

ARDMS Topic:
Ultrasound Physical Principles

Unit 4: The Five Parameters of Pulsed Sound

Sononerds Ultrasound Physics
Workbook & Lectures

Unit 4: The Five Parameters of Pulsed Sound

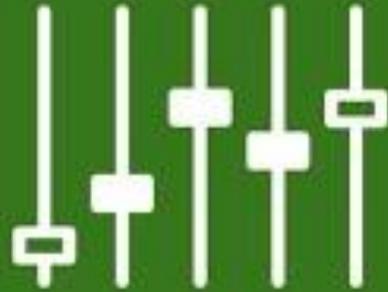
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Unit 4: The Five Parameters of Pulsed Sound

[Entire Unit 4 Lecture:](#)

Sononerds
in the classroom

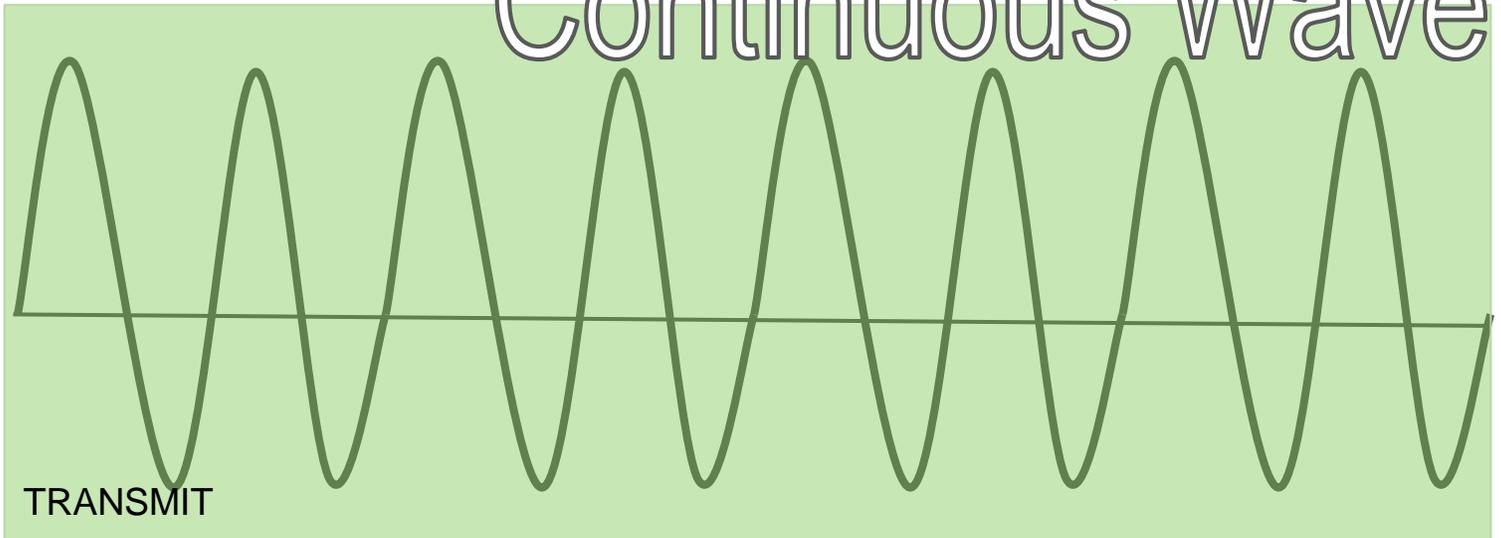


Unit 4: The 5 Parameters of Pulsed Sound

Unit 4: The Five Parameters of Pulsed Sound

Ultrasound uses both continuous waves and pulsed waves, which can be described by the 7 parameters of sound: Frequency, Period, Propagation Speed, Wavelength, Amplitude, Power & Intensity.

Continuous Wave

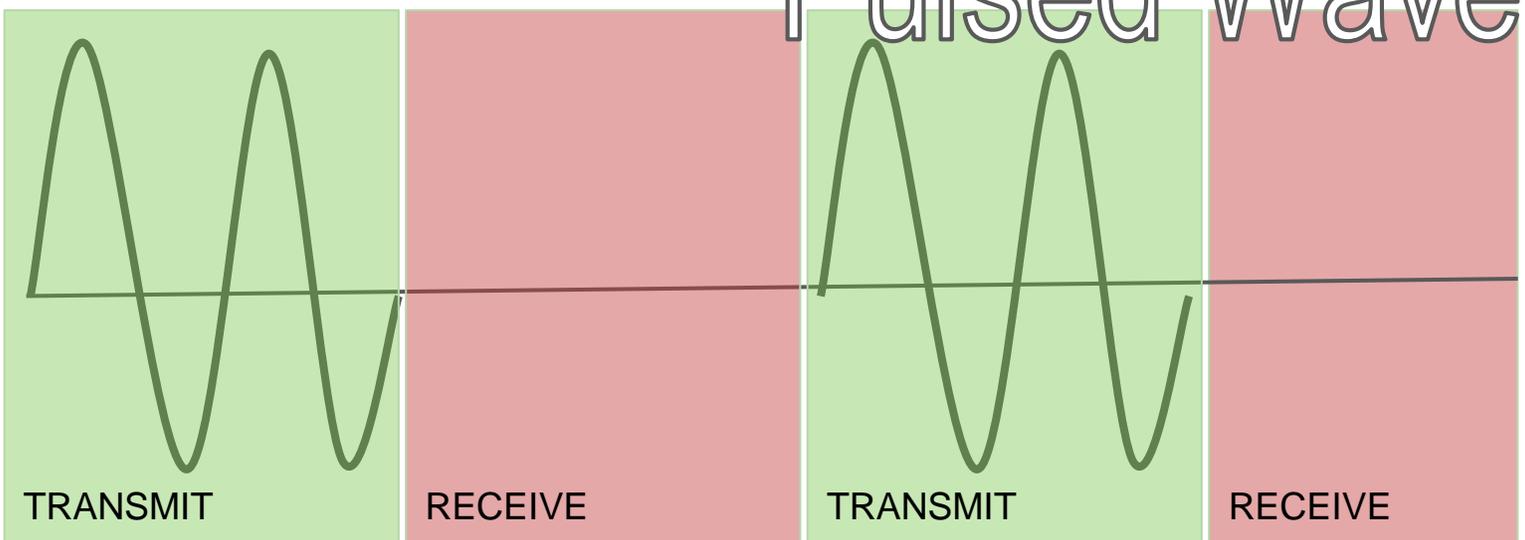


But pulsed waves are the only way an image can be created.

→ **Pulse waves or pulsed sound has a transmit time (when sound is being produced) and a receive time (when the sound is off).**

During the receive time is when the machine can process the echoes and create image information. The transmit time can be thought of as the on-time or talking time. The receive time can be thought of as the off-time or the listening time.

Pulsed Wave



Take a look at this image →

The top one says: "continuous wave ultrasound is kind of like writing in cursive without any spaces or periods. It is all connected and there isn't a way for the brain to read the "picture" without "time" to figure out each word.

The bottom says: " pulsed wave ultrasound sends sound energy out in bursts just like each of the words. You can understand each "pulse" because there is a clear beginning and end.

continuous wave ultrasound is kind of like writing in cursive without any spaces or periods it is all connected and there is no way for the brain to create the picture without time to figure out each word.

pulsed wave ultrasound sends sound energy out in bursts just like each of these words. you can understand each "pulse" because there is a clear beginning and an end.

By having receive time, the machine can process the information from the pulse and create an image.

Just like words are up made of letters, each pulse is made up of cycles, but the **cycles work as a unit and travel together.**

There are five new parameters that we can use to define parts of the pulsed wave which include:

- **Pulse Duration**
- **Spatial Pulse Length**
- **Pulse Repetition Period**
- **Pulse Repetition Frequency**
- **Duty Factor**

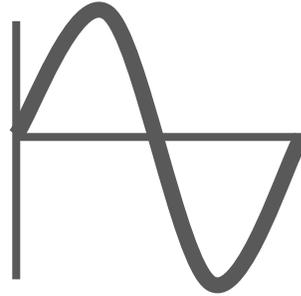
For each of these new parameters, you should also know the definition & synonyms, units, symbol (or common abbreviation), formulas & relationships and how the sonographer impact for each parameter.

Section 4.1 Identifying a Pulse

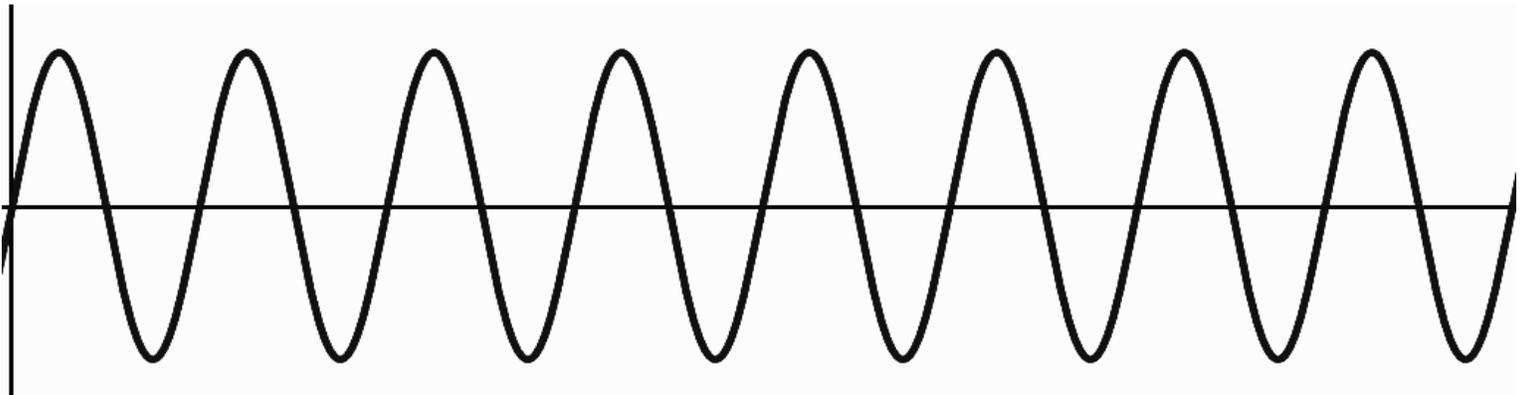
Before we get into the 5 parameters of pulsed sound, let's spend some time defining what a pulse will look like in our studies.

→ **A pulse is made of multiple cycles**

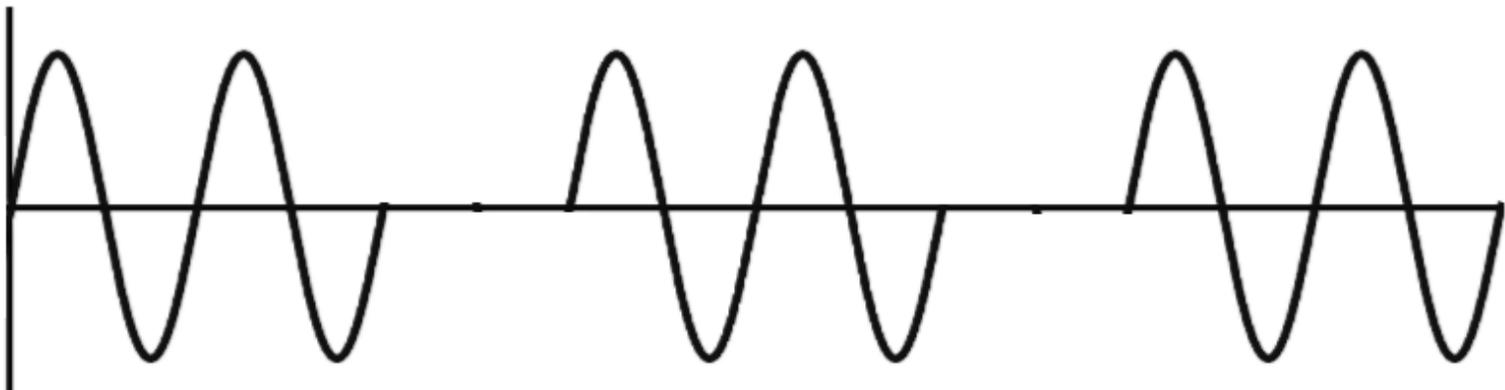
We know that this is one cycle:



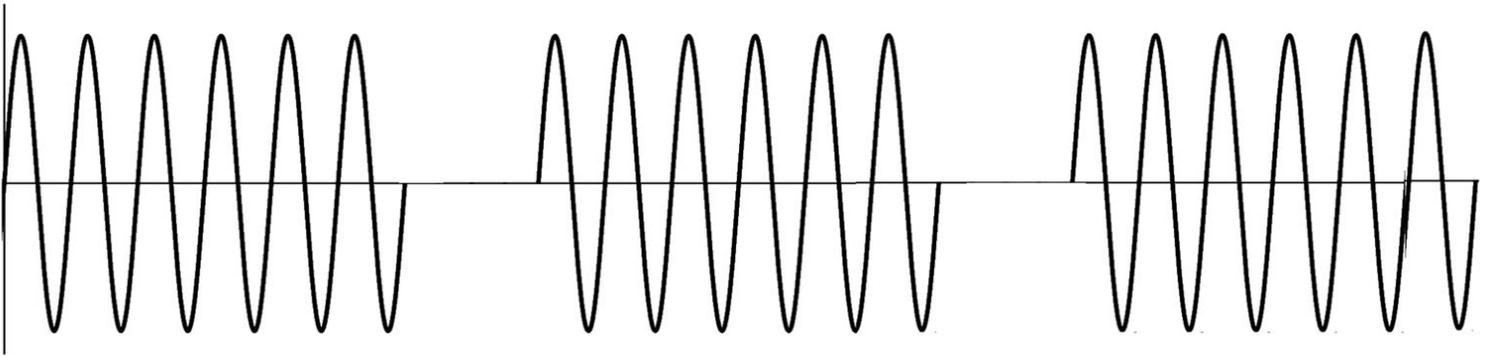
When there is a non-ending string of cycles together, we are looking at a continuous wave, it just keeps going.



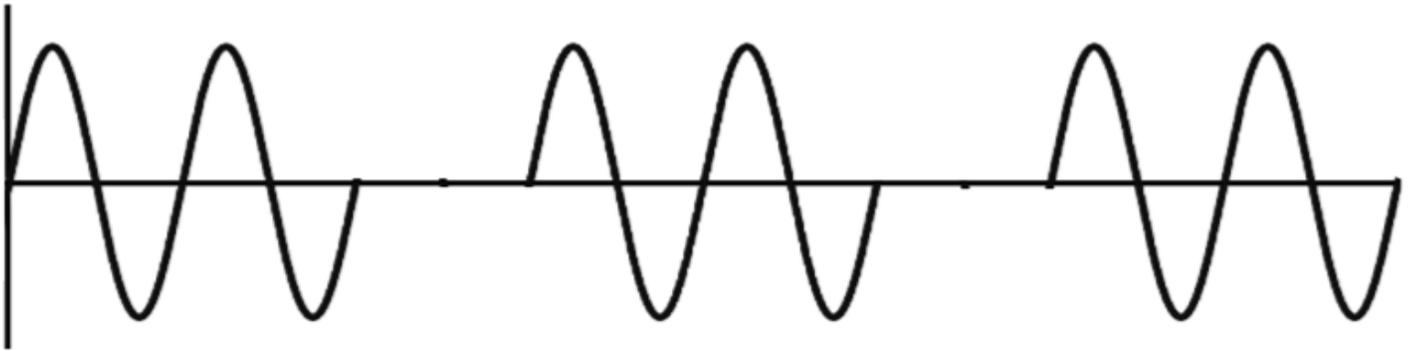
When we have a group of cycles with a clear break, we are looking at a pulse.



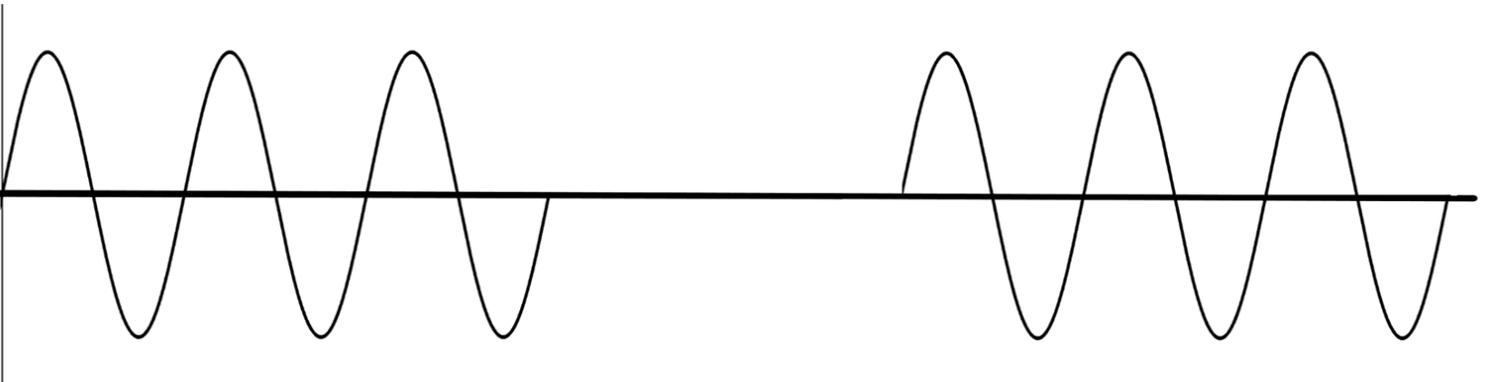
Pulses can have many cycles:



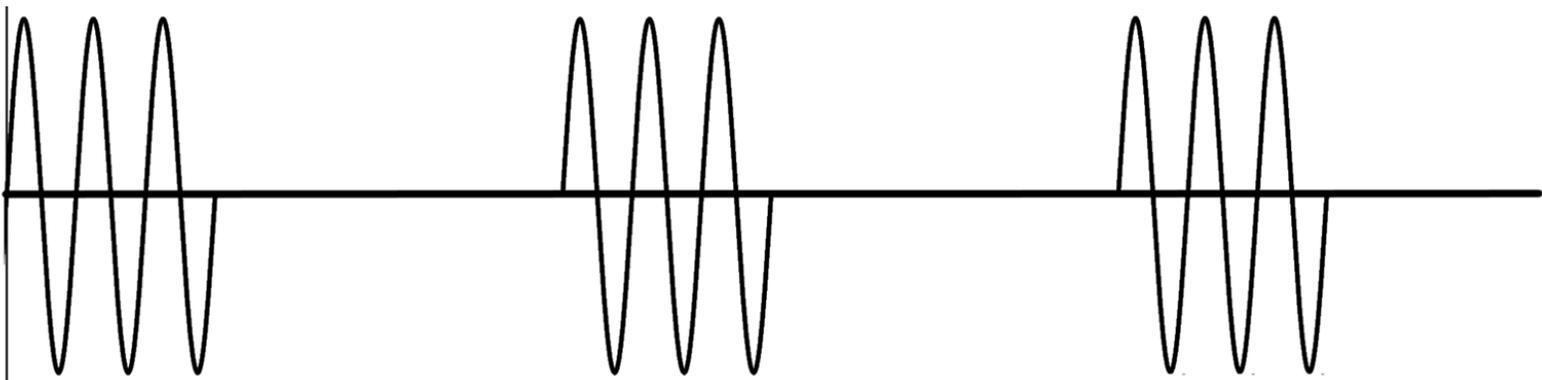
Or few cycles:



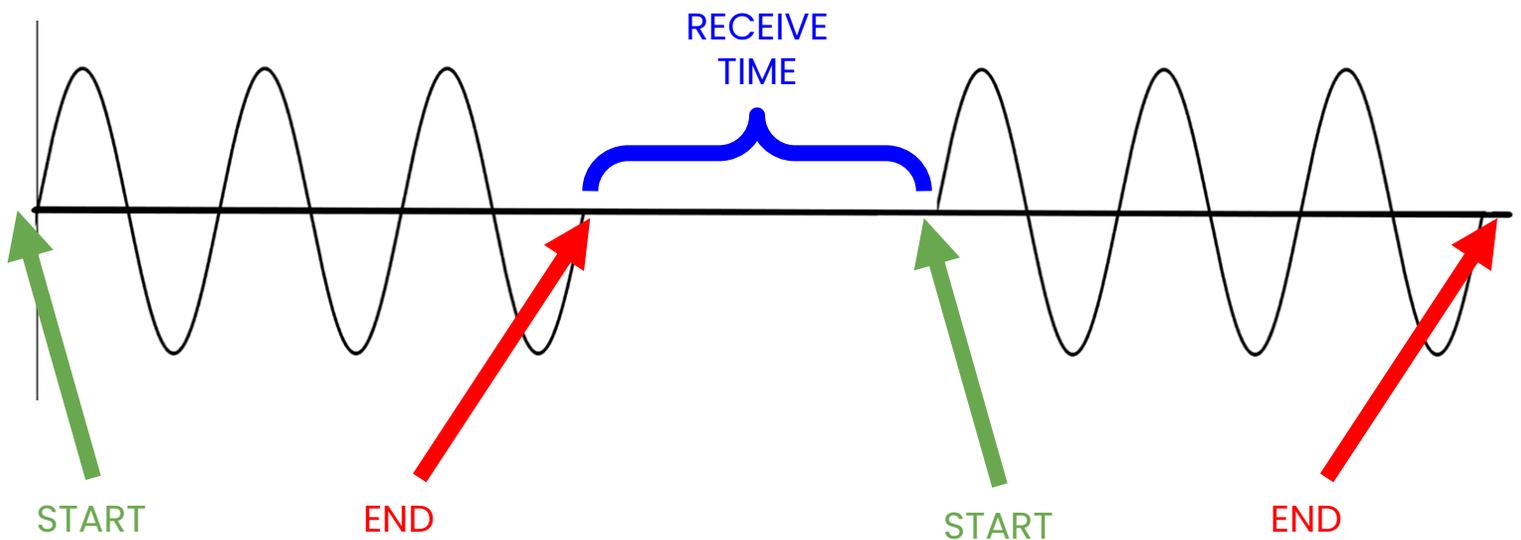
Long wavelengths:



Or short wavelengths:



The important part is that there is a start & end to the pulse, with receive time before the start of the next pulse.



In clinical ultrasound imaging, most machines emit a pulse that has **2 to 4 cycles** to create the grayscale (b-mode) image. When we use Doppler (color or pulsed wave) more cycles are used per pulse.

The most accurate ultrasound pulsed waves have:

→ **Short Pulses**

- ◆ **Fewer cycles**
- ◆ **Short wavelengths**
- ◆ **Short periods**
- ◆ **High frequencies**

→ **Short Receive Time**

- ◆ **Less total imaging depth**

Section 4.2 Pulse Duration

Definition

The **time** it takes to complete one pulse.

Pulse duration is the amount of time it takes for just the transmit time of a pulse.

Common Abbreviation

PD

Units

Microseconds (μs) or any time unit.

Pulse duration is expressed in a unit of time, typically microseconds as it is derived from period and is complementary to the frequency unit of megahertz. The average ultrasound value for pulse duration is 0.3 to 2 microseconds

Formulas

$$PD (\mu s) = \# \text{ cycles} \times T (\mu s)$$

$$PD (\mu s) = \frac{\# \text{ cycles}}{f (MHz)}$$

Relationships

Pulse duration is directly related to the number of cycles in a pulse and time.

If there are more cycles \rightarrow PD time is longer

If there are less cycles \rightarrow PD time is shorter

If period time is long \rightarrow PD time is long

If period time is short \rightarrow PD time is short

Pulse duration is inversely related to frequency.

If frequency is low \rightarrow PD takes more time

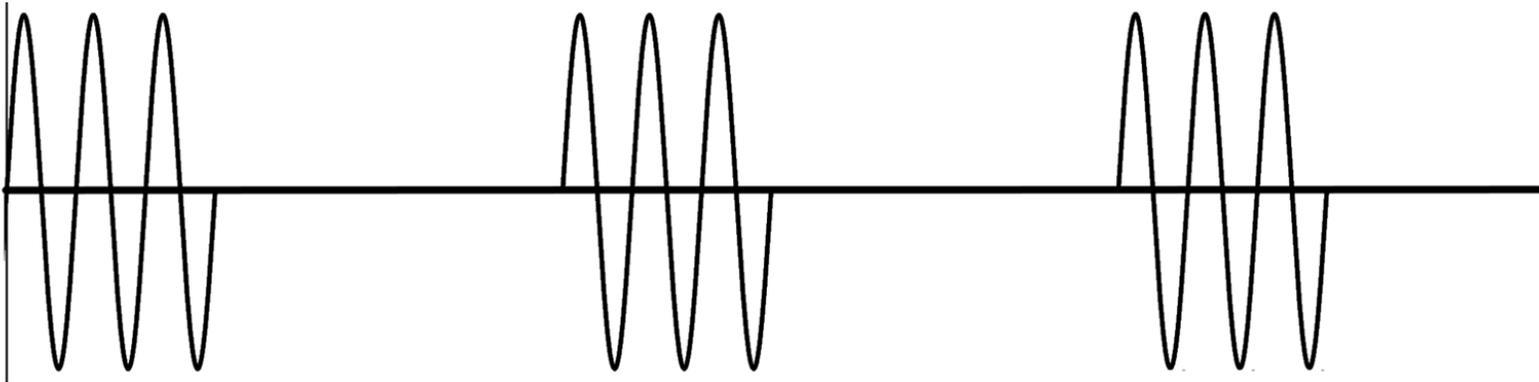
If frequency is high \rightarrow PD takes less time

Sonographer Impact

Pulse duration is determined by the machine and it cannot be changed by the sonographer. We can reason this out knowing the PD is related to period and frequency - both of which are also controlled by the machine and not adjustable.

Pulse duration answers the question:

How long does it take for one pulse to occur?



Using this graph, let's say that this is a pulsed wave traveling in soft tissue. The frequency is 5 MHz.

Let's calculate pulse duration using this equation first:

$$PD (\mu s) = \frac{\# \text{ cycles}}{f (\text{MHz})}$$

To do so, we would count the number of cycles, which is 3 per pulse and divide that by 5 MHz. The Pulse Duration is 0.6 μs

We can also use the other formula: $PD (\mu s) = \# \text{ cycles} \times T (\mu s)$

But we have to calculate the period of the wave first. Remember that period is the reciprocal of the frequency. The reciprocal of 5 MHz is $1/5,000,000$ or 0.2 μs . Now we can again count the cycles (3) and multiply that by the period. $3 \times 0.2 =$ Pulse Duration of 0.6 μs

→ **Pulse duration might sound familiar to period, but it is not period. It is related to period, frequency and the number of cycles in a pulse.**

4.2 Pulse Duration Practice

Using the 2 formulas for pulse duration and your formulas from Unit 3, see if you can fill in this chart. Assume all waves are in soft tissue

# of cycles per pulse	Frequency	Period	Pulse Duration
6	2 MHz		
3	2 MHz		

What happened to pulse duration when the # of cycles decreased?

# of cycles per pulse	Frequency	Period	Pulse Duration
5		0.1 μs	
5		0.3 μs	

What happened to pulse duration when the period increased?

# of cycles per pulse	Frequency	Period	Pulse Duration
2	10 MHz		
2	7 MHz		

What happened to pulse duration when the frequency decreased?

Section 4.3 Spatial Pulse Length

Definition

The **distance** that a pulse takes up in space.

Similar to wavelengths, spatial pulse lengths are distance measurements. If such a ruler existed, we could measure the length, but there are formulas that will help us to calculate the spatial pulse length as well.

Common Abbreviation

SPL

Units

Millimeters (mm) or any length unit

Clinical ultrasound typically has spatial pulse lengths between 0.1 and 1 mm in **soft tissue**.

Formulas

$$SPL (mm) = \# \text{ cycles} \times \lambda (mm)$$

Relationships

Spatial pulse length is directly related to the number of cycles in a pulse and the wavelength of the cycles.

If there are more cycles → SPL gets longer

If there are less cycles → SPL gets shorter

If the wavelength gets longer → SPL gets longer

If wavelength gets shorter → SPL gets shorter

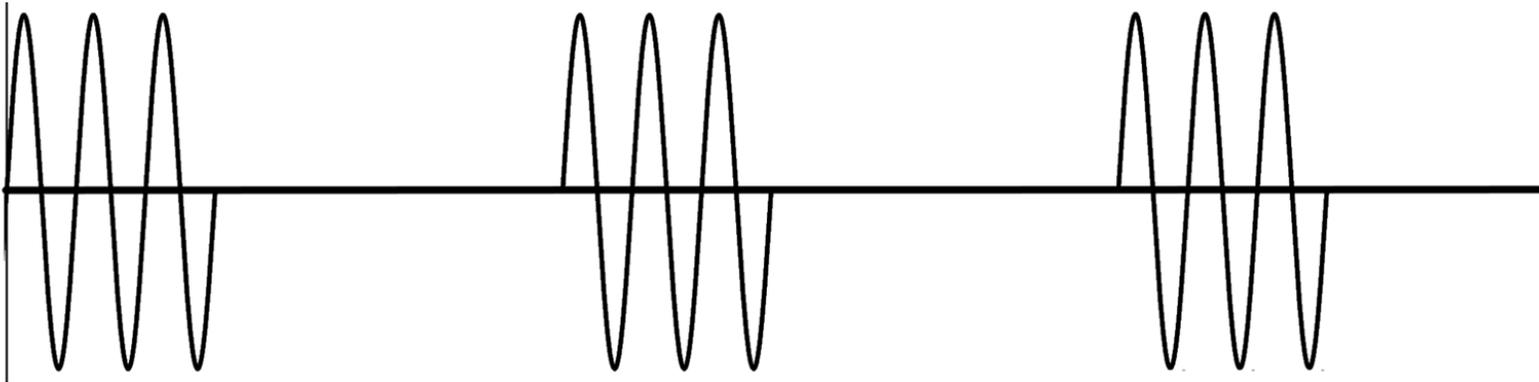
Sonographer Impact

Spatial pulse length is based in part by the wavelength, therefore, spatial pulse length is also determined by the machine and the medium.

An important feature of spatial pulse length is its effect on axial resolution. Shorter SPL = better axial resolution = better detail. This further illustrates that we want the highest frequency possible as high frequencies have short wavelengths, short wavelengths produce short SPLs.

Spatial Pulse Length answers the question:

How much space does one pulse take up?



Using this graph, let's say that this is a pulsed wave traveling in soft tissue. The frequency is 5 MHz.

This is the same example from pulse duration, but now we're going to use the information to calculate a new variable, SPL.

We are going to use our new formula: $SPL (mm) = \# \text{ cycles} \times \lambda (mm)$

We have not been provided the wavelength, but we can calculate it based on the medium and the frequency. Recall the wavelength is equal to propagation speed divided by frequency.

1.54 mm/ μ s divided by 5 MHz equals a 0.31 mm wavelength.

Now we can count the cycles and plug in the 0.31.

3 cycles x 0.31 mm = Spatial Pulse Length of 0.93 mm

4.3 Spatial Pulse Length Practice

Using the formula for spatial pulse length and your formulas from Unit 3, see if you can fill in this chart. Assume all waves are in soft tissue.

# of cycles per pulse	Frequency	SPL
6	2 MHz	
3	2 MHz	

What happened to SPL when the # of cycles decreased?

# of cycles per pulse	Frequency	SPL
5	12 MHz	
5	6 MHz	

What happened to SPL when frequency decreased?

Section 4. 4 Depth Dependent Parameters

To review:

Pulse Duration → machine controlled, cannot be adjusted

Spatial Pulse Length → machine controlled & medium dependent , cannot be adjusted

The depth dependent parameters include:

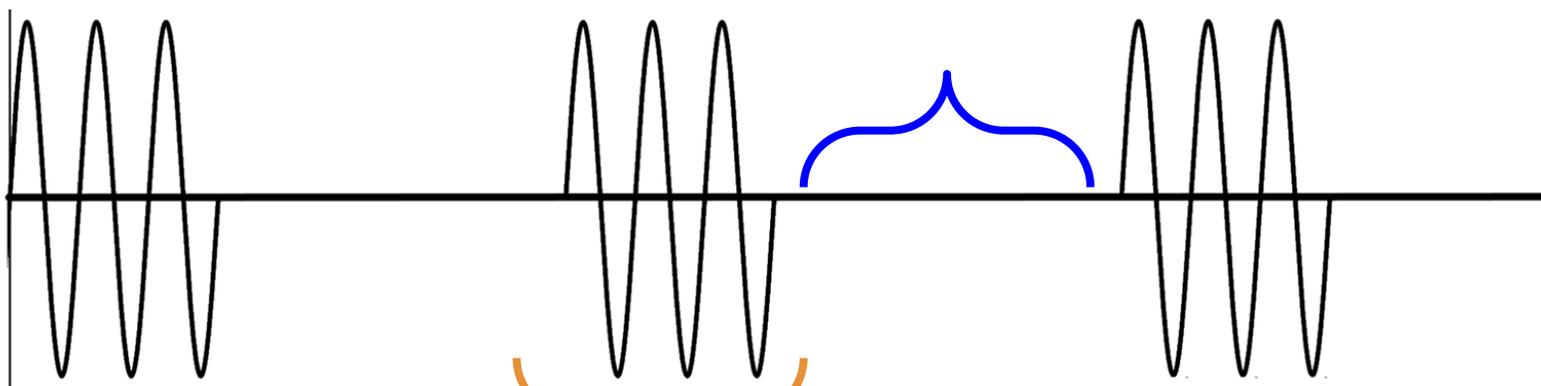
- **Pulse Repetition Period**
- **Pulse Repetition Frequency**
- **Duty Factor**

PRP & PRF have NOTHING to do with period or frequency!

These 3 factor are determined by the machine , BUT the sonographer has control over the imaging depth and therefore can impact the pulse repetition period, pulse repetition frequency and duty factor.

When the sonographer adjusts the depth, the receive time or "off-time" is impacted.

When determining PRP, PRF & DF, the receive time is impacted by depth

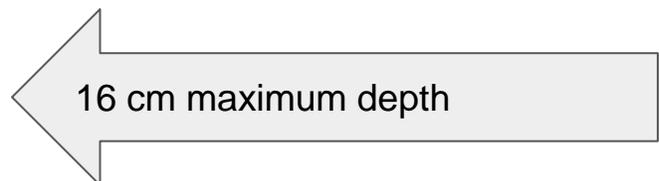
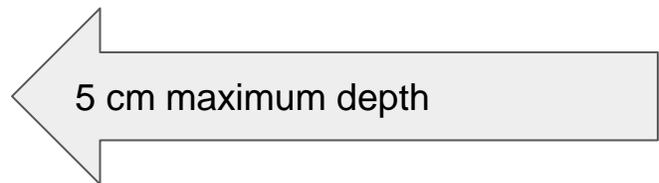
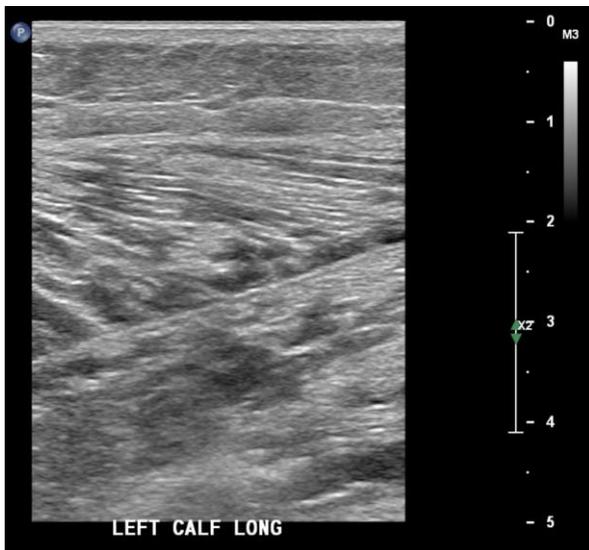
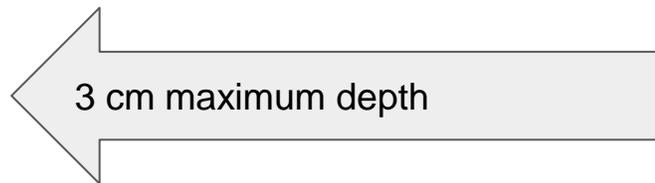


When defining time, PD is determined by source

When defining length, SPL is determine by source & medium

What is the maximum imaging depth?

Along the side of an image is a scale, the scale tells us the depth of an image, typically in centimeters. The maximum imaging depth is the bottom of the field of view. To change the maximum depth, there is a knob or toggle on the machine that will adjust the depth.



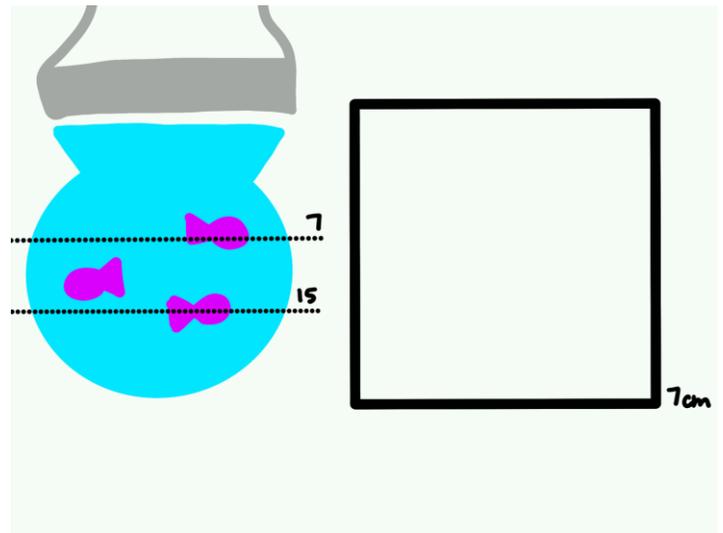
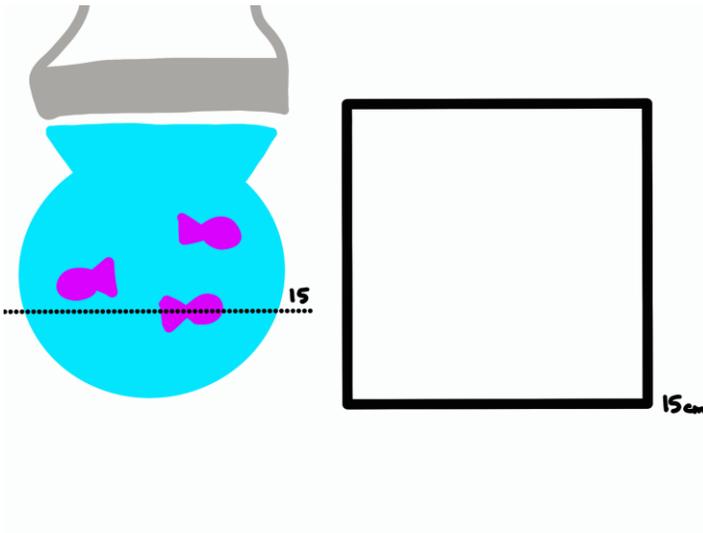
Without getting too far into the physics (yet!), when an image is created a sound pulse is sent into the body. The machine waits for it to travel to the set maximum depth and return to the transducer.

This creates one scan line which is just one tiny bit of the image.

Another pulse is sent, waits, line created and this occurs until the whole image is completed.

The whole reason that PRP, PRF and DF are related to depth is because of the waiting period. The more depth there is, the more waiting that occurs before the next pulse can be sent.

Watch these two image being created for a while. You will see that the image set to 7 cm max depth can create more images in a set amount of time compared to the depth of 15 cm.



4.4.1 Pulse Repetition Period

Definition

The **time** from the start of one pulse to the start of the next pulse.

Pulse duration was *only* the time of the pulse. Pulse repetition period defines the transmit time (PD) + receive time. Pulse repetition period has NOTHING to do with the period of the wave.

Common Abbreviation

PRP

Units

Microseconds (μs) or any time unit.

Pulse repetition period is dependent on the depth of the image, so the time can vary greatly, but averages between $13 \mu\text{s}$ (depth at 1 cm) and $260 \mu\text{s}$ (depth at 20 cm).

Formulas

$$PRP \times PRF = 1$$

$$PRP = \frac{1}{PRF}$$

$$PRP(\mu\text{s}) = 13 \mu\text{s} \times \text{depth (cm)}$$

Relationships

Pulse repetition period is a reciprocal of pulse repetition frequency.

If PRF gets lower \rightarrow PRP get longer

If PRF gets higher \rightarrow PRP gets shorter

Pulse repetition period is directly related to depth.

If the maximum imaging depth is deep \rightarrow PRP is long

If the maximum imaging depth is shallow \rightarrow PRP is short

Sonographer Impact

The sonographer can change the PRP by changing the depth. Shallow depths reduce the PRP where deeper depths will increase it.

Sonographer should adjust imaging depth to area of interest to minimize the PRP and improve the temporal resolution.

4.4.2 Pulse Repetition Frequency

Definition

The **number of pulses per second** a system can send.

Pulse repetition frequency tells us how many times a pulse can be sent into the body per second. If pulses are sent very quickly, then full images are created very quickly, but when the maximum depth is really deep, the longer the waiting, which means the longer it takes to create a full image.

Common Abbreviation

PRF

Units

Kilohertz (kHz) or a derivative of Hz

Since we are looking at a per second unit, hertz is our go to, but the speed at which ultrasound typically sends pulses make kilohertz the better unit. Average PRF in ultrasound is 1 to 10 kHz.

Formulas

$$PRP \times PRF = 1$$

$$PRF = \frac{1}{PRP}$$

$$PRF(\text{hz}) = \frac{77,000 \text{ cm/s}}{\text{depth (cm)}}$$

Relationships

Pulse repetition period is a reciprocal of pulse repetition frequency.

If PRP gets longer → PRF gets lower

If PRP gets shorter → PRF gets higher

Pulse repetition frequency is inversely related to depth

If the max imaging depth is deep → PRF is low

If the max imaging depth is shallow → PRF is high

Sonographer Impact

The sonographer can change the PRF by changing the depth. Shallow depths allow for more pulses per second, where deep depths reduce the number of pulses per second.

Sonographer should adjust imaging depth to area of interest to minimize the PRF and improve the temporal resolution.

4.4.3 PRP & PRF

→ **PRP and PRF are reciprocals**

Essentially, if one increases, the other must decrease and vice versa.

→ **The pulse duration is what it is, that cannot be changed.**

→ **When depth changes, the listening time changes.**

If we increase the listening time (increases PRP) that means we can't get as many pulses out during the time frame of one second (decreases PRF).

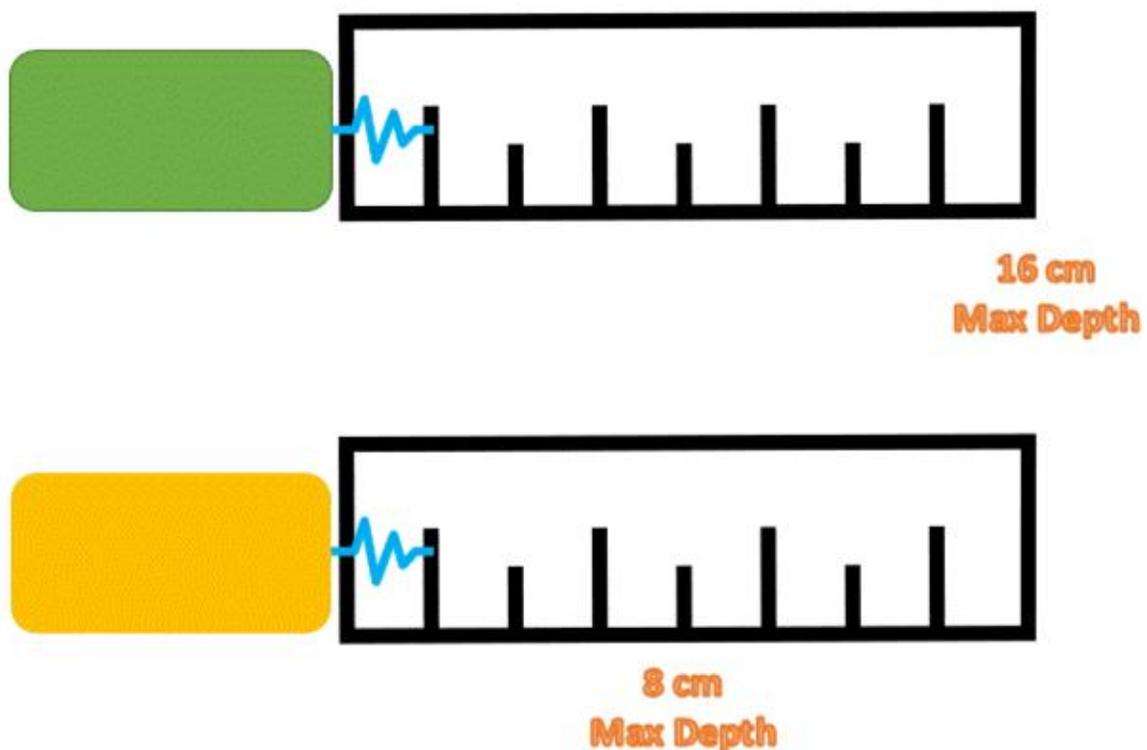
Increasing the listening time comes with increasing the depth.

The opposite is true then too, with less listening time (decreases PRP), more pulses can be emitted in one second, therefore raising the PRF. Decreasing the listening time comes with decreased depths.

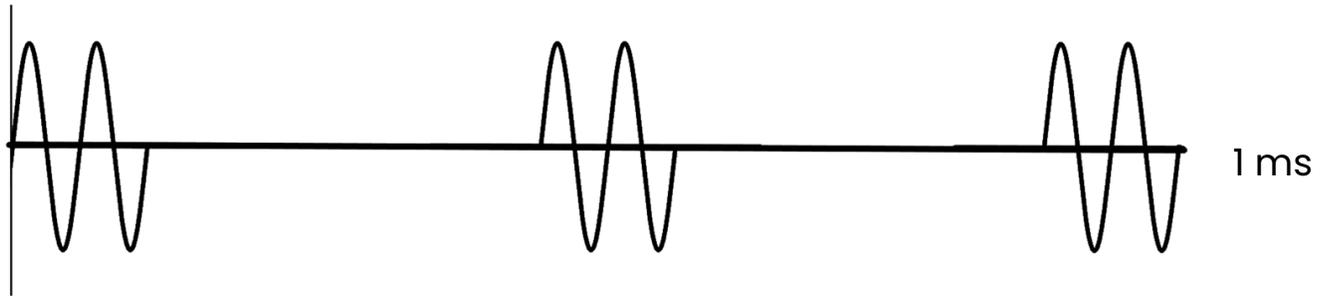
The Pulse Duration, Frequency, Period, Propagation Speed, SPL and wavelength are the same for the green and yellow transducers below.

The green transducer is imaging to a deeper max depth. Therefore it has a LONG listening time which means increased PRP and decreased PRF.

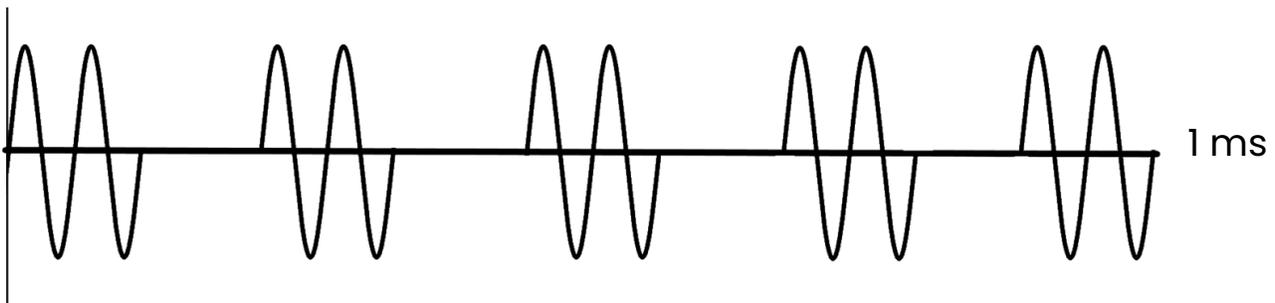
The yellow transducer is imaging to a shallower max depth. Therefore it has a SHORT listening time which means decreased PRP and increased PRF.



Let's say that both these pulsed waves are traveling in soft tissue with a frequency of 5 MHz. These are snapshots of the wave for a 1 millisecond time frame. What is the PRP & PRF?



Knowing that this is occurring over 1 millisecond, we can count the pulses and know that our PRF is 3 kHz. (3 pulses per millisecond). The PRP is the reciprocal ($\frac{1}{3}$) or 0.33 ms.



We can do the same thing for this wave. There are 5 pulses, so this wave has a PRF of 5 kHz (5 pulses per millisecond). The PRP then is the reciprocal ($\frac{1}{5}$) or 0.2 ms.

Since these are the same PD, SPL, Frequency and Wavelength, we know that the first wave is imaging to a deeper max depth and the second wave is imaging to a shallow max depth. In fact using the other PRP or PRF formula, the first wave is imaging to a max depth of 26 cm and the second wave is imaging to a max depth of 15 cm. Bonus...can you figure out the Pulse Duration? We'll need it later.

4.4.4 Duty Factor

Definition

The **percentage** of time that the machine is transmitting.

In pulsed wave ultrasound, there is the on-time and the off time. Duty factor is the fraction of on-time (PD) divided by the on- and off-time. It helps to quantify the percentage of time a patient is being exposed to ultrasound energy.

Common Abbreviation

DF

Units

No Unit!! DF is a percentage!

Average value of DF in ultrasound is <1 % when imaging in grayscale, but can vary from 1-10% when using Doppler. Continuous wave ultrasound has a DF of 100%.

Formulas

$$DF (\%) = \frac{PD (\mu s)}{PRP (\mu s)} \times 100$$

Relationships

Duty factor is directly related to pulse duration..

If the PD get longer → DF increases

If the PD gets shorter → DF decreases

Duty factor is inversely related to PRP.

If PRP get longer → DF decreases

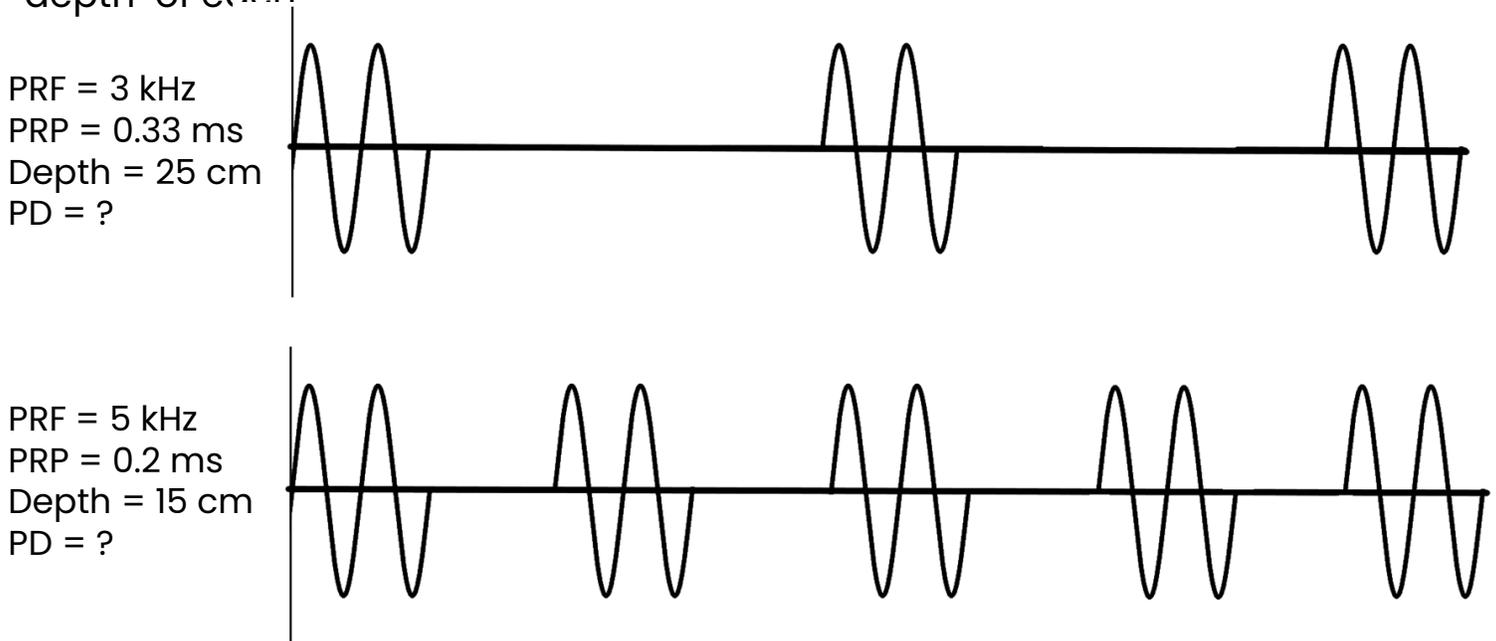
If PRP gets shorter → DF increases

Sonographer Impact

Duty factor is determined by the machine based on the pulse duration, but the sonographer can change the DF by changing the depth. Less depth means more on time, means higher duty factor.

→ **Duty factor is also related to depth because of its relationship to PRP.**

We saw the two waves below earlier. Both these pulsed waves are traveling in soft tissue with a frequency of 5 MHz. These are snapshots of the wave for a 1 millisecond time frame. We already calculated the PRP & PRF and imaging depth of each



Visually, we can see that the one with the higher PRF, lower PRP and less depth is on more, so its duty factor has to be increased. But we can mathematically prove it too. We just learned the the formula for DF is :

$$DF (\%) = \frac{PD (\mu s)}{PRP (\mu s)} \times 100$$

But unless you calculated PD already, we're missing that information. To calculate PD, we can take the # of cycles and divide it by the frequency. Since pulse duration is NOT affected by depth, both waves have a PD of 0.4 μ s or 0.0004 ms.

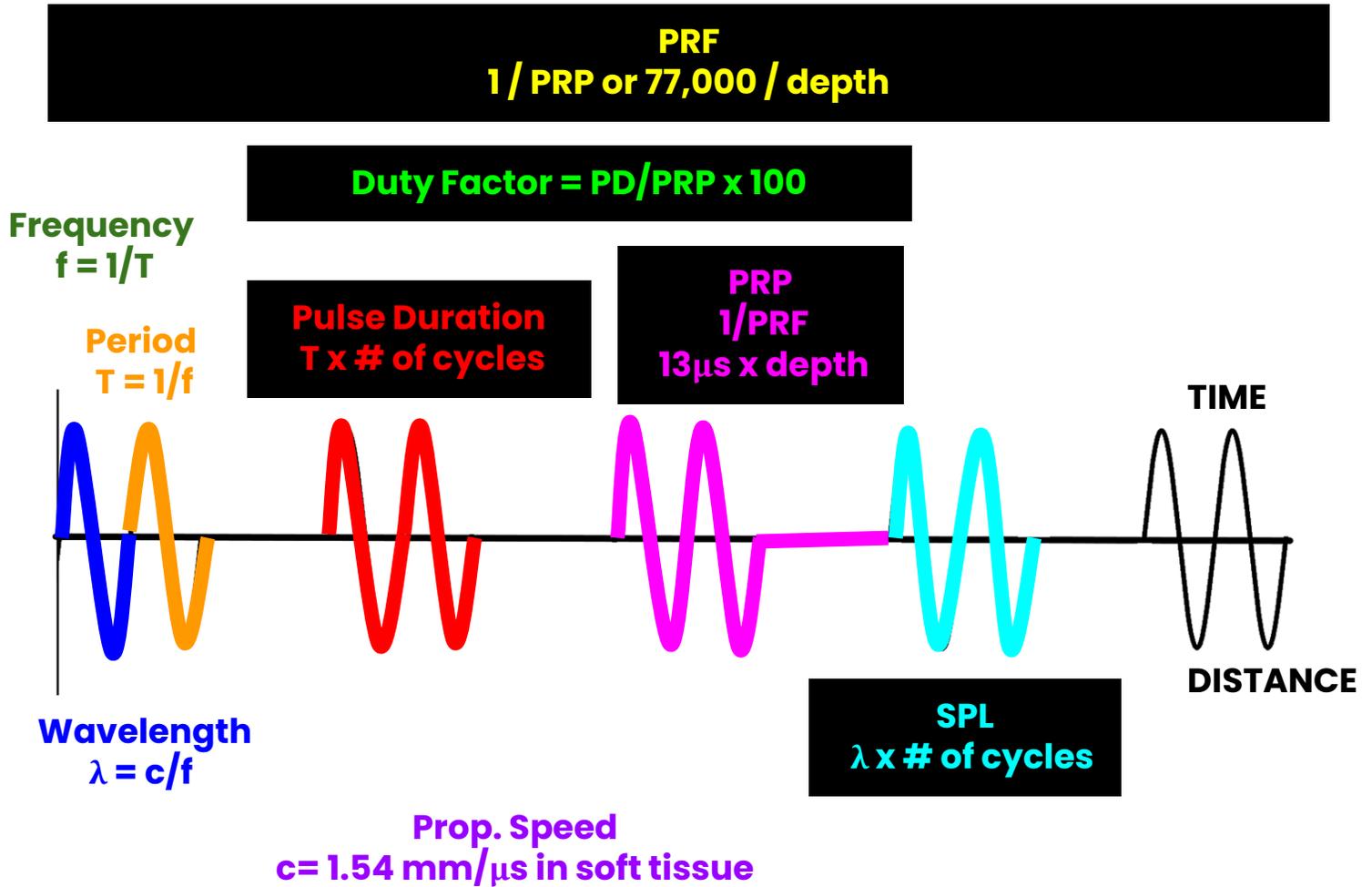
To use our DF formula correctly, we need to convert PRP and PD into the same unit. Since I've already done that with PD, we can plug in our numbers.

The top wave is $0.0004 \text{ ms} / 0.33 \text{ ms} = 0.0012 \times 100 = 0.1\% \text{ DF}$

The bottom wave is $0.0004 \text{ ms} / 0.002 \text{ ms} = 0.002 \times 100 = 0.2\% \text{ DF}$

The wave that has more transmit time has a higher DF. More transmit time occurs when there is shallow imaging.

Section 4.5 Summary & Practice



Parameters that describe continuous & pulsed waves	Parameters that <u>only</u> describe pulsed waves
Frequency	Pulse Duration
Period	Spatial Pulse Length
Propagation Speed	Pulse Repetition Period
Wavelength	Pulse Repetition Frequency
Amplitude	Duty Factor
Power	
Intensity	

 Short Pulse Duration	Long Pulse Duration
Few cycles in pulse	Many cycles in pulse
Short Periods	Long Periods

TIME

 Short Spatial Pulse Lengths	Long Spatial Pulse Lengths
Few cycles in pulse	Many cycles in pulse
Short wavelengths	Long wavelengths

DISTANCE

 Shallow Imaging	Deep Imaging
Less off-time	More off-time
Short PRP	Long PRP
High PRF	Low PRF
High DF	Low DF

 Typically provides superior image detail

Duty Factor %	Machine Status
0 %	Off
< 1%	2-D Imaging
1-10%	Doppler Imaging
100%	Continuous Wave

Duty Factor %

- Controlled by machine
- Changes when depth changes
- Unitless
- Fraction of on-time
- $DF = PD / PRP \times 100$

PRP (μs) & PRF (Hz)

- Controlled by machine
- Changes when depth changes
- Reciprocals
- $PRP \times PRF = 1$

Duty Factor

Pulse Repetition Period

Pulse Repetition Frequency



Pulse Duration

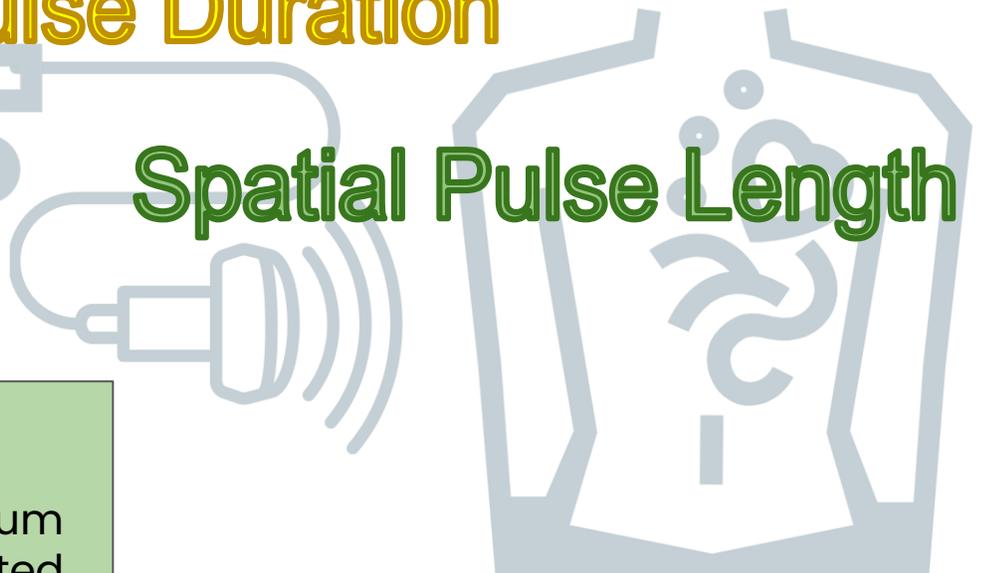
- Controlled by machine, cannot be adjusted
- $PD = \# \text{ cycles} \times T$

Pulse Duration

Spatial Pulse Length

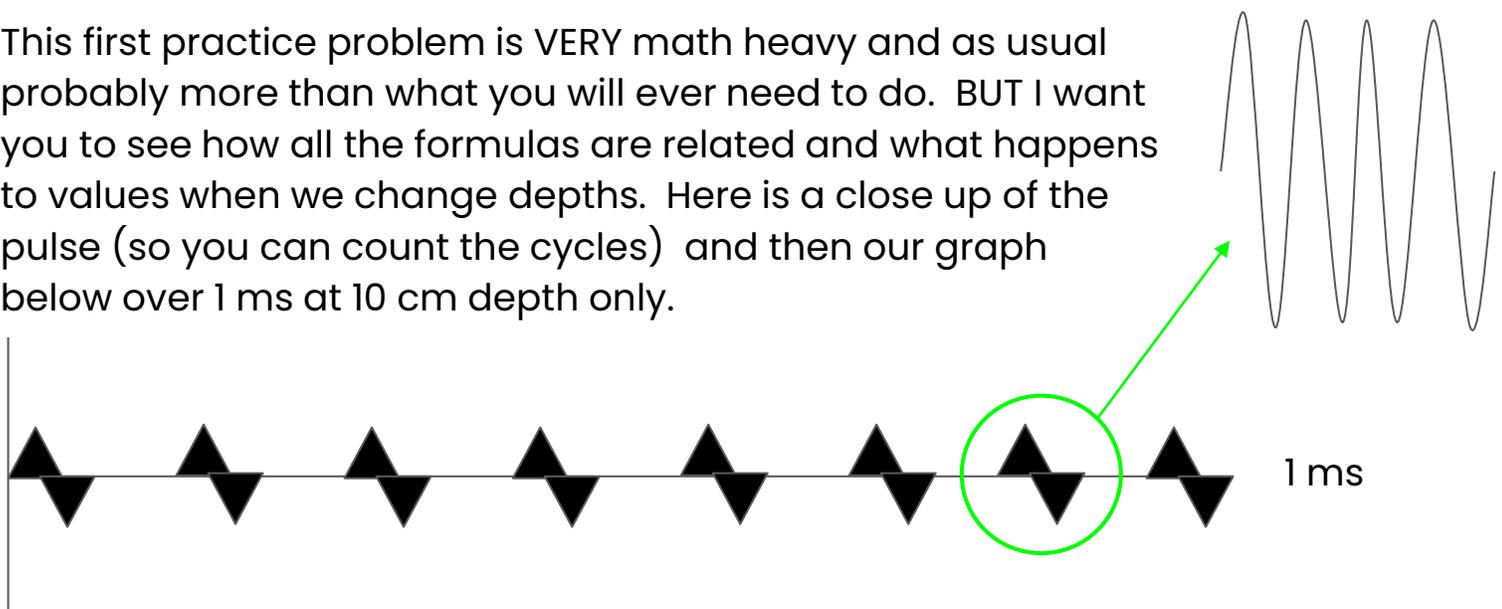
SPL (mm)

- Dependent on machine & medium
- Cannot be adjusted
- $SPL = \# \text{ cycles} \times \lambda$



4.5.1 Practice #1

This first practice problem is VERY math heavy and as usual probably more than what you will ever need to do. BUT I want you to see how all the formulas are related and what happens to values when we change depths. Here is a close up of the pulse (so you can count the cycles) and then our graph below over 1 ms at 10 cm depth only.



Parameter	At 10 cm max depth	At 5 cm max depth
Frequency	5 MHz	5 MHz
Period		
Speed in Soft Tissue		
Wavelength		
# of cycles / pulse		
PRF		
PRP		
PD		
SPL		
DF		

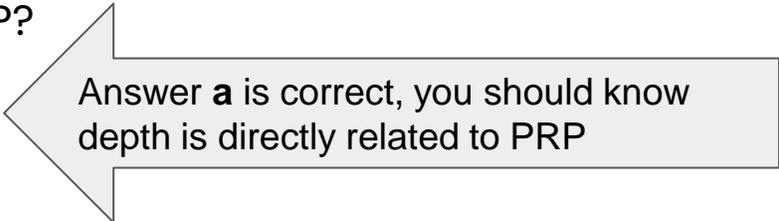
Practice #1 Takeaways:

- Parameters that do NOT change with depth:
 - Frequency
 - Period
 - Propagation Speed
 - Wavelength
 - # of cycles per pulse
 - PD
 - SPL
- Parameters that DO change with depth:
 - PRF
 - PRP
 - DF
- When depth was **decreased by a factor of 2** (10 cm to 5 cm)
 - PRF increased by a factor of 2
 - PRP decreased by a factor of 2
 - DF increased by a factor of 2

Sample test questions:

A sonographer is imaging at 10 cm and increases the depth to 20 cm. What happened to the PRP?

- a. Doubled
- b. Halved
- c. Stayed the same
- d. Depth is not related to PRP

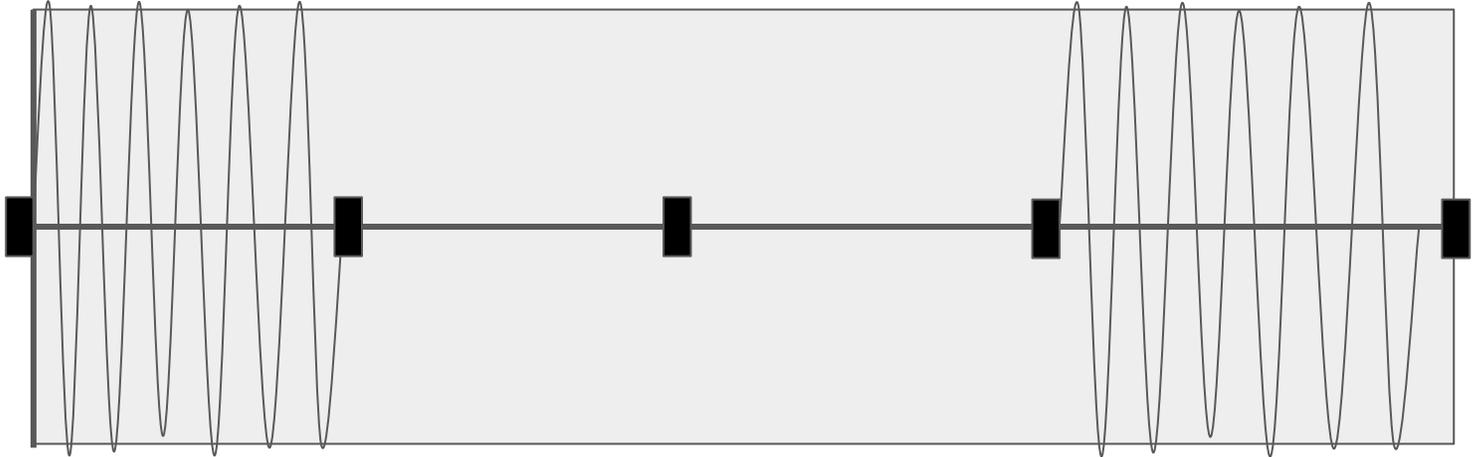
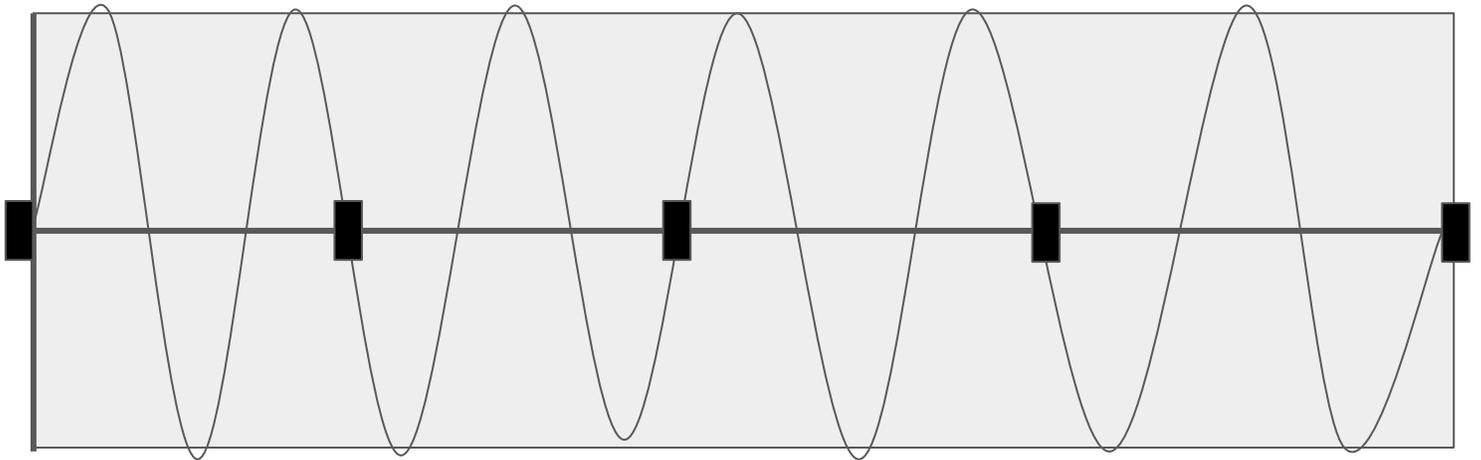


Answer a is correct, you should know depth is directly related to PRP

4.5.1 Practice #2

Duty factor may be graphically demonstrated too, rather than calculating it based on PD & PRP.

What are the duty factors of these pulses if each dash represents an equal amount of time?



Section 4.6 Activities ← Answer Link

1. Match the term with a statement. All are used once.

- A. Pulse Duration**
- B. PRP**
- C. PRF**
- D. SPL**
- E. Duty Factor**
- F. Maximum Imaging Depth**
- G. Pulse**
- H. Period**
- I. Frequency**
- J. Wavelength**

	The distance a pulse takes up in space
	The time a pulse occurs in
	Has nothing to do with Pulse Repetition Period
	The percentage of time that the pulse is on
	How many pulses can occur in a second
	Changes the PRP, PRF and DF
	Has nothing to do with Pulse Repetition Frequency
	Includes both the on-time and the off-time
	A collection of cycles that move together as one
	A distance that is the same in a continuous wave and pulsed wave.

2. Drag the formula to its matching parameter.

Frequency (MHz) =

$$\frac{PD (\mu s)}{PRP (\mu s)} \times 100$$

Period (μs) =

$$\# \text{ cycles} \times \lambda (\text{mm})$$

Propagation Speed (mm/ μs) =

$$\frac{1}{PRP}$$

Wavelength (mm) =

$$\frac{1}{T (\mu s)}$$

PRF (kHz) =

$$\frac{1}{PRF}$$

PRP (ms) =

$$\frac{1}{f (\text{MHz})}$$

PD (μs) =

$$1.54 (\text{mm}/\mu s)$$

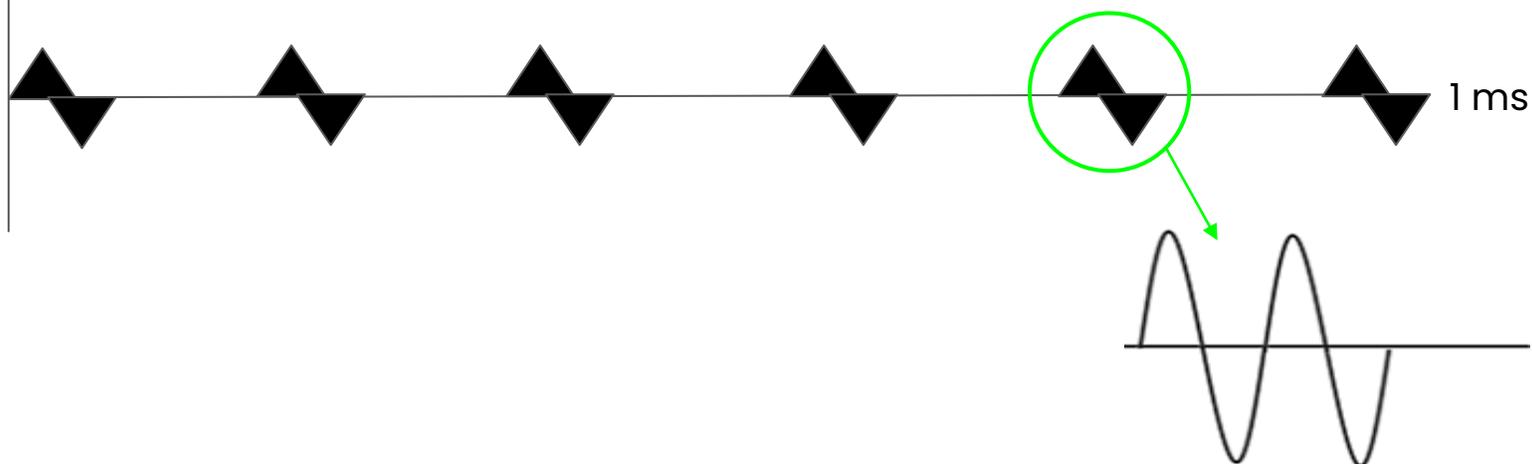
SPL (mm) =

$$\frac{c (\text{mm}/\mu s)}{f (\text{MHz})}$$

DF (%) =

$$\# \text{ cycles} \times T (\mu s)$$

3. This is a pulsed wave traveling through soft tissue with the initial depth set at 12 cm, fill in the chart for the 12 cm depth and then recalculate for the 24 cm depth. An enlarged pulse is shown so you can count the cycles.



Parameter	Value at 12 cm depth:	Value at 24 cm depth:
Frequency	10 MHz	10 MHz
Period		
Speed in Soft Tissue		
Wavelength		
# of cycles / pulse		
PRF		
PRP		
PD		
SPL		
DF		

Looking back at the last chart:

4. What happened to PRF when the sonographer increased the depth?

5. What happened to PRP when the sonographer increased the depth?

6. What happened to duty factor when the sonographer increased the depth?

7. Which of these images is the most likely representation of the pulse at 24 cm and why?

A



B

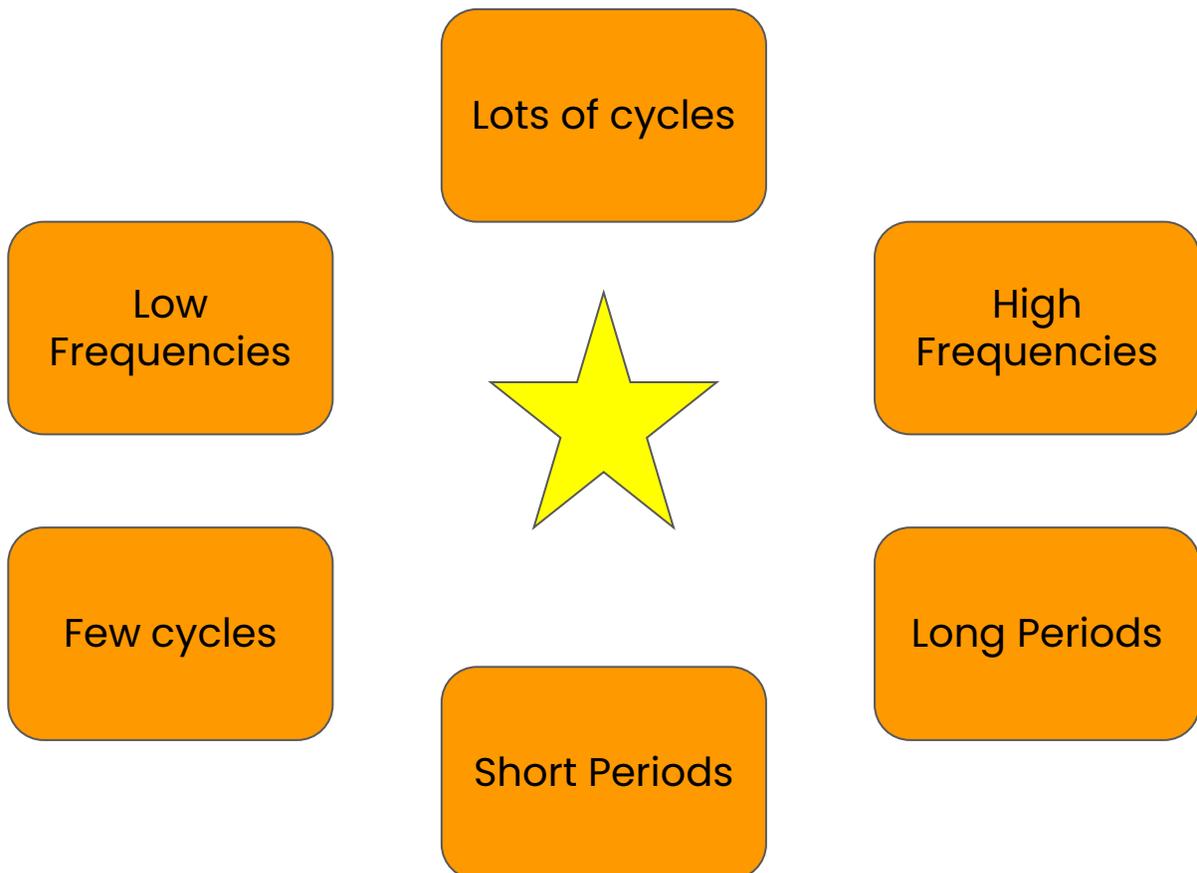


8. Sort the statements regarding Pulse Duration. Move the STAR to the list that creates more desirable images.

Create LONG Pulse Durations



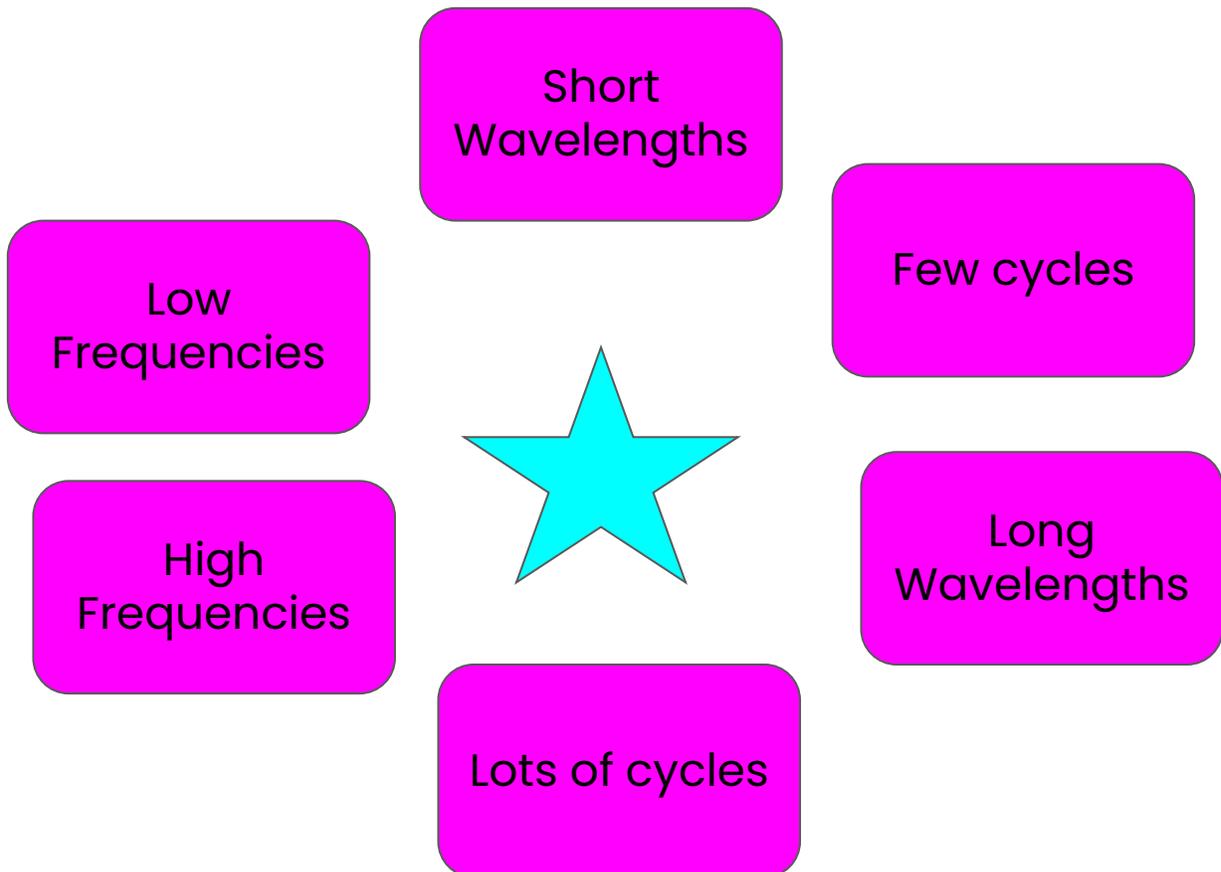
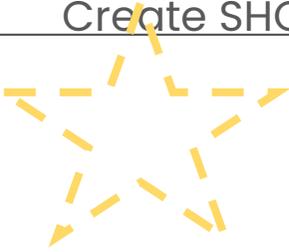
Create SHORT



9. Sort the statements regarding Spatial Pulse Length. Move the STAR to the list that creates more desirable images.

Create LONG SPLs

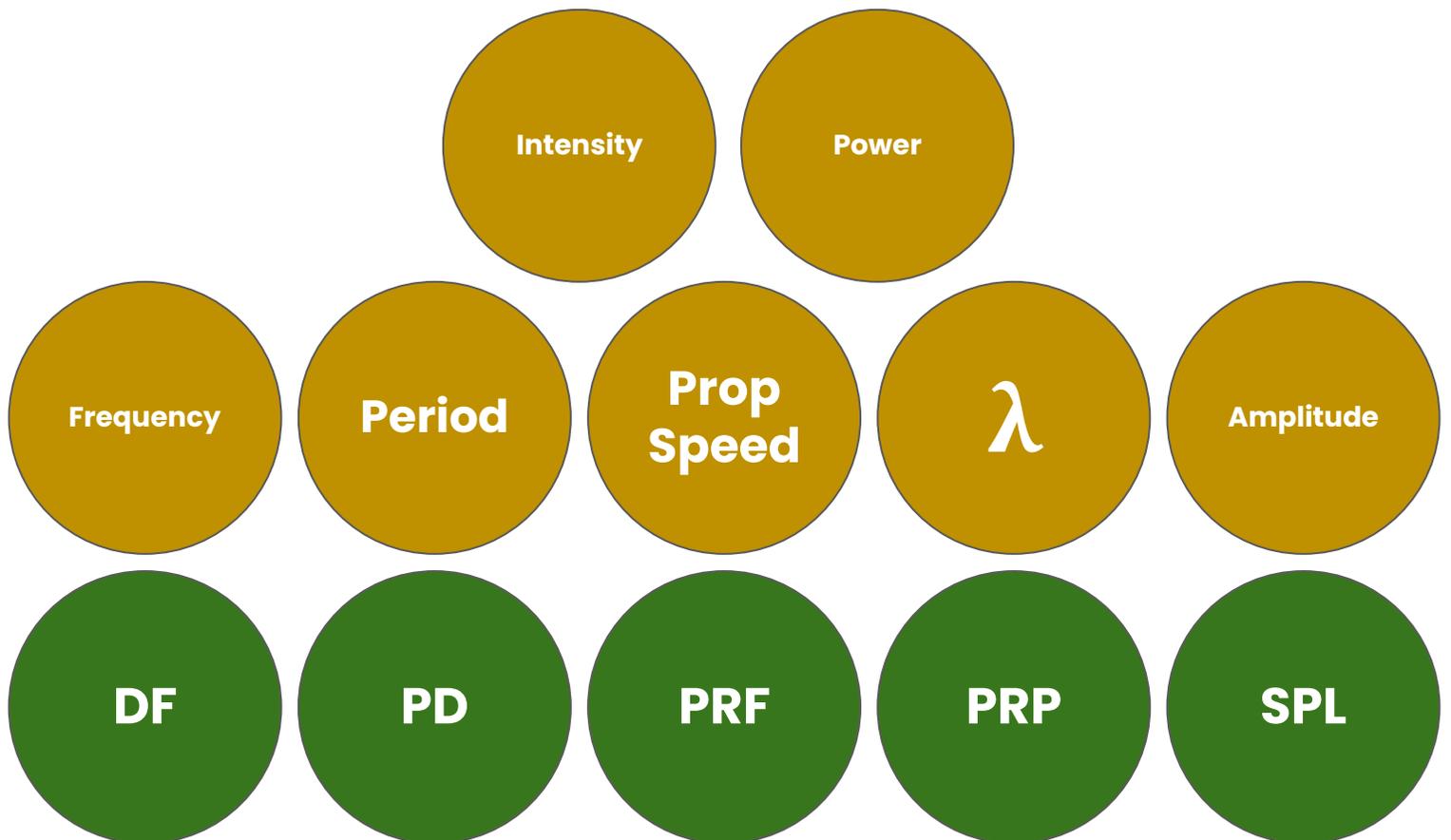
Create SHORT SPLs



10. Sort the parameters:

Adjustable

Not Adjustable

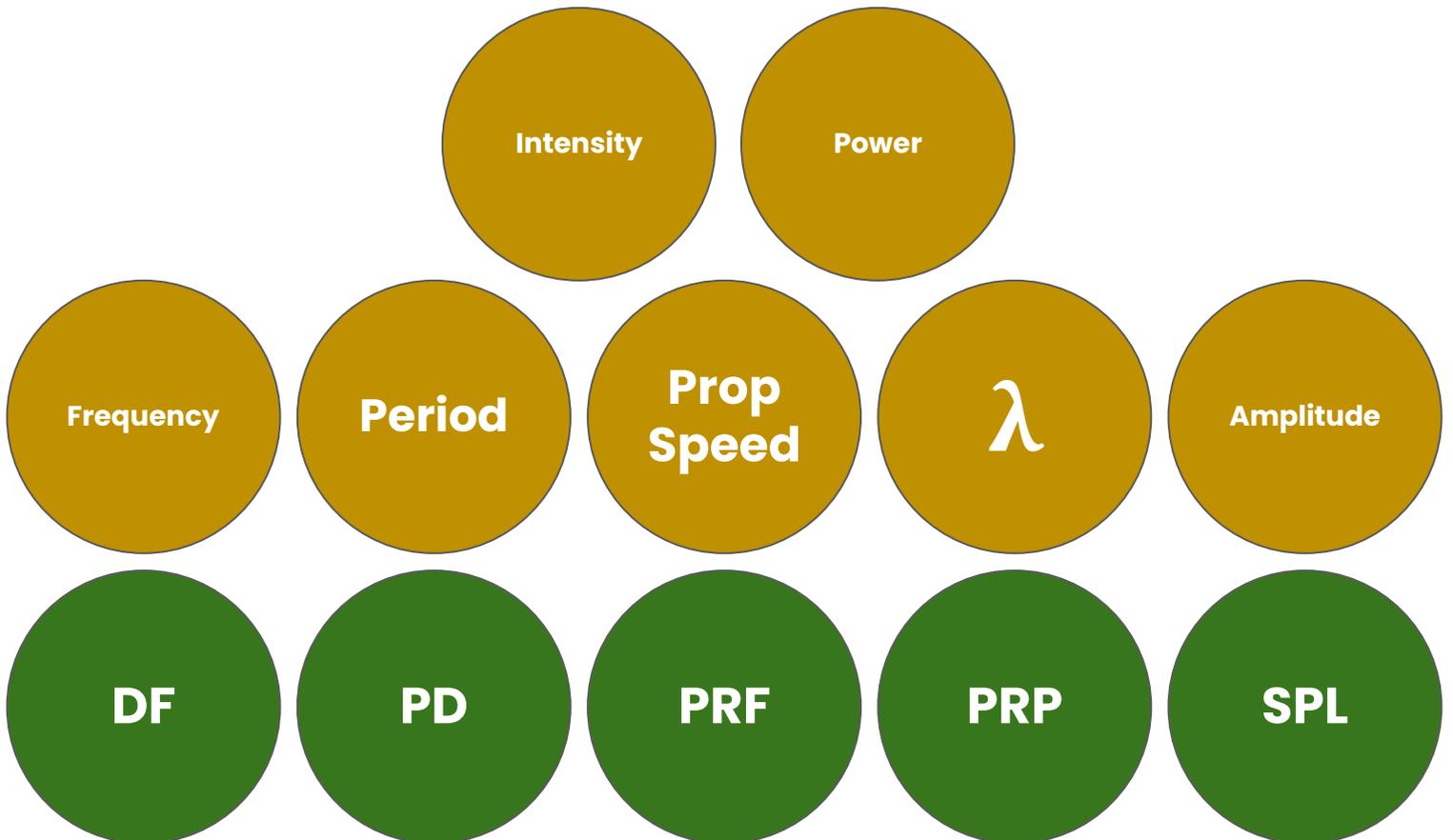


11. Sort the parameters by what determines them:

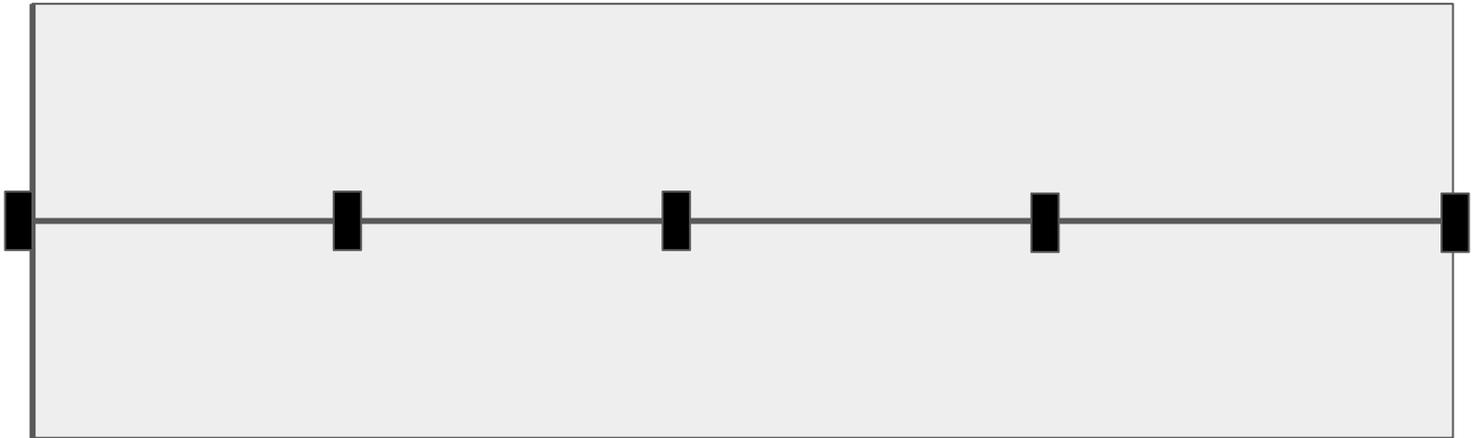
Machine

Both

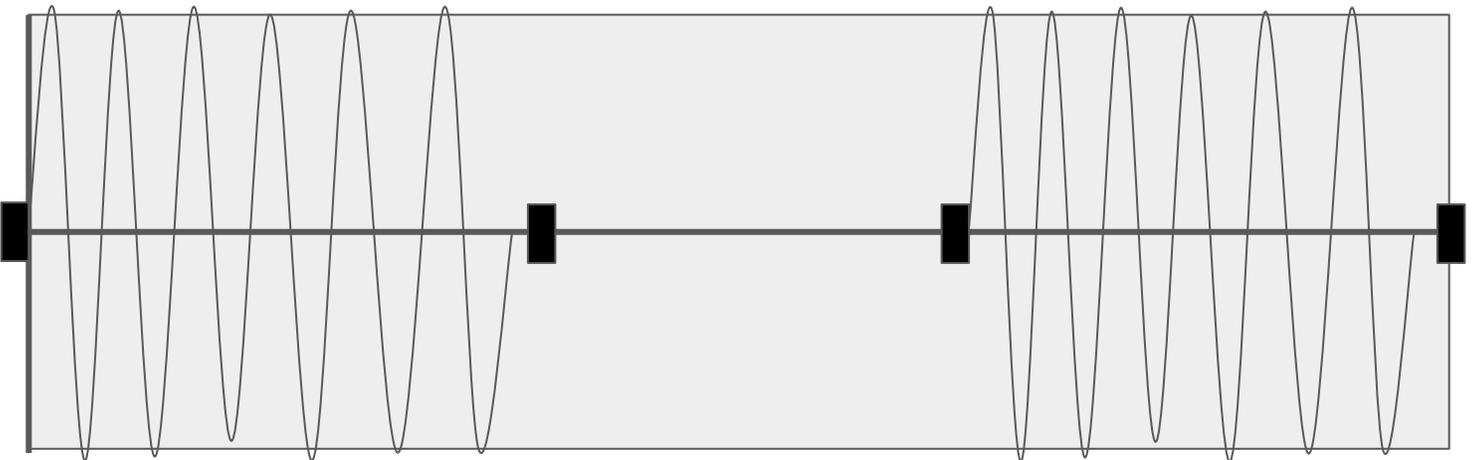
Medium



12. Determine the duty factor based on these images.



Duty Factor =



Duty Factor =

4.7 Nerd Check!

1. What are the 7 parameters that can describe both continuous waves and pulsed waves?
2. What 2 components does a pulsed wave have?
3. Which type of wave creates images?
4. When a pulsed wave is in transmit, what does that mean?
5. When a pulsed wave is in receive, what does that mean?
6. Why is it important for the machine to have the off-time?
7. How do the cycles of a pulse move?
8. What are the 5 parameters that can describe pulsed waves?
9. What is a pulse?
10. Describe how to identify a pulse.
11. How many cycles are in a pulse for clinical ultrasound?
12. What features do waves that produce superior images have?
13. What is pulse duration?
14. What unit is pulse duration in?
15. What is the average value of pulse duration?
16. How are pulse duration and the # of cycles related?
17. How are pulse duration and period related?
18. How are pulse duration and frequency related?
19. Can pulse duration be adjusted?
20. Who/what controls pulse duration?
21. What is the definition of spatial pulse length?
22. What are the units of SPL?
23. What is the average value of SPL?
24. How are SPL and # of cycles related?
25. How are SPL and wavelength related?
26. Who/what controls SPL?
27. Why is a short SPL important?
28. What three parameters are depth dependent?
29. How are PRF & PRP related to Frequency and Period?
30. What is maximum imaging depth?
31. Why is maximum imaging depth important?
32. Can the sonographer change depth?
33. Explain how an image is created.

34. What is the pulse repetition period?
35. What unit is PRP in?
36. What is the average PRP in ultrasound?
37. How does PRP change?
38. How are PRP and PRF related?
39. How are PRP and depth related?
40. Can PRP be adjusted by the sonographer?
41. Describe PRP on a graph of a wave.
42. What is pulse repetition frequency?
43. What are the units of PRF?
44. What are the average values of PRF?
45. How are PRF and PRP related?
46. How are PRF and depth related?
47. How does a sonographer control PRF?
48. How does depth affect Pulse duration?
49. What part of the pulse wave changes when depth changes?
50. Which image would be created faster and more accurately? An image with a depth of 16 cm or 8 cm?
51. A graph has 6 pulses displayed in a time frame of 1 ms, what is the PRF and PRP?
52. What is duty factor?
53. What is the unit for duty factor?
54. How is duty factor calculated?
55. How are duty factor and pulse duration related?
56. How are duty factor and PRP related?
57. How does duty factory change?
58. Who/what controls duty factor?
59. In general if a pulse has more time, what can be said about the duty factor?