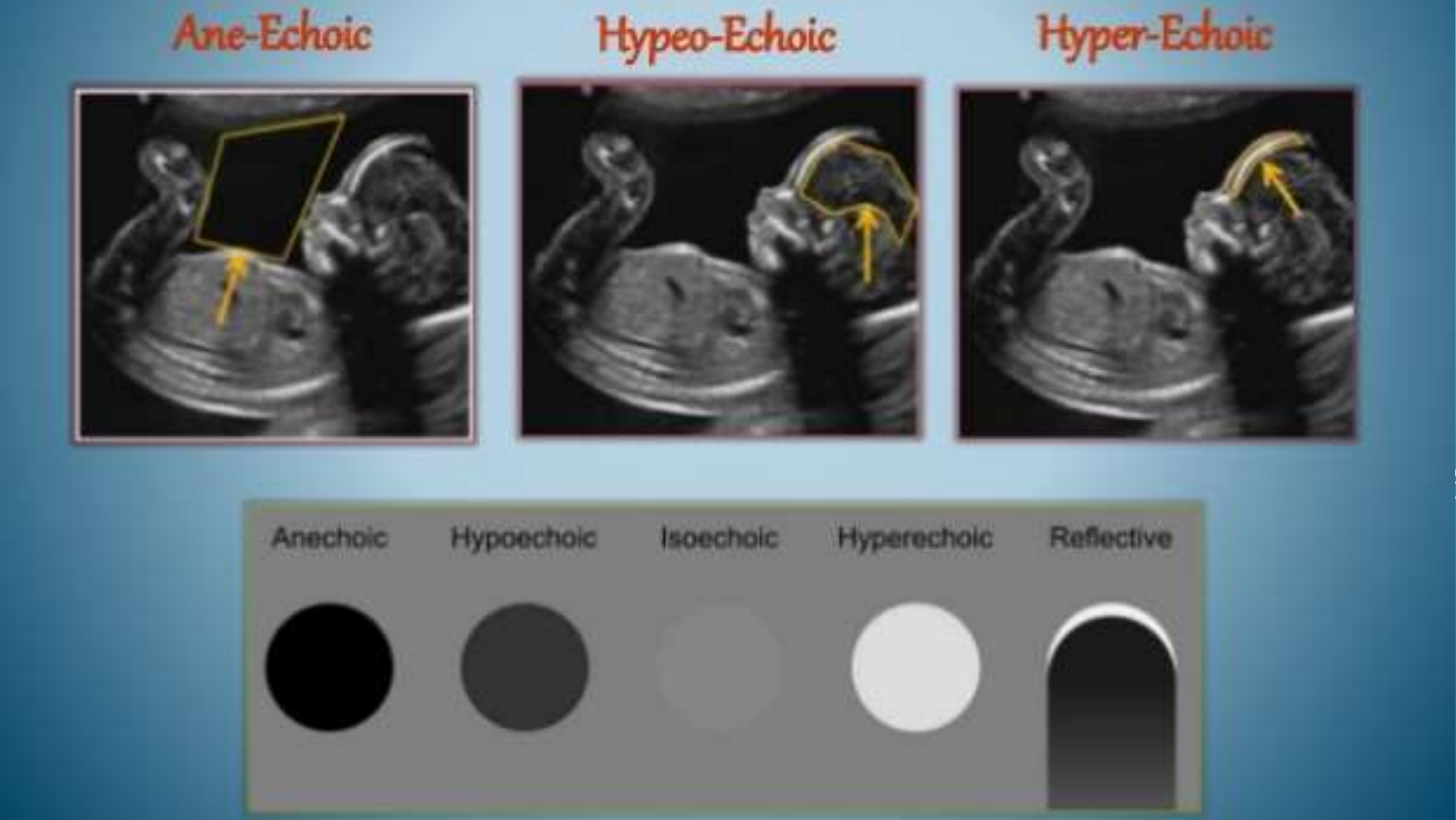
Reflection

The Signal behind the bone is An-echoic

Attenuation Co-efficient

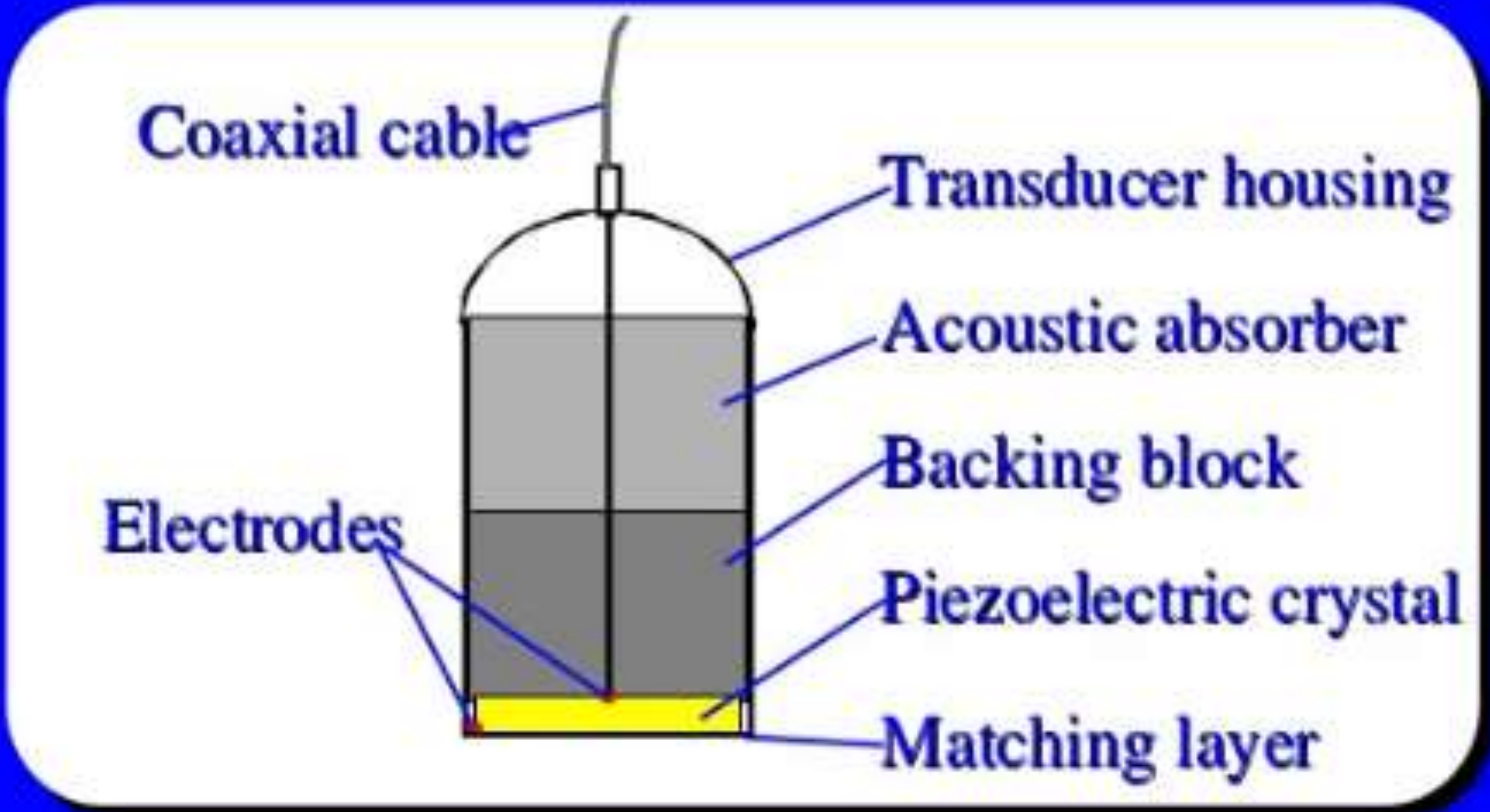
- Gas | Fluid - Low AC - allow Wave to pass
- Bones - High AC - will block

Echogenicity (caused by Reflection)



Ultrasound Transducers

Can be used both to transmit & receive ultrasound

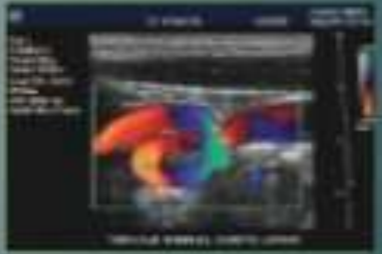


Probes

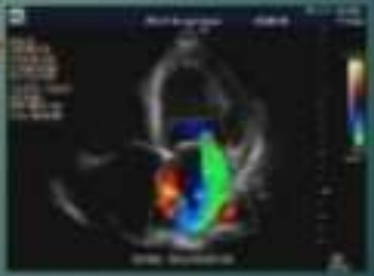
Range is ideal to switch between General, High and low Resolution

Curvilinear or Abdom

Linear or Vascular



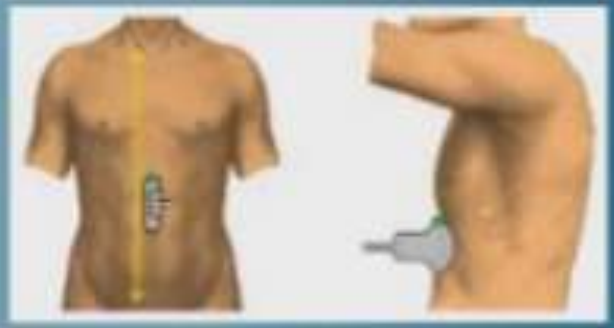
Phased Array or Cardiac



Imaging Planes

- Transverse or Axial

- Longitudinal or Saggital



- Coronal

DIFFERENT MODES OF ULTRASOUND IMAGING

- A mode
- B mode
- M mode
- Doppler imaging

- **A-mode**: A-mode is the simplest type of ultrasound. A single transducer scans a line through the body with the echoes plotted on screen as a function of depth. Therapeutic ultrasound aimed at a specific tumor or calculus is also A-mode, to allow for pinpoint accurate focus of the destructive wave energy.

- **B-mode**: In B-mode ultrasound, a linear array of transducers simultaneously scans a plane through the body that can be viewed as a two-dimensional image on screen.
- **M-mode**: M stands for motion. In m-mode a rapid sequence of B-mode scans whose images follow each other in sequence on screen enables doctors to see and measure range of motion, as the organ boundaries that produce reflections move relative to the probe.

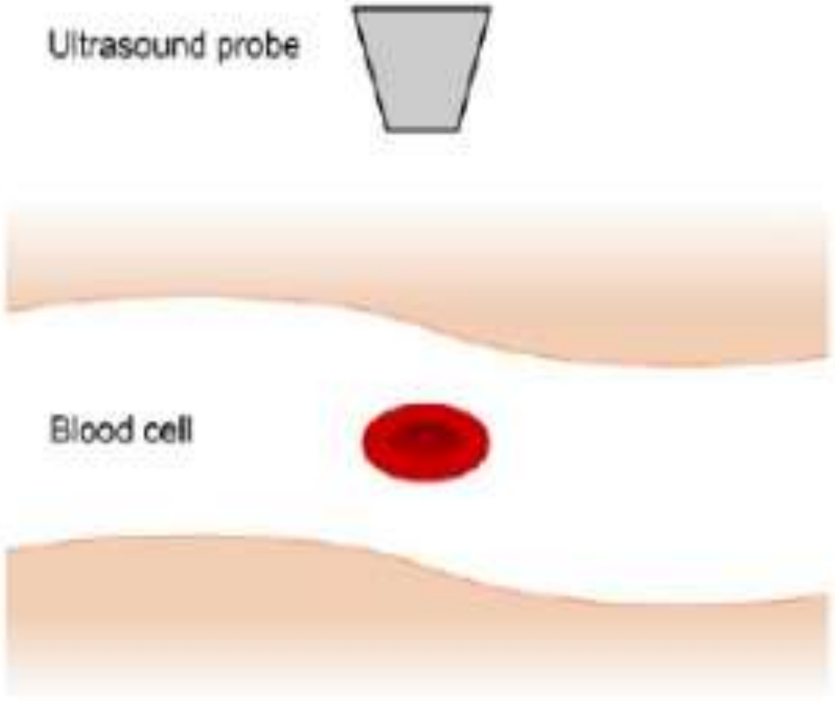
- Doppler mode: This mode makes use of the Doppler effect in measuring and visualizing blood flow. Sonography can be enhanced with Doppler measurements, which employ the Doppler effect to assess whether structures (usually blood) are moving towards or away from the probe, and its relative velocity.
- By calculating the frequency shift of a particular sample volume, for example a jet of blood flow over a heart valve, its speed and direction can be determined and visualized. This is particularly useful in cardiovascular studies (sonography of the vasculature system and heart) and essential in many areas such as determining reverse blood flow in the liver vasculature in portal hypertension .
- The Doppler information is displayed graphically using spectral Doppler, or as an image using color Doppler (directional Doppler) or power Doppler (non directional Doppler).

The Doppler Effect

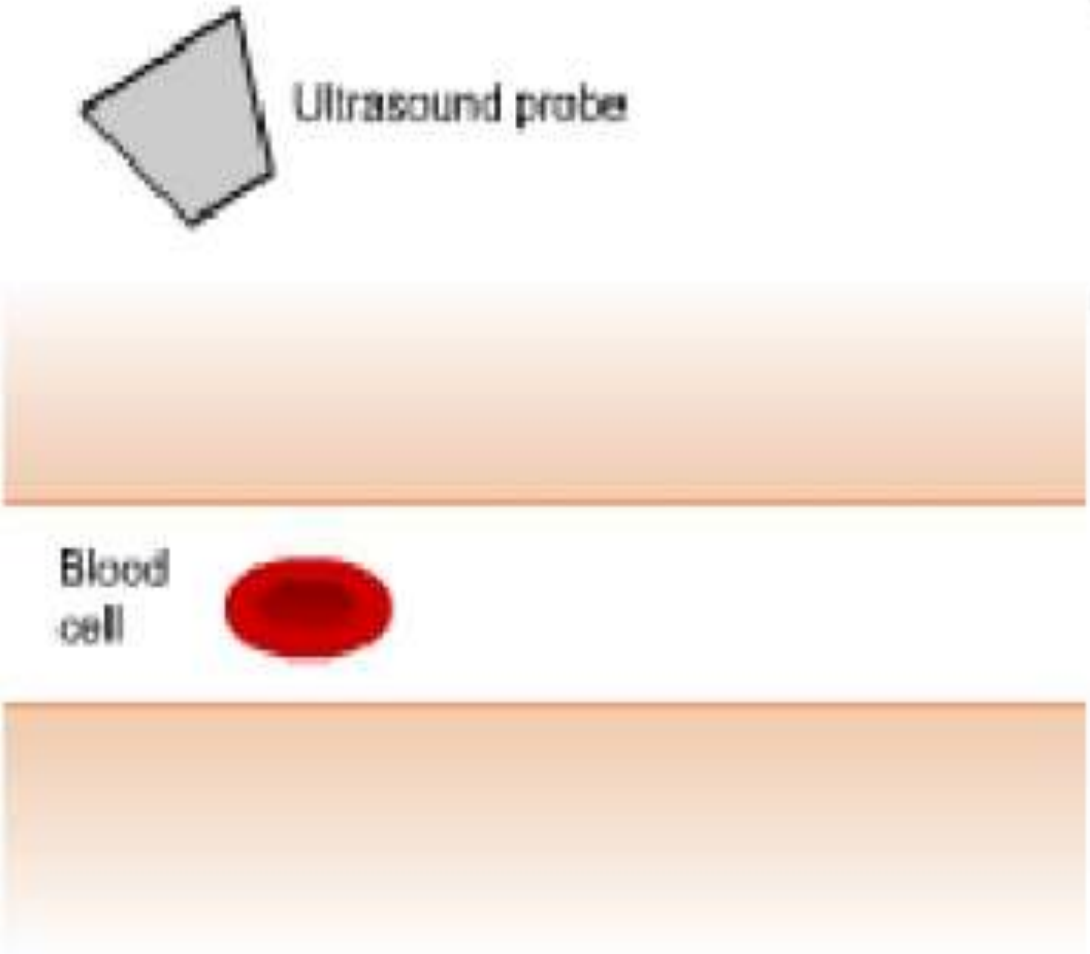
- Apparent change in received frequency due to a relative motion between a sound source and sour receiver
  - Sound TOWARD receiver = frequency 
  - Sound AWAY from receiver = frequency 

- Ultrasound, like normal sound, is a wave.
- If a source of sound moves towards the listener, the waves begin to catch up with each other. The wavelength gets shorter and so the frequency gets higher – the sound has a higher pitch.

- We use this principle to work out how fast blood cells move. Ultrasound reflects off the blood cells and causes a Doppler shift

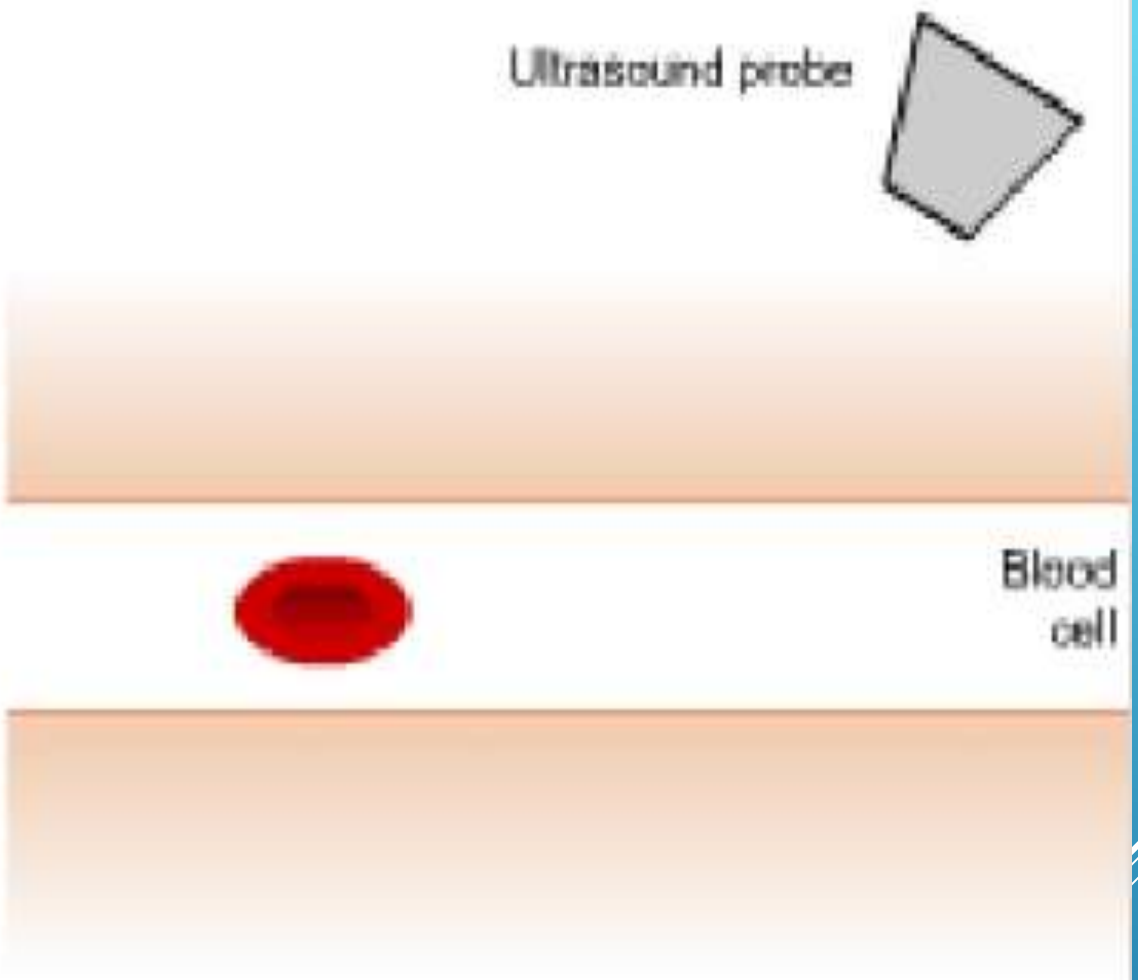


- The ultrasound probe emits an ultrasound wave
- A stationary blood cell reflects the incoming wave with the same wavelength: there is no Doppler shift



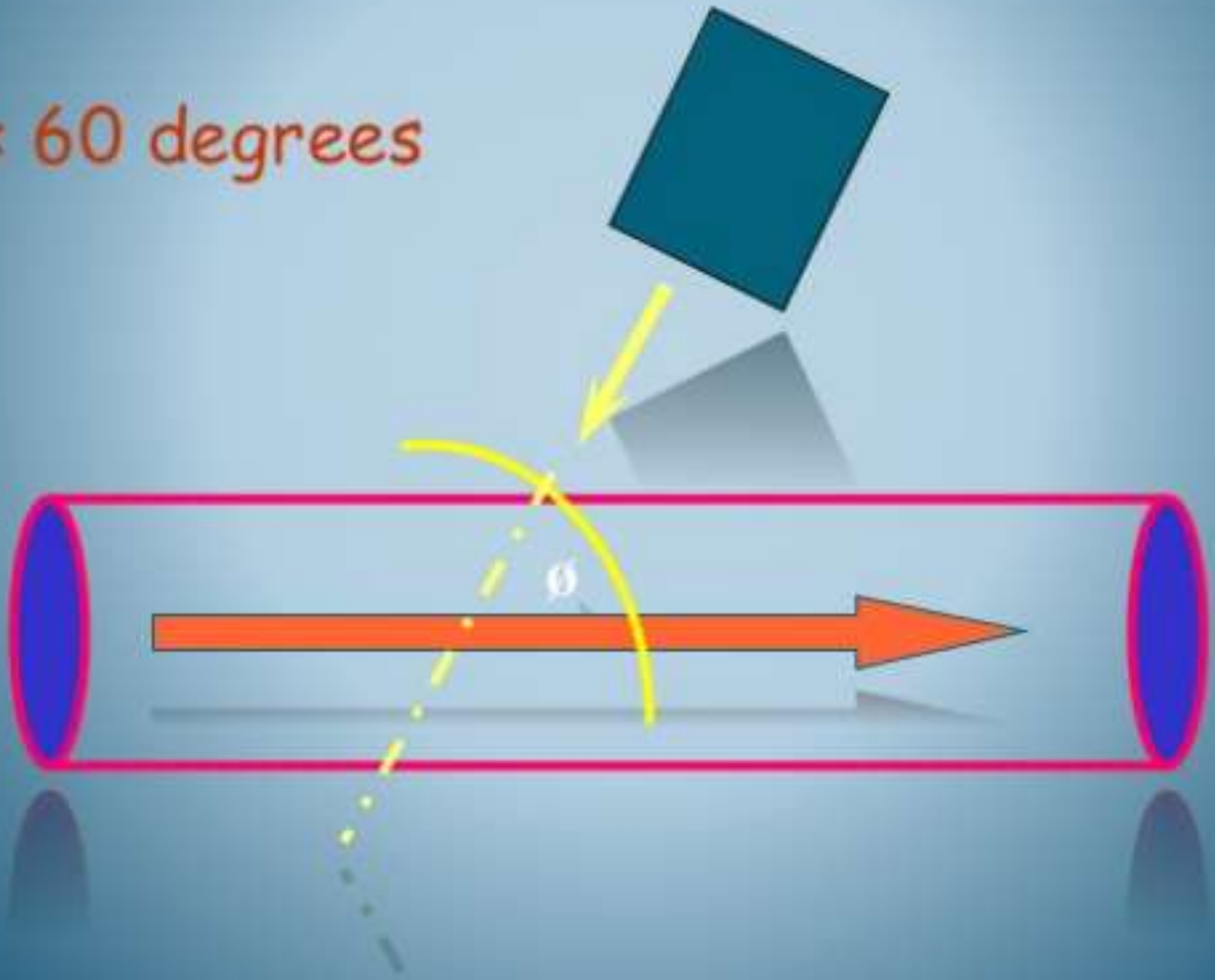
- The ultrasound probe emits an ultrasound wave
- A blood cell moving away from the probe reflects the incoming wave with a longer wavelength
- In reality, there is actually two Doppler shifts. The first one occurs between the probe and the moving blood cell (not shown here) and the second one occurs as the red blood cell reflects the ultrasound.

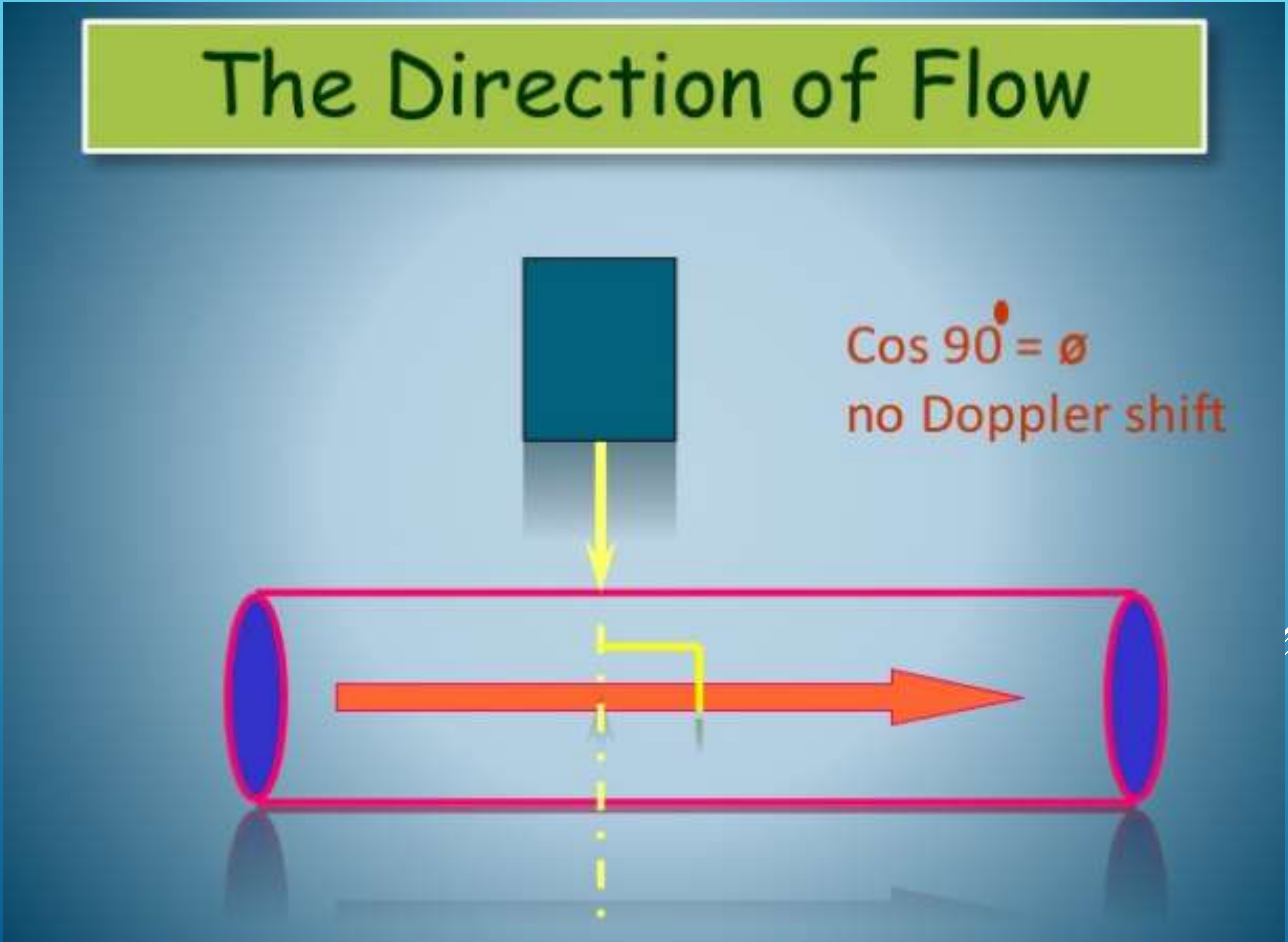
- Now, the blood cell moves towards the probe. It reflects the incoming wave with a shorter wavelength



The Direction of Flow

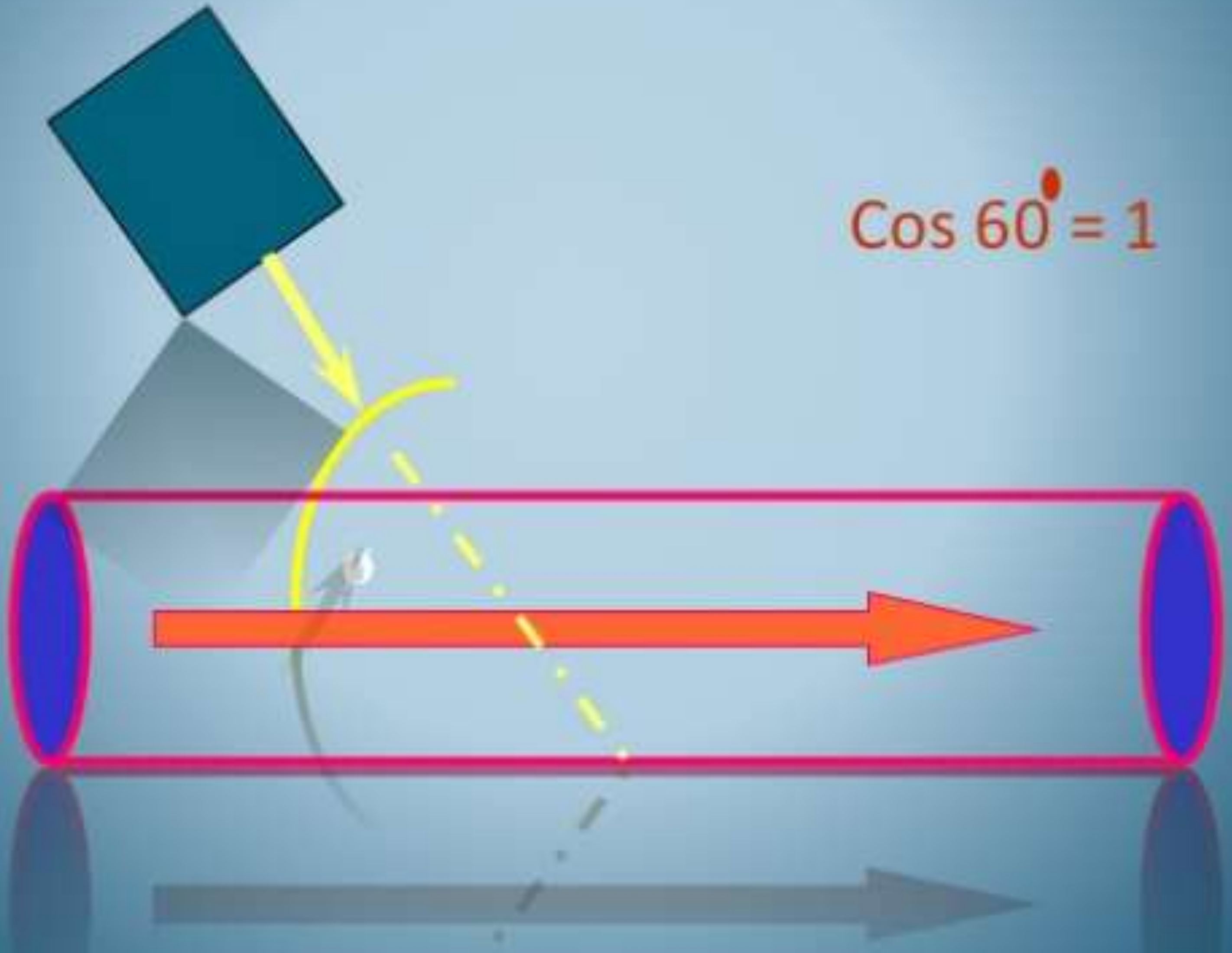
ø < 60 degrees




The Direction of Flow
Cos 90° = ø
no Doppler shift

The Direction of Flow

Cos 60° = 1



Doppler Ultrasound

- Used to monitor heartbeats, blood flow, etc.
- Can produce images showing motion
  - i.e. Imaging beating heart