

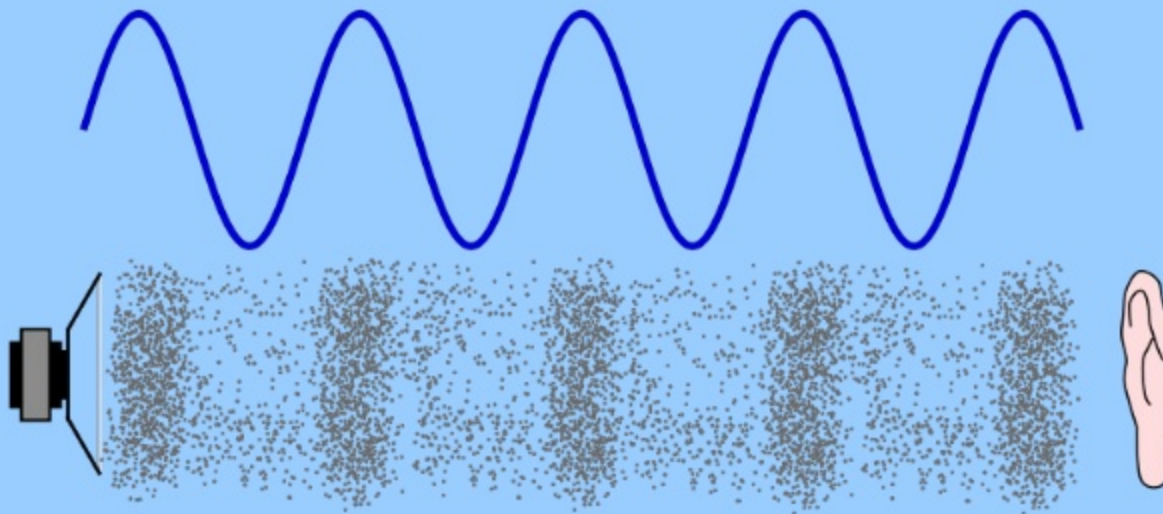
Physics (basics) of Ultrasound

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What is Sound ?

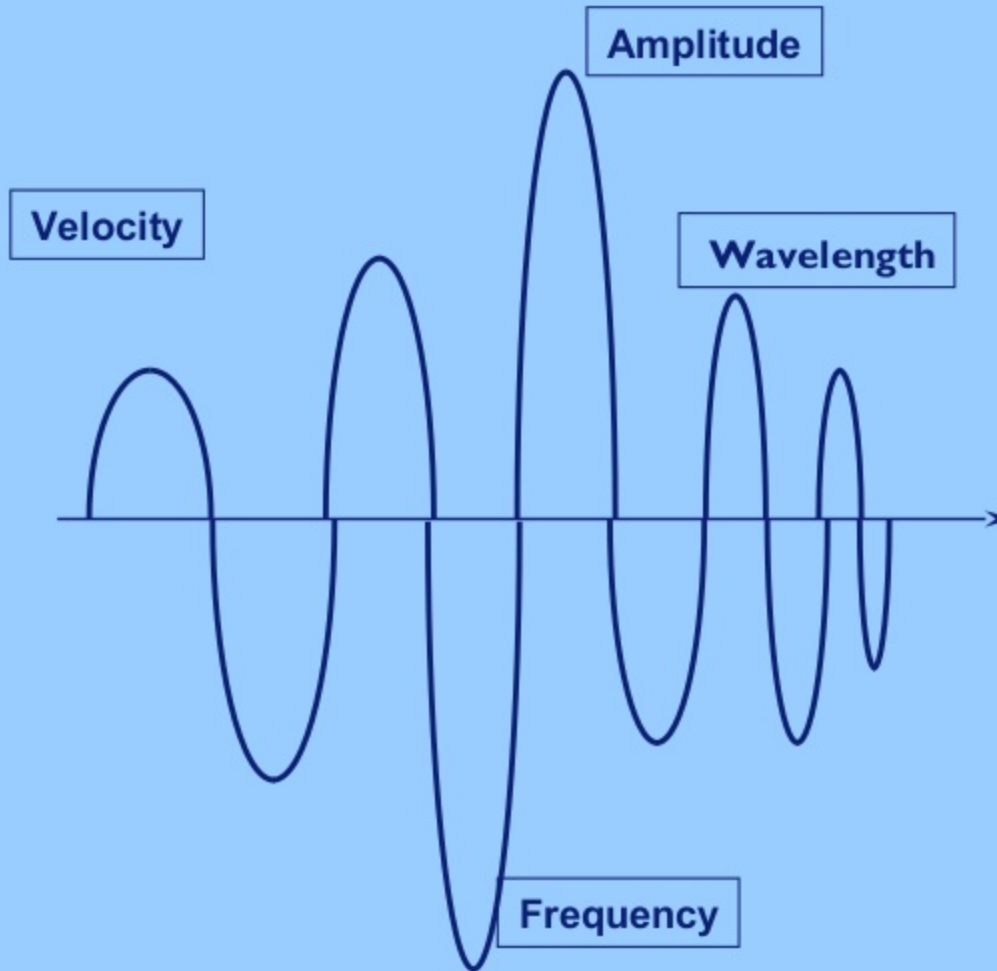
- Mechanical and Longitudinal waves wave that can transfer a distance using a media.
- Cannot travel through Vacuum.



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.

Basic Ultrasound Physics

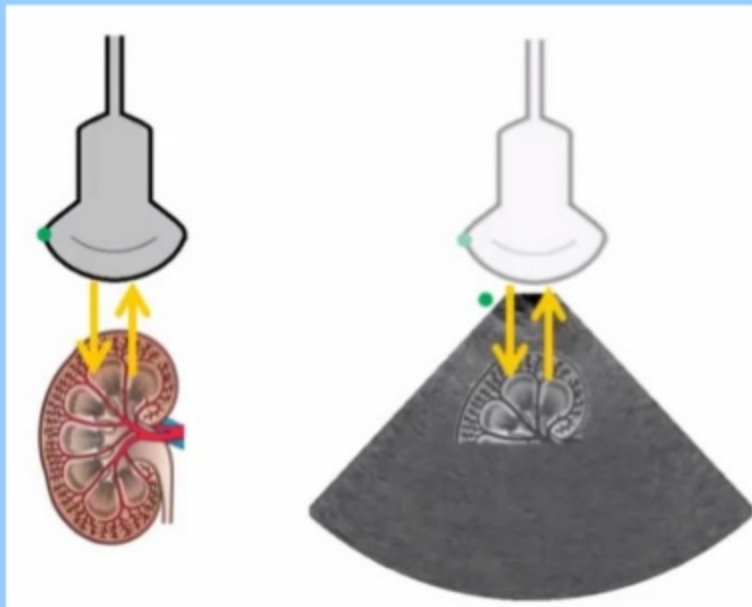


Velocity

- Speed at which a sound wave travels through a medium(cm/sec)
- Determined by density and stiffness of media
 - Slowest in air/gas
 - Fastest in solids
- Average speed of ultrasound in body is 1540m/sec

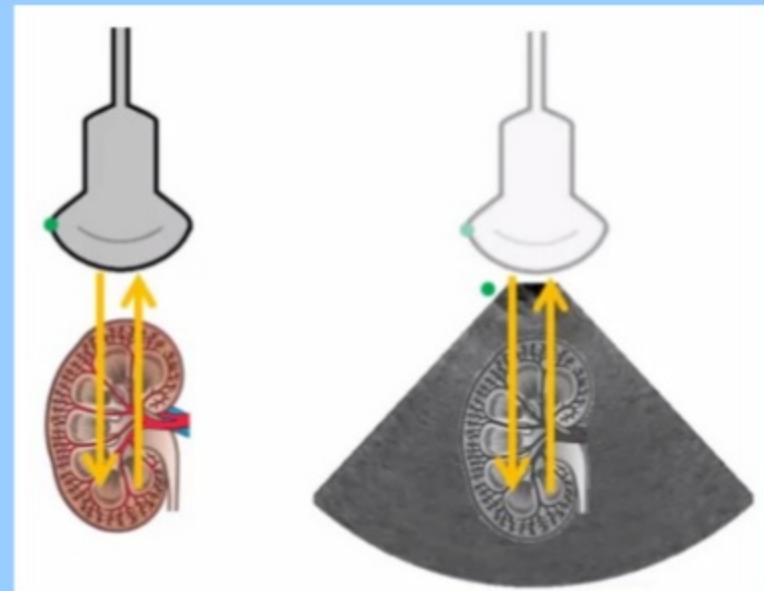
Velocity

Near Field Imaging



Tissues closer appear on top and faster the waves return

Far Field Imaging



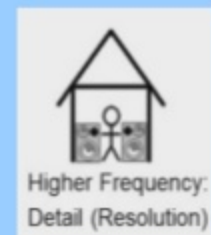
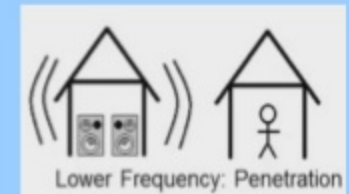
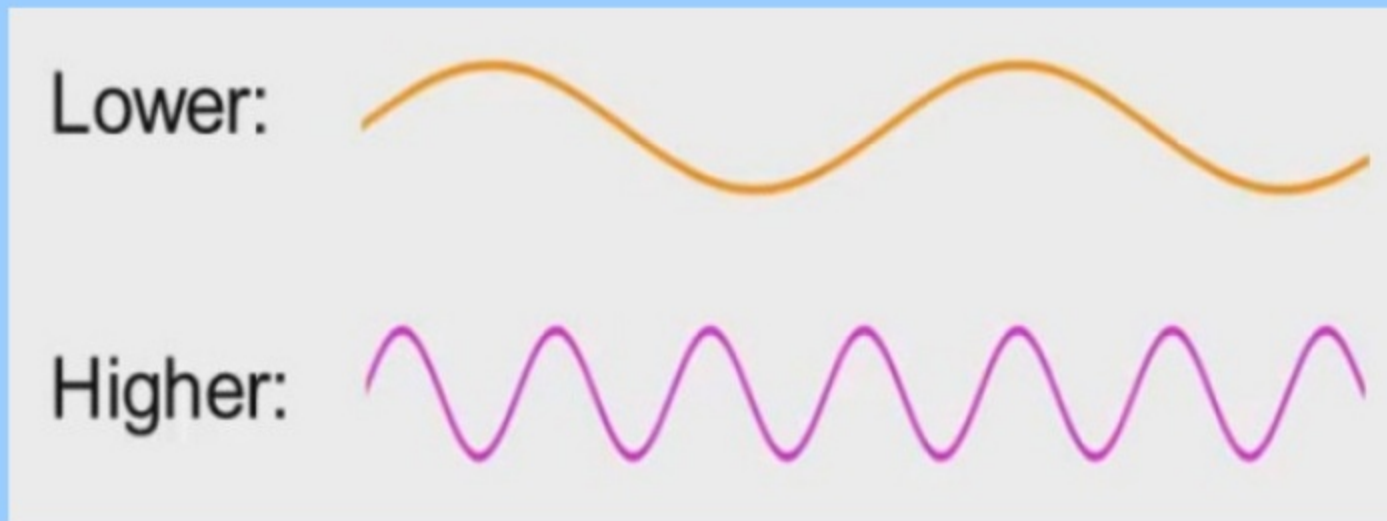
Tissues further appear at the bottom & slower the waves return

Frequency

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

Frequency

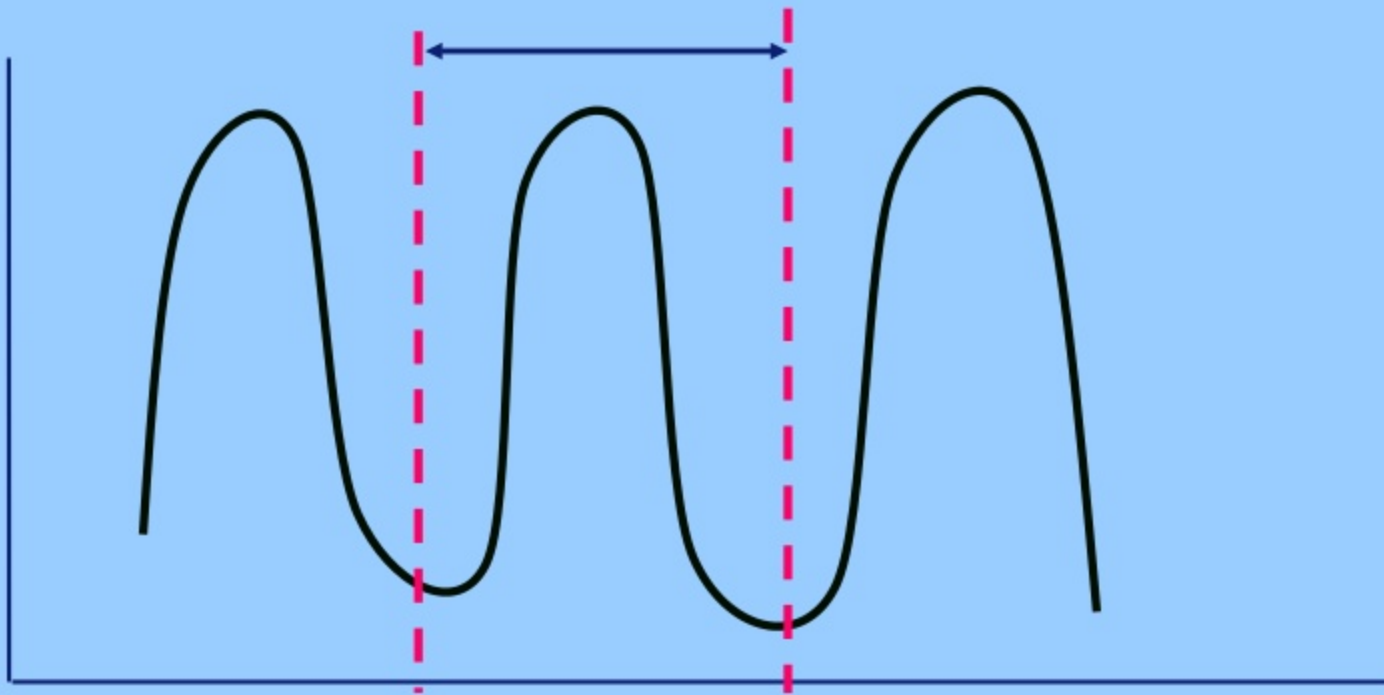
Low the freq higher the penetration and lower the resolution



Higher the freq Lower the penetration and Higher the resolution

Wavelength

- Distance over which one cycle occurs



Velocity (v), Frequency (f), & Wavelength (λ)

- Given a constant velocity, as frequency increases wavelength decreases

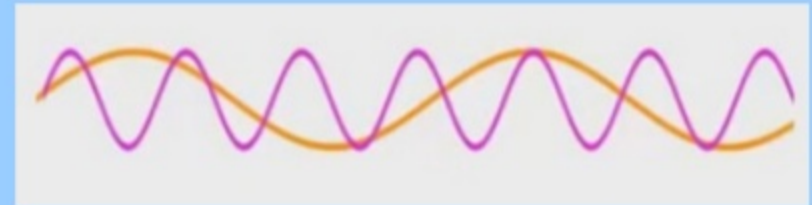
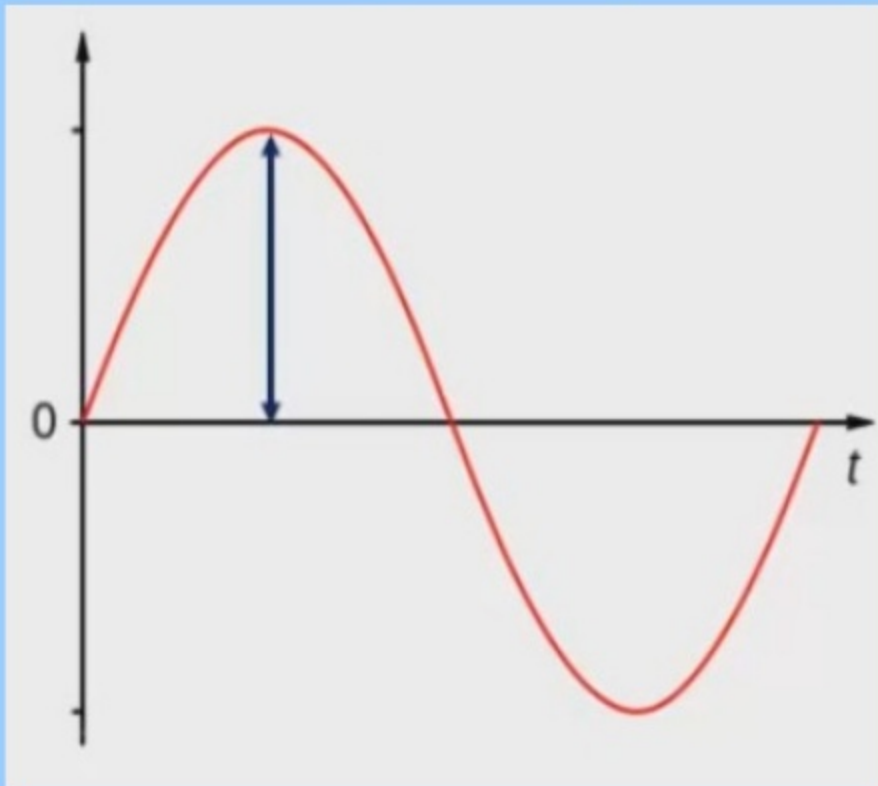
$$V = f \lambda$$

Amplitude

- The strength/intensity of a sound wave at any given time
- Represented as height of the wave
- Decreases with increasing depth

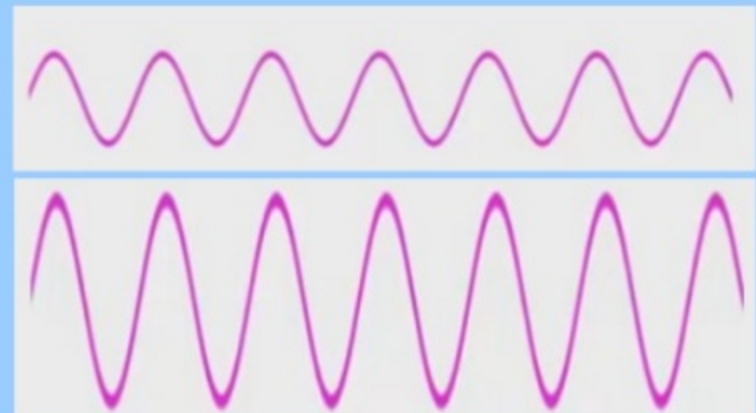
Amplitude

Defines the Brightness of the image



Irrespective of the Freq the Amp remains constant

Returning Waves

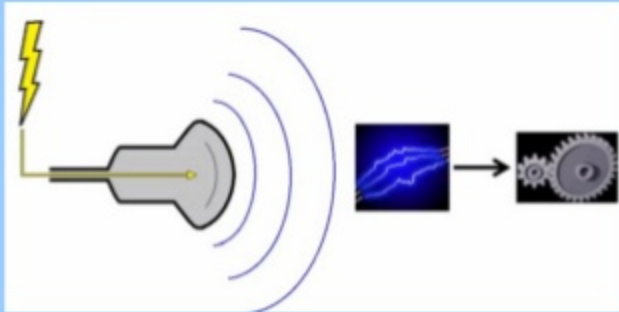


The Higher the Amp the brighter the image and the lower the more darker the images

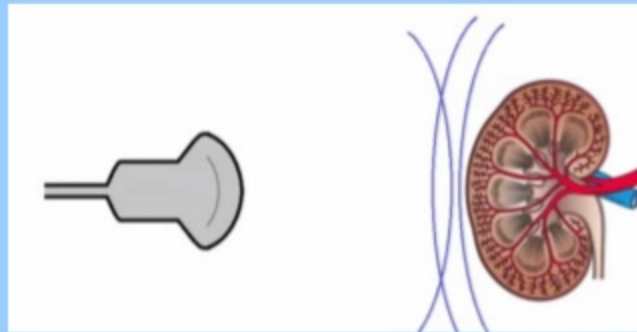
How Ultrasound Works...

- How does an ultrasound machine make an image ?

Piezoelectric Effect of Ultrasound



1. Electrical Energy converted to Sound waves



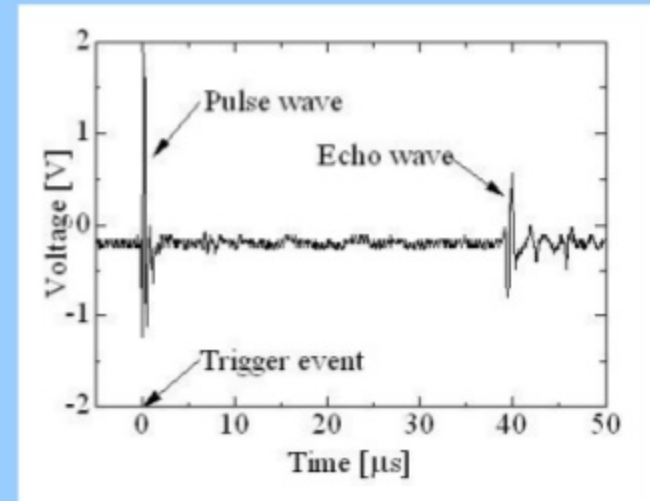
2. The Sound waves are reflected by tissues



3. Reflected Sound waves are converted to electrical signals and later to Image

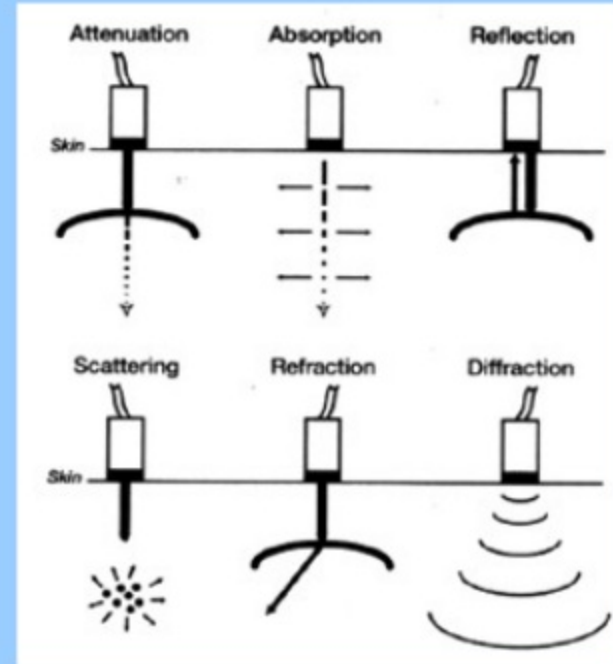
Pulse-Echo Method

- 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



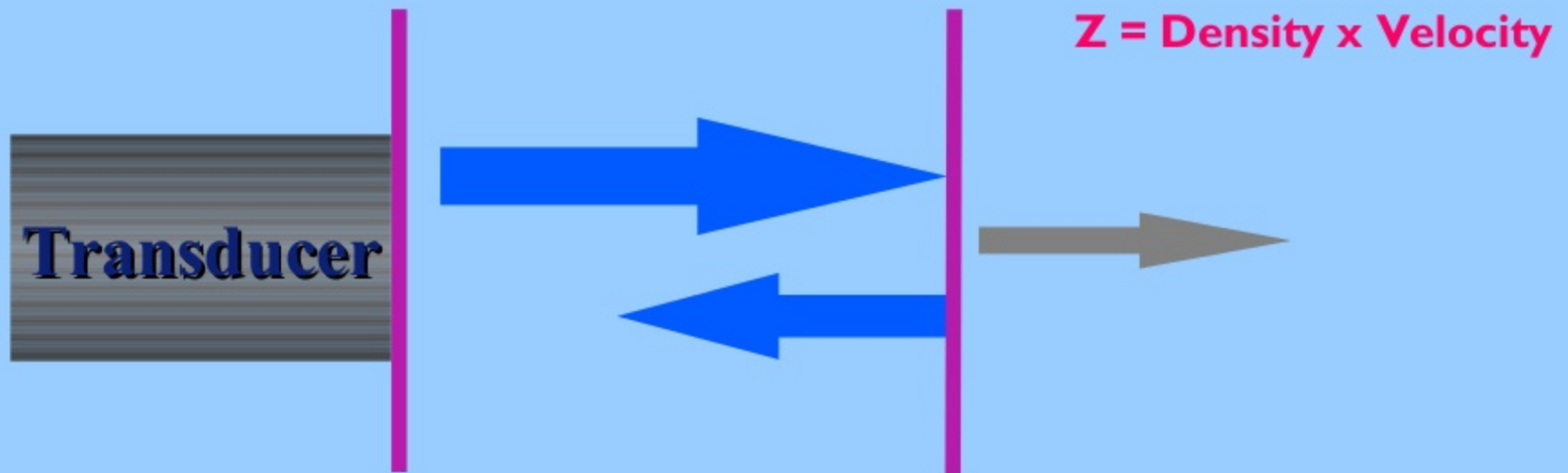
Interactions of Ultrasound with tissue

- Reflection
- Transmission
- Attenuation
- Scattering



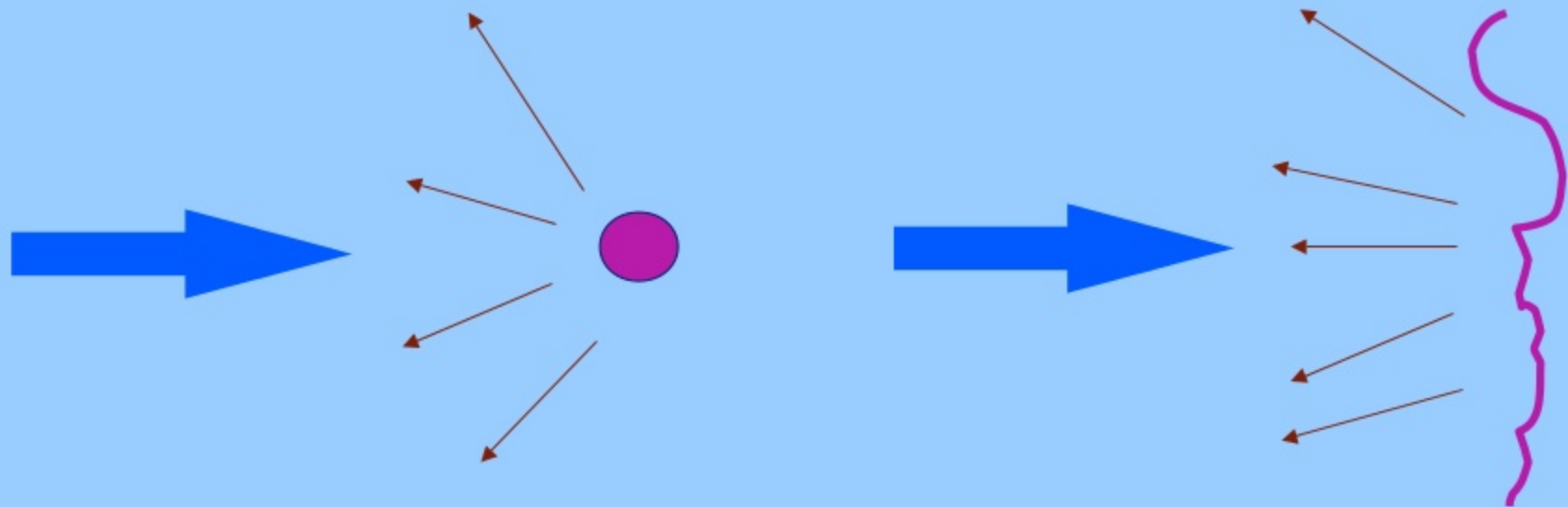
Reflection

- 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



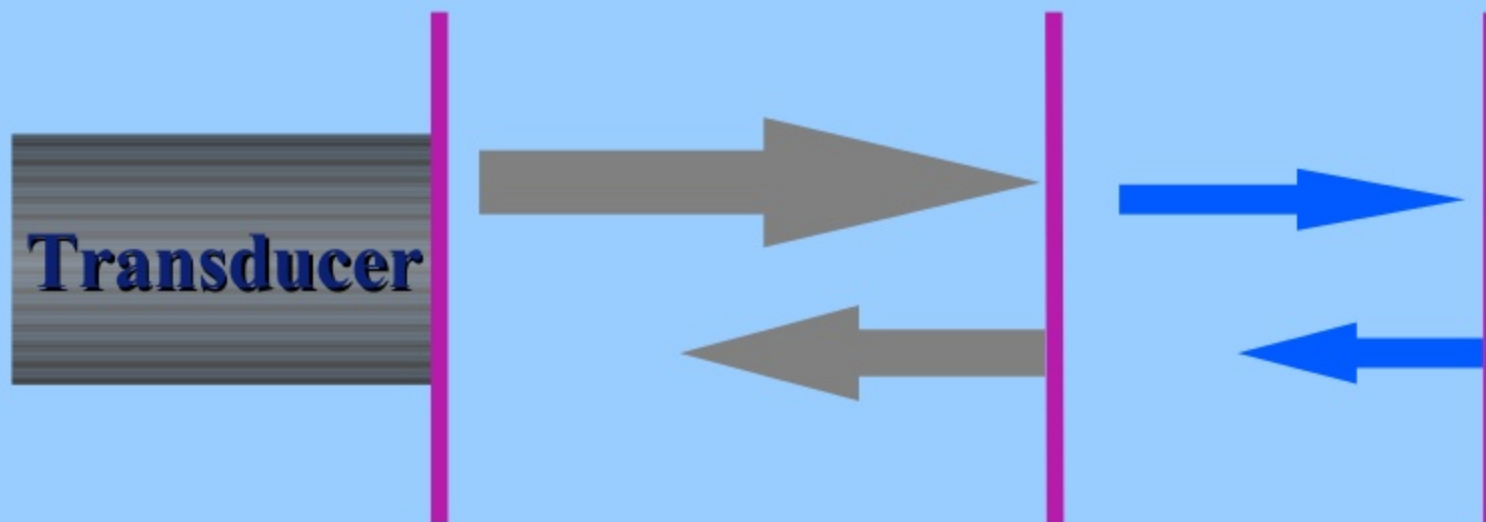
Scattering

- 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

