Acoustic Variables

Pressure (Pascals (Pa)):	concentration of force in an area
Density (km/cm^3):	concentration of mass in a volume
Distance (cm or mm):	refers to the distance a particle moves.

Used to differentiate between the different types of waves (heat, light, sound etc). If one of the 3 variables have rhythmic oscillations then it is a sound waves.

Basic Review

All waves carry what?

> Energy

Sound must travel in a _____ line

> Straight

ALL sound waves are _____ and _____

> Longitudinal and mechanical

Sound (mechanical waves) need a _____ to travel through

> Medium

Molecules in a sound wave are _____ and _____.

> Compressed and rarefied

Acoustic Propagation Properties

> The effect medium has on sound waves.

Bioeffects

> The effects sound waves have on body tissue.

What are 2 types of mechanical waves?

> Transverse and longitudinal.

What is the average speed of sound in soft tissue?

> 1540 m/s OR 1.54 mm

Another word for stiffness is?

> Bulk modulus

Basic Review (cont)

Stiffness and speed are _____ related.

> Directly; increased speed = increased stiffness.

Speed and density are _____ related.

> Inversely; increased speed = decreased density.

Sound travels the same speed no matter what _____.

> Frequency; 5Mhz probe and 15 Mhz probe will travel at the same speed.

Acoustic Parameters

Period (microseconds):	Time it take to complete one cycle.	Source, NO
Frequency (MHz):	# of cycles per second.	Source, NO
Power (Watts):	Rate of energy	Source, YES by adjusting output power.
Intensity (W/cm^2)	Concentration of energy.	Source, YES by adjusting output power.
Amplitude (Pa):	The difference between the baseline and peak of a wave (bigness).	Source, YES by adjusting output power.
Wavelength (mm):	Distance to complete one cycle. (1.54mm/frequency)	Source AND medium, NO

Acoustic Parameters (cont)

Propagation speed (m/s)	How fast a sound wave travels through a medium.	Medium, NO

Used to define characteristics of a continuous wave (wave that is unable to produce an image).

- Period and frequency are reciprocals.
- Frequency is inversely related to period and wavelength.
- Wavelength and period are directly related.
- Propagation speed is determined by stiffness and density.

Intensity

Used to evaluate tissue exposure to sound energy

> Determines the effects sound has on tissue.

Intensity is important when studying what?

> Bioeffects

The strongest intensity is at they _____ of the beam.

> Center/Focus (smallest area).

What intensity is the most important when studying bioeffects?

> SPTA

SPTP is the _____ intensity

> Highest

SATA is the _____ intensity.

> Lowest

ALL intensities have units of?

> W/cm^2 (power/area)

5 Parameters of Pulsed Sound

Pulse duration (microseconds):	Time is takes to complete one pulse.	Source, NO
Spatial Pulse Length (mm):	Distance it takes to complete one pulse.	Source, NO
Pulse Repetition Period (PRP):	Time from the start of one pulse to the start of the next (includes transmit and receiving time).	Source, YES by adjusting depth (Directly related).
Pulse Repetition Frequency (PRF) (kHz):	# of pulses per second.	Source, Yes by adjusting depth (inversely related).
Duty Factor (%):	Percentage of time that the pulse is on.	Source, YES by adjusting depth (inversely related).

Characteristics used to define a pulse wave (wave that is able to produce an image).
- A pulse is made up of multiple cycles.
- 3 out the 5 parameter can be adjusted using depth.

How Sound Travels Through Media

Attenuation

> Decrease in power, intensity, and amplitude due to sound waves decreasing as they propagate through media.

How Sound Travels Through Media (cont)

Distance and attenuation are _____ related.

> Directly; increased distance = increased attenuation.

Frequency and attenuation are _____ related.

> Directly; increased frequency = increased attenuation.

3 processes that contribute to attenuation:

> 1. Reflection 2. Scattering 3. Absorption

2 types of reflection (energy reflected back):

> **1. Specular:** smooth boundary, one direction **2. Diffuse:** irregular border, multiple directions.

Scattering

> Waves redirected in many directions due to small tissue interface; when tissue is < wavelength. Directly related to frequency.

Rayleigh scattering

> When structures are MUCH smaller than the beams wavelength. EX: RBC. Rayleigh scattering = frequency^4. They are directly proportional; increased frequency = increased Rayleigh scattering.

Absorption

> Ultrasonic energy is converted into heat. Directly related to frequency.

Attenuation Coefficient (dB/cm)

> Used to compare the amount of attenuation in certain circumstances. Measured in decibels for when sound travels 1 cm.

Total attenuation = Attenuation coefficient x Distance (cm)

> EX: depth = 5cm AC = 2 dB/cm then total attenuation = 10 dB.

Attenuation Coefficient in soft tissue = frequency/2

How Sound Travels Through Media (cont)

Half layer thickness (penetration depth or half-boundary layer)

> The distance sound travels in tissue that reduces intensity in half; Thin half layer = attenuates more

Impedance (rayls)

> Resistance to sound traveling in a medium. Impedance = density x speed.

Normal incidence

> Sound beam strikes boundary at 90 degrees (orthogonal, perpendicular, right). Reflection occurs if the boundaries have different impedances.

Oblique incidence

> Sound beam strikes at any other angle other than 90 degrees; angle of incidence = angle of reflection.

Incident intensity (%)

> Intensity before striking boundary; incident intensity = reflected intensity + transmitted intensity.

Reflected intensity

> Intensity of sound wave after striking boundary and retuning.

Transmitted intensity

> intensity of sound wave after striking boundary.

Refraction

> Transmission with a bend. Can only occur IF 1. oblique incidence and 2. different propagation speeds of 2 media.