

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

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1. In ultrasound, with an incident planar wave that is not perpendicular to a boundary where the acoustic impedance Z changes, the following are true:

- I. Reflection will always occur.
- II. Refraction will occur if and only if the wave velocity c changes.
- III. Particle velocity v will always equal wave velocity c on either side of the boundary

- A. I, II, and III
- B. I and III
- C. II and III
- D. I
- E. I and II

2. The following are true about theoretical plane waves in ultrasound, *except*

- A. Their pressure is attenuated by $1/r$ where r is the distance traveled.
- B. They can be viewed equally well as functions of time or of distance.
- C. Their general solution includes the superposition of a forward-traveling wave and a backward-traveling wave.
- D. Spatial variation occurs only along one particular dimension.
- E. They are approximated within the Very Near Field of the ultrasound transducer.

3. The following are true about the waves used in clinical ultrasound imaging, *except*

- A. They are generally produced in short bursts.
- B. They are primarily shear rather than compression waves.
- C. They do not travel well through air or bone.
- D. Distance to a target is determined by time of flight.
- E. Their absorption coefficient in biological tissue is roughly inversely proportional to frequency.

4. In ultrasound, the space being imaged is organized into three regions. In each region, a particular approximation best describes the beam pattern. Those approximations are

I - the Fraunhofer approximation

II - the geometric approximation (the very near field)

III - the Fresnel approximation

In what order do the corresponding regions of space occur, as one moves *away from the transducer*?

A. III, I, II

B. I, II, III

C. II, III, I

D. I, III, II

E. II, I, III

5. Which of the following statements is *false* about the Fraunhofer zone? (or all are true)

A. It is also known as the “far field”.

B. The field pattern is basically a function of angle off the axis.

C. There are *no* null points due to destructive interference along the axis in this zone.

D. There *are* null points due to destructive interference off the axis in this zone.

E. All are true.

6. Which of the following statements is *false* about the use of the complex exponential in modeling ultrasound?

A. It is also the foundation of much of modern optics.

B. It allows for the imaginary component of a physical quantity, by assuming that the imaginary component will be canceled by a complex conjugate.

C. It permits mathematically tenable integration of many sources of ultrasound waves converging on a single point to determine the extent of constructive or destructive interference.

D. It applies only to single crystals and not to phased arrays.

E. It generally assumes superposition of the ultrasound waves.

7. Which of the following statements is *false* about the piezoelectric crystals used in ultrasound transducers?

A. The strain produced by a unit electric field (“transmitting constant” in meters per volt) and the potential produced by unit stress (“receiving constant” in volt-meters per Newton) are always numerically equal values.

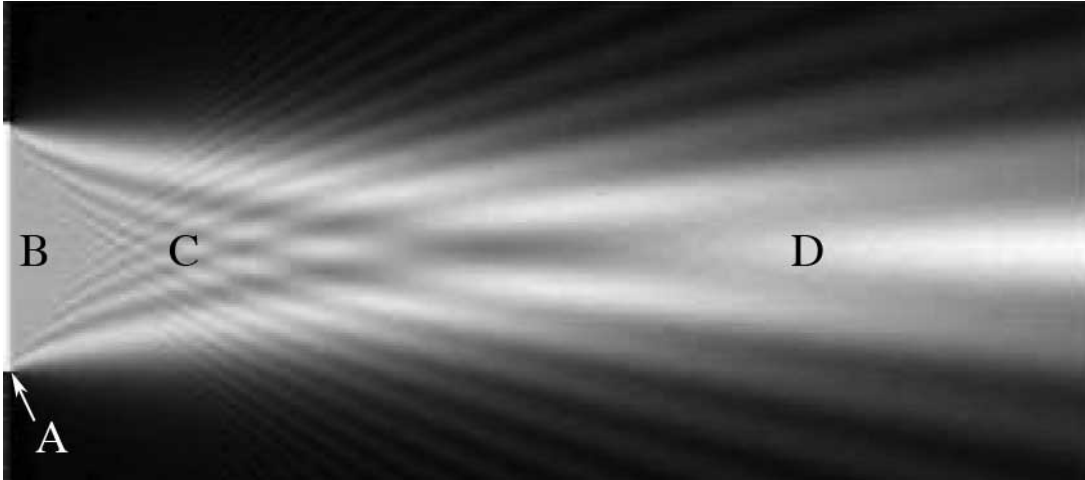
B. Energy is mainly lost due to damping by the acoustic backing behind the crystal, which is intentionally included to shorten the duration of the transmit pulse.

C. An incoming acoustic wave creates mechanical displacement, which creates an electrical potential.

D. The resonant frequency of a crystal (typically 1-20 MHz in medical ultrasound) is largely determined by the thickness of that crystal

E. An induced electric field produces strain (mechanical displacement), which causes an acoustic wave.

8. In ultrasound, which of the following is *not* true about the *field pattern*, an example of which is shown below (the figure actually shows a field pattern for light, but is analogous to that found with ultrasound).



- A. The label “B” marks the Very Near Field, where the aperture appears infinitely large.
 - B. The field pattern represents a pattern of standing waves of constructive and destructive interference for a given aperture and wavelength, and is independent of the particular target being scanned.
 - C. The label “C” marks the Fraunhofer zone.
 - D. The label “A” marks the aperture (or indicator function) of the transducer.
 - E. In the region labeled “D” the field pattern becomes a function simply of angle from the axis.
9. The following are true about theoretical plane waves in ultrasound, *except*
- A. They are approximated within the Fraunhofer zone.
 - B. Spatial variation occurs only along one particular dimension orthogonal to the plane of the wave.
 - C. No attenuation occurs with distance along the direction of propagation.
 - D. They can be viewed equally well as functions of time or of distance.
 - E. Their general solution includes the superposition of a forward-traveling wave and a backward-traveling wave.
10. The following are true about the waves used in clinical ultrasound imaging, *except*
- A. Distance to a target is determined by time of flight.
 - B. Velocity in soft tissue (not air or bone) is fairly constant at around 1540 meters/second ($< \pm 10\%$).
 - C. Their absorption coefficient in biological tissue is largely independent of wavelength.
 - D. They are primarily compression rather than shear waves.
 - E. They are used primarily to detect changes in acoustic impedance.

11. Which of the following statements is *false* about the use of the complex exponential in modeling ultrasound, (or all are true)?

- A. All are true.
- B. It generally assumes superposition of the ultrasound waves in a linear system.
- C. It allows for the imaginary component of a physical quantity, by requiring that the imaginary component will be canceled by a complex conjugate.
- D. It is also the foundation of much of modern optics.
- E. It permits mathematically tenable integration of many sources of ultrasound waves converging on a single point to determine the extent of constructive or destructive interference.

12. Which of the following statements is *false* about resolution in ultrasound?

- A. Lateral resolution generally increases (gets better) with increasing range.
- B. Resolution in the range direction is limited by the duration of the envelope of the transmitted pulse.
- C. Resolution increases (gets better) with increasing frequency.
- D. Resolution in the range direction generally stays constant with increasing range.
- E. Resolution is manifested by a “resolution cell” within which many actual reflectors create a total reflection of variable brightness, accounting for speckle.

13. Which of the following statements is (are) *true* about the pulse-echo mode of operation in a phased array ultrasound scanner?

- I. The same transducers usually generate and receive the ultrasound pulses.
- II. The beam is steered by changing the duration of the transmit pulse envelope.
- III. Color Doppler is possible with pulse-echo ultrasound.

- A. I, II, and III.
- B. II and III.
- C. I and II.
- D. I and III.
- E. I.

14. Posterior enhancement (through transmission) is a type of ultrasound artifact often used in diagnosis because

- A. it can measure the blood volume of the ventricle.
- B. it can cause a reflection of the image at a very large discontinuity in acoustic impedance, such as between the lung and the diaphragm.
- C. it enables speckle tracking of cells within the fluid in any direction, even orthogonal to the ultrasound beam.
- D. it helps determine the velocity of blood flowing through a vessel.
- E. it can differentiate a solid mass vs a fluid filled cyst, where this may not be possible CT.

15. Which of the following statements is *false* about phased arrays in ultrasound?

- A. Given a two-dimensional array of transducer elements, 3D ultrasound images may be acquired by steering the beam in both azimuth and elevation.
- B. Grating lobes will occur if the spacing between the elements of the array is greater than a wavelength of the ultrasound.
- C. Timing between the elements can be used to focus a beam both for transmitting and receiving.
- D. Dynamic focusing of the array, i.e., during the transmission and reception of a single pulse, is possible for both transmission and reception.
- E. Timing between the elements can be used to steer a beam both for transmitting and receiving.

16. Which of the following statements is *false* about Doppler in ultrasound?

- A. Motion away from the transducer results in a shift to a lower frequency, but motion orthogonal to the ultrasound beam results in no Doppler shift.
- B. In continuous-wave Doppler, discrete pulses of ultrasound are not used, but rather a continuous sinusoid is transmitted, received, and shifted by the transmit frequency down to the audio range, where motion may simply be heard as a “whooshing” sound.
- C. Power Doppler delivers a more sensitive measure of absolute motion but cannot determine the direction of that motion.
- D. In Color Doppler, pulses of ultrasound are analyzed as to their phase shift over the period between pulses, and therefore aliasing can result if enough phase shift occurs.
- E. Doppler shift is due to the relativistic effect of phonons.

17. Which of the following statements regarding the Doppler effect is (are) true?

- I Given a stationary source, moving the receiver toward the source will result in a higher frequency heard by the receiver than if the receiver were stationary.
- II Given a stationary receiver, moving the source toward the receiver will result in a lower frequency heard by the receiver than if the source were stationary.
- III If the source and receiver are moving in the same direction at the same speed, the receiver will not hear any change in frequency.

- A. I and III
- B. III only
- C. II and III
- D. I and II
- E. II only

18. Ultrasound is useful for non-invasive imaging of all of the following, it except:

- A. Heart
- B. Blood vessels
- C. Lungs
- D. Fetus
- E. Liver

19. Which of the following statements about clinical ultrasound is *false*?

- A. Ultrasound operates in the megahertz range.
- B. Ultrasound transmits well through air.
- C. Most of the delivered energy becomes heat.
- D. Ultrasound detects changes in acoustic impedance.
- E. Ultrasound does not expose the patient to ionizing radiation.

20. As the frequency of an ultrasound beam increases:

- A. Resolution increases and depth of penetration decreases
- B. Resolution increases and depth of penetration increases
- C. Resolution increases and depth of penetration remains the same
- D. Resolution decreases and depth of penetration increases
- E. Resolution decreases and depth of penetration decreases

21. Ultrasound is sound with frequencies above

- A. 2000 Hz
- B. None of them
- C. 20 Hz
- D. 20 kHz
- E. 20 MHz

22. In ultrasound imaging, SNR increases with

- A. Increasing transducer focal distance because intensity is higher
- B. Increasing transducer focal distance because intensity is lower
- C. None of them
- D. Decreasing transducer focal distance because intensity is lower
- E. Decreasing transducer focal distance because intensity is higher

23. The following is true about resolution in ultrasound

- A. Transverse resolution degrades with shorter focal distance and longitudinal resolution improves with shorter pulses.
- B. Transverse resolution improves with shorter focal distance and longitudinal resolution improves with shorter pulses.
- C. Transverse resolution degrades with shorter focal distance and longitudinal resolution degrades with shorter pulses.
- D. Transverse resolution improves with shorter focal distance and longitudinal resolution degrades with shorter pulses.
- E. None of them

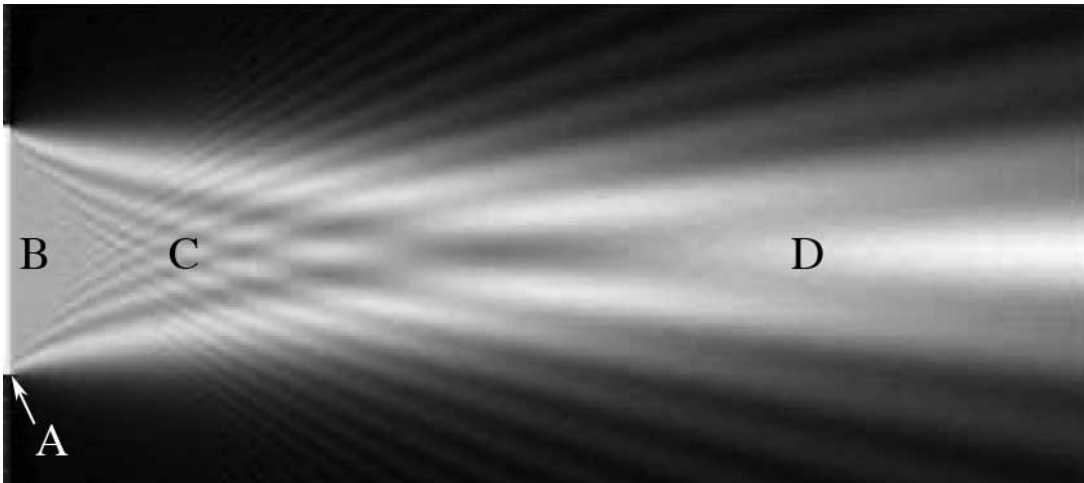
24. Which of the following statements is *false* about resolution in ultrasound?

- A. Resolution in the range direction is limited by the duration of the envelope of the transmitted pulse.
- B. Lateral resolution generally decreases (gets worse) with increasing range.
- C. Resolution in the range direction decreases (gets worse) with increasing range.
- D. Resolution is manifested by a “resolution cell” within which many actual reflectors create a total reflection of variable brightness, accounting for speckle.
- E. Resolution increases (gets better) with increasing frequency.

25. Which of the following statements is *false* about the use of the complex exponential in modeling ultrasound, (or all are true)?

- A. It may be used for compression waves as found in ultrasound, but is not applicable to optics, where the electromagnetic waves are transverse.
- B. All are true.
- C. It permits mathematically tenable integration over an aperture of an infinite number of ultrasound sources according to Huygen’s principle.
- D. It leads directly to the use of Fourier transform, especially in the far field.
- E. It permits the mathematical manipulation of an imaginary component of a physical quantity, by always requiring the presence of a complex conjugate for each complex exponential.

26. Which of the following is *not* true about the *field pattern* shown below representing ultrasound produced by a flat transducer (marked “A”), or all the others are true.



- A. In the Fraunhofer zone the field pattern becomes a function basically of angle from the axis.
- B. All the others are true.
- C. The label “B” marks the Very Near Field, where plane waves are approximated, at least near the center axis, and thus do not create significant standing waves.
- D. In the Fresnel zone no null points exist along the central axis.
- E. The field pattern represents a pattern of standing waves of constructive and destructive interference for a given aperture and wavelength, and is equally applicable to either transmission or reception by the transducer.

- 27.** The following are true about theoretical spherical waves in ultrasound, *except*
- A. Spatial variation occurs only along radial directions from the center of the spherical wave.
 - B. They can be viewed equally well as functions of time or of distance.
 - C. Their general solution includes the superposition of an outward-traveling wave and an inward-traveling wave, although often only the outward-traveling wave is used.
 - D. They are central to Huygen's principle.
 - E. No attenuation occurs with distance along the direction of propagation.
- 28.** Which of the following affects the intensity of a pixel in an ultrasound image ?
- I. changes in acoustic impedance of the tissue at the pixel location.
 - II. the particular configuration of scatterers smaller than the resolution of the ultrasound within the pixel's resolution cell.
 - III. attenuation, reflection, or scattering between the transducer and the pixel location.
- A. I and III.
 - B. II and III.
 - C. None of the other answers
 - D. I, II, and III.
 - E. I and II.
- 29.** The following are true about the waves used in clinical ultrasound imaging, *except*
- A. Velocity of ultrasound waves in soft tissue (not air or bone) is fairly constant at around 1540 meters/second ($< \pm 10\%$).
 - B. Absorption in biological tissue is roughly proportional to frequency.
 - C. The frequency of reflected ultrasound waves is independent of the velocity of moving target in the tissue.
 - D. Distance to a target is determined by time of flight.
 - E. They are primarily compression rather than shear waves.
- 30.** Which of the following statements is (are) *true* about the pulse-echo mode of operation in a phased array ultrasound scanner?
- I. The transmit beam is steered and focussed by controlling the relative timing of the transmit pulses to the elements of the array.
 - II. The receive beam pattern can be changed even after the transmit pulse has been sent.
 - III. Grating lobes result if the spacing between transducer elements is too large.
- A. I and II.
 - B. I, II, and III.
 - C. II and III.
 - D. I and III.
 - E. None of the others is correct.

31. Which of the following statements is *false* about Doppler in ultrasound (or all of the others are true)?

- A.** Motion orthogonal to the ultrasound beam results in Doppler shift to a lower frequency.
- B.** All of the others are true
- C.** In continuous-wave Doppler, discrete pulses of ultrasound are not used, but rather a continuous sinusoid is transmitted, received, and shifted by the transmit frequency down to the audio range, where motion may simply be heard as a “whooshing” sound.
- D.** Power Doppler delivers a more sensitive measure of absolute motion but cannot determine the direction of that motion.
- E.** In Color Doppler, pulses of ultrasound are analyzed as to their phase shift over the period between pulses, and therefore aliasing can result if enough phase shift occurs.

32. Ultrasound is commonly used in adults for non-invasive imaging of all of the following, it except:

- A.** Kidney
- B.** Fetus
- C.** Heart
- D.** Brain
- E.** Liver

33. Which of the following statements is (are) *true* about resonance in an ultrasound transducer?

- I.** The resonant frequency is largely determined by the thickness of the transducer and the speed of sound within it.
 - II.** The longer the resonance lasts for a given transmit pulse, the better the resolution in the range direction of the resulting image .
 - III.** Resonant energy is primarily and intentionally lost out the back of the transducer.
- A.** None of the others is correct.
 - B.** I and III.
 - C.** II and III.
 - D.** I, II, and III.
 - E.** I and II.

34. Which of the following statements is *false* about the Fraunhofer zone? (or all are true)

- A.** The lateral resolution in this zone falls off linearly with distance to the transducer.
- B.** The field pattern is basically a function of angle off the axis.
- C.** All are true.
- D.** There are null points due to destructive interference along the axis in this zone.
- E.** It is also known as the “far field”.

35. Which of the following statements is (are) *true* about the pulse-echo mode of operation in a phased array ultrasound scanner?

- I. Grating lobes are possible with phased arrays, but not with single array transducers.
- II. The transmit beam as well as the receive field pattern is steered by changing the relative timing between the elements of the array.
- III. Dynamic focusing is possible during the reception of echos from a given ultrasound pulse, but not during its transmission.

- A.** I and III.
- B.** I and II.
- C.** I, II, and III.
- D.** II
- E.** II and III.

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1. In ultrasound, with an incident planar wave that is not perpendicular to a boundary where the acoustic impedance Z changes, the following are true:

- I. Reflection will always occur.
- II. Refraction will occur if and only if the wave velocity c changes.
- III. Particle velocity v will always equal wave velocity c on either side of the boundary

- A. I and II
- B. I and III
- C. II and III
- D. I, II, and III
- E. I

Explanation: Refraction depends only on c . Reflection depends only on Z and the angle of incidence. Particle velocity v is generally much slower than wave velocity c .

[*imaging0044.mcq*]

2. The following are true about theoretical plane waves in ultrasound, *except*

- A. Their pressure is attenuated by $1/r$ where r is the distance traveled.
- B. Their general solution includes the superposition of a forward-traveling wave and a backward-traveling wave.
- C. They can be viewed equally well as functions of time or of distance.
- D. Spatial variation occurs only along one particular dimension.
- E. They are approximated within the Very Near Field of the ultrasound transducer.

Explanation: Whereas spherical waves spread out attenuating pressure by $1/r$, planar waves do not spread out, and thus maintain their full amplitude.

[*imaging0045.mcq*]

3. The following are true about the waves used in clinical ultrasound imaging, *except*

- A. They are primarily shear rather than compression waves.
- B. Their absorption coefficient in biological tissue is roughly inversely proportional to frequency.
- C. They are generally produced in short bursts.
- D. Distance to a target is determined by time of flight.
- E. They do not travel well through air or bone.

Explanation: Clinical ultrasound uses compression waves.

[*imaging0046.mcq*]

4. In ultrasound, the space being imaged is organized into three regions. In each region, a particular approximation best describes the beam pattern. Those approximations are

I - the Fraunhofer approximation

II - the geometric approximation (the very near field)

III - the Fresnel approximation

In what order do the corresponding regions of space occur, as one moves *away from the transducer*?

A. II, III, I

B. I, II, III

C. I, III, II

D. II, I, III

E. III, I, II

Explanation: The order is geometric (very near field), Fresnel (near field), and then Fraunhofer (far field).

[*imaging0053.mcq*]

5. Which of the following statements is *false* about the Fraunhofer zone? (or all are true)

A. All are true.

B. It is also known as the “far field”.

C. The field pattern is basically a function of angle off the axis.

D. There are *no* null points due to destructive interference along the axis in this zone.

E. There *are* null points due to destructive interference off the axis in this zone.

Explanation: These are all true. Null points on the axis do occur in the Fresnel zone, but in the far field the aperture appears small enough that the field pattern is only fall off with distance squared and otherwise only varies with angle off the axis.

[*imaging0054.mcq*]

6. Which of the following statements is *false* about the use of the complex exponential in modeling ultrasound?

A. It applies only to single crystals and not to phased arrays.

B. It permits mathematically tenable integration of many sources of ultrasound waves converging on a single point to determine the extent of constructive or destructive interference.

C. It allows for the imaginary component of a physical quantity, by assuming that the imaginary component will be canceled by a complex conjugate.

D. It is also the foundation of much of modern optics.

E. It generally assumes superposition of the ultrasound waves.

Explanation: The use of complex exponentials instead of real sinusoids encapsulates phase in such a way that algebra and calculus are straightforward, and is the heart of not only ultrasound design, but of modern optics. A linear system with superposition of the waves is generally assumed. This powerful mathematical approach applies as well to phased arrays as to single crystals.

[*imaging0055.mcq*]

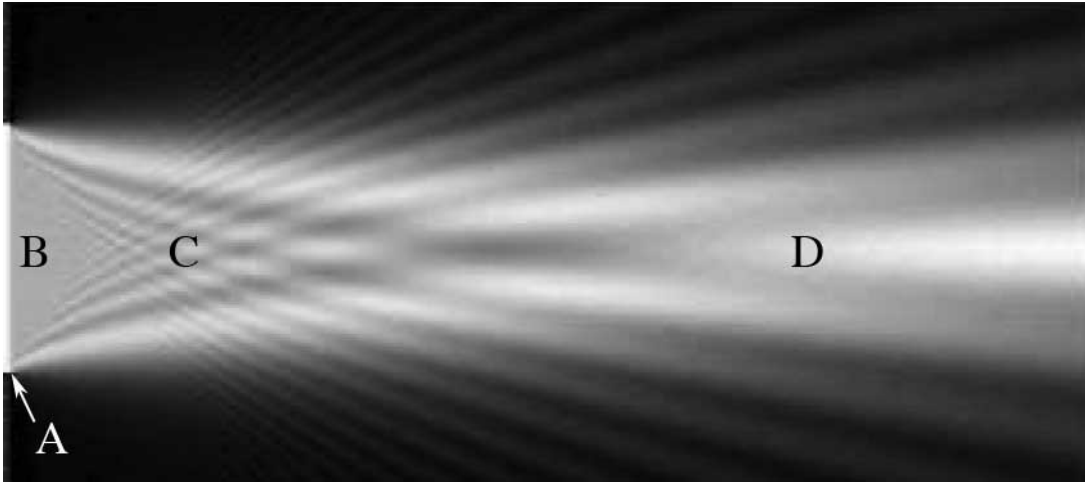
7. Which of the following statements is *false* about the piezoelectric crystals used in ultrasound transducers?

- A. The strain produced by a unit electric field (“transmitting constant” in meters per volt) and the potential produced by unit stress (“receiving constant” in volt-meters per Newton) are always numerically equal values.
- B. An induced electric field produces strain (mechanical displacement), which causes an acoustic wave.
- C. An incoming acoustic wave creates mechanical displacement, which creates an electrical potential.
- D. The resonant frequency of a crystal (typically 1-20 MHz in medical ultrasound) is largely determined by the thickness of that crystal
- E. Energy is mainly lost due to damping by the acoustic backing behind the crystal, which is intentionally included to shorten the duration of the transmit pulse.

Explanation: The transmitting constant and receiving constants don’t even have the same physical units, so they will certainly *not* have the same numerical values.

[*imaging0056.mcq*]

8. In ultrasound, which of the following is *not* true about the *field pattern*, an example of which is shown below (the figure actually shows a field pattern for light, but is analogous to that found with ultrasound).



- A. The label “C” marks the Fraunhofer zone.
- B. The field pattern represents a pattern of standing waves of constructive and destructive interference for a given aperture and wavelength, and is independent of the particular target being scanned.
- C. The label “A” marks the aperture (or indicator function) of the transducer.
- D. The label “B” marks the Very Near Field, where the aperture appears infinitely large.
- E. In the region labeled “D” the field pattern becomes a function simply of angle from the axis.

Explanation: The Fraunhofer zone, otherwise known as the *far field* is labeled “D.”

[*imaging0119.mcq*]

9. The following are true about theoretical plane waves in ultrasound, *except*

- A. They are approximated within the Fraunhofer zone.
- B. Their general solution includes the superposition of a forward-traveling wave and a backward-traveling wave.
- C. They can be viewed equally well as functions of time or of distance.
- D. Spatial variation occurs only along one particular dimension orthogonal to the plane of the wave.
- E. No attenuation occurs with distance along the direction of propagation.

Explanation: They are approximated within the Very Near Field of the transducer, not in the Fraunhofer zone. In the Fraunhofer zone the waves diverge at a constant angle acting more like spherical waves.

[*imaging0124.mcq*]

10. The following are true about the waves used in clinical ultrasound imaging, *except*

- A. Their absorption coefficient in biological tissue is largely independent of wavelength.
- B. Velocity in soft tissue (not air or bone) is fairly constant at around 1540 meters/second ($< \pm 10\%$).
- C. They are primarily compression rather than shear waves.
- D. Distance to a target is determined by time of flight.
- E. They are used primarily to detect changes in acoustic impedance.

Explanation: Absorption in biological tissue is roughly proportional to frequency and thus inversely proportional to wavelength, given that velocity (in soft tissue) is fairly constant at around 1540 meters/second.

[*imaging0125.mcq*]

11. Which of the following statements is *false* about the use of the complex exponential in modeling ultrasound, (or all are true)?

- A. All are true.
- B. It permits mathematically tenable integration of many sources of ultrasound waves converging on a single point to determine the extent of constructive or destructive interference.
- C. It allows for the imaginary component of a physical quantity, by requiring that the imaginary component will be canceled by a complex conjugate.
- D. It is also the foundation of much of modern optics.
- E. It generally assumes superposition of the ultrasound waves in a linear system.

Explanation: The use of complex exponentials instead of real sinusoids encapsulates phase in such a way that algebra and calculus are straightforward, and is the heart of not only ultrasound design, but of modern optics. A linear system with superposition of the waves is generally assumed.

[*imaging0128.mcq*]

12. Which of the following statements is *false* about resolution in ultrasound?

- A. Lateral resolution generally increases (gets better) with increasing range.
- B. Resolution increases (gets better) with increasing frequency.
- C. Resolution is manifested by a “resolution cell” within which many actual reflectors create a total reflection of variable brightness, accounting for speckle.
- D. Resolution in the range direction generally stays constant with increasing range.
- E. Resolution in the range direction is limited by the duration of the envelope of the transmitted pulse.

Explanation: Lateral resolution generally *decreases* (gets worse) with increasing range.

[*imaging0129.mcq*]

13. Which of the following statements is (are) *true* about the pulse-echo mode of operation in a phased array ultrasound scanner?

- I. The same transducers usually generate and receive the ultrasound pulses.
- II. The beam is steered by changing the duration of the transmit pulse envelope.
- III. Color Doppler is possible with pulse-echo ultrasound.

- A. I and III.
- B. I and II.
- C. II and III.
- D. I, II, and III.
- E. I.

Explanation: The beam is steered by changing the relative delay for each of the elements of the array, not the duration of the transmit pulse envelope.

[*imaging0130.mcq*]

14. Posterior enhancement (through transmission) is a type of ultrasound artifact often used in diagnosis because

- A. it can differentiate a solid mass vs a fluid filled cyst, where this may not be possible CT.
- B. it can measure the blood volume of the ventricle.
- C. it can cause a reflection of the image at a very large discontinuity in acoustic impedance, such as between the lung and the diaphragm.
- D. it helps determine the velocity of blood flowing through a vessel.
- E. it enables speckle tracking of cells within the fluid in any direction, even orthogonal to the ultrasound beam.

Explanation: Posterior enhancement makes tissue beyond a fluid filled structure appear brighter.

[*imaging0131.mcq*]

15. Which of the following statements is *false* about phased arrays in ultrasound?

- A. Dynamic focusing of the array, i.e., during the transmission and reception of a single pulse, is possible for both transmission and reception.
- B. Grating lobes will occur if the spacing between the elements of the array is greater than a wavelength of the ultrasound.
- C. Timing between the elements can be used to steer a beam both for transmitting and receiving.
- D. Timing between the elements can be used to focus a beam both for transmitting and receiving.
- E. Given a two-dimensional array of transducer elements, 3D ultrasound images may be acquired by steering the beam in both azimuth and elevation.

Explanation: Dynamic focusing of the array is possible only for reception as the echoes from a single transmit pulse are being received. Once a pulse is transmitted it can no longer be controlled (like a bowling ball).

[*imaging0134.mcq*]

16. Which of the following statements is *false* about Doppler in ultrasound?

- A. Doppler shift is due to the relativistic effect of phonons.
- B. In continuous-wave Doppler, discrete pulses of ultrasound are not used, but rather a continuous sinusoid is transmitted, received, and shifted by the transmit frequency down to the audio range, where motion may simply be heard as a “whooshing” sound.
- C. Motion away from the transducer results in a shift to a lower frequency, but motion orthogonal to the ultrasound beam results in no Doppler shift.
- D. In Color Doppler, pulses of ultrasound are analyzed as to their phase shift over the period between pulses, and therefore aliasing can result if enough phase shift occurs.
- E. Power Doppler delivers a more sensitive measure of absolute motion but cannot determine the direction of that motion.

Explanation: Although the quantum particle for sound is indeed called the phonon, the speeds involved are far below those at which relativistic effects come into play. Doppler shift is simply due to the motion of a body relative to the waves it is receiving or reflecting through a stationary medium.

[*imaging0135.mcq*]

17. Which of the following statements regarding the Doppler effect is (are) true?

- I Given a stationary source, moving the receiver toward the source will result in a higher frequency heard by the receiver than if the receiver were stationary.
- II Given a stationary receiver, moving the source toward the receiver will result in a lower frequency heard by the receiver than if the source were stationary.
- III If the source and receiver are moving in the same direction at the same speed, the receiver will not hear any change in frequency.

- A. I and III
- B. I and II
- C. II and III
- D. III only
- E. II only

Explanation: If source and receiver move toward each other, the frequency heard by the receiver will be higher due to the Doppler effect.

[*imaging0183.mcq*]

18. Ultrasound is useful for non-invasive imaging of all of the following, it except:

- A. Lungs
- B. Liver
- C. Fetus
- D. Heart
- E. Blood vessels

Explanation: Ultrasound does not penetrate air and thus is not used to image the normal lungs. The other tissues are commonly imaged with ultrasound.

[*imaging0186.mcq*]

19. Which of the following statements about clinical ultrasound is *false*?

- A. Ultrasound transmits well through air.
- B. Ultrasound detects changes in acoustic impedance.
- C. Ultrasound operates in the megahertz range.
- D. Most of the delivered energy becomes heat.
- E. Ultrasound does not expose the patient to ionizing radiation.

Explanation: Ultrasound does not travel through bone very well, which is why "ultrasound gel" is used when scanning a patient (to remove any air from in between the probe and the patient).

[*imaging0191.mcq*]

20. As the frequency of an ultrasound beam increases:

- A. Resolution increases and depth of penetration decreases
- B. Resolution decreases and depth of penetration decreases
- C. Resolution increases and depth of penetration increases
- D. Resolution decreases and depth of penetration increases
- E. Resolution increases and depth of penetration remains the same

Explanation: Higher frequency ultrasound yields greater spatial resolution at the cost of poorer depth of penetration.

[*imaging0195.mcq*]

21. Ultrasound is sound with frequencies above

- A. 20 kHz
- B. 20 MHz
- C. 20 Hz
- D. 2000 Hz
- E. None of them

Explanation: 20 kHz

[*imaging0211.mcq*]

22. In ultrasound imaging, SNR increases with

- A. Decreasing transducer focal distance because intensity is higher
- B. Increasing transducer focal distance because intensity is lower
- C. Increasing transducer focal distance because intensity is higher
- D. Decreasing transducer focal distance because intensity is lower
- E. None of them

Explanation: Decreasing transducer focal distance because intensity is higher due to less attenuation in tissue and 1/R effects.

[*imaging0217.mcq*]

23. The following is true about resolution in ultrasound

- A. Transverse resolution improves with shorter focal distance and longitudinal resolution improves with shorter pulses.
- B. Transverse resolution degrades with shorter focal distance and longitudinal resolution improves with shorter pulses.
- C. Transverse resolution improves with shorter focal distance and longitudinal resolution degrades with shorter pulses.
- D. Transverse resolution degrades with shorter focal distance and longitudinal resolution degrades with shorter pulses.
- E. None of them

Explanation: Transverse resolution improves with shorter focal distance and longitudinal resolution improves with shorter pulses

[*imaging0219.mcq*]

24. Which of the following statements is *false* about resolution in ultrasound?

- A. Resolution in the range direction decreases (gets worse) with increasing range.
- B. Resolution increases (gets better) with increasing frequency.
- C. Resolution is manifested by a “resolution cell” within which many actual reflectors create a total reflection of variable brightness, accounting for speckle.
- D. Lateral resolution generally decreases (gets worse) with increasing range.
- E. Resolution in the range direction is limited by the duration of the envelope of the transmitted pulse.

Explanation: Resolution in the range direction stays the same with increasing range.

[*imaging0270.mcq*]

25. Which of the following statements is *false* about the use of the complex exponential in modeling ultrasound, (or all are true)?

- A. It may be used for compression waves as found in ultrasound, but is not applicable to optics, where the electromagnetic waves are transverse.
- B. It permits mathematically tenable integration over an aperture of an infinite number of ultrasound sources according to Huygen’s principle.
- C. It permits the mathematical manipulation of an imaginary component of a physical quantity, by always requiring the presence of a complex conjugate for each complex exponential.
- D. It leads directly to the use of Fourier transform, especially in the far field.
- E. All are true.

Explanation: Complex exponentials are also the foundation of much of modern optics.

[*imaging0271.mcq*]

26. Which of the following is *not* true about the *field pattern* shown below representing ultrasound produced by a flat transducer (marked “A”), or all the others are true.



- A. In the Fresnel zone no null points exist along the central axis.
- B. The field pattern represents a pattern of standing waves of constructive and destructive interference for a given aperture and wavelength, and is equally applicable to either transmission or reception by the transducer.
- C. All the others are true.
- D. The label “B” marks the Very Near Field, where plane waves are approximated, at least near the center axis, and thus do not create significant standing waves.
- E. In the Fraunhofer zone the field pattern becomes a function basically of angle from the axis.

Explanation: The Fresnel zone, also known as the “*near* field” (labeled “C”) has nodes along the central axis.
 [*imaging0272.mcq*]

27. The following are true about theoretical spherical waves in ultrasound, *except*

- A. No attenuation occurs with distance along the direction of propagation.
- B. Their general solution includes the superposition of an outward-traveling wave and an inward-traveling wave, although often only the outward-traveling wave is used.
- C. They can be viewed equally well as functions of time or of distance.
- D. Spatial variation occurs only along radial directions from the center of the spherical wave.
- E. They are central to Huygen’s principle.

Explanation: Attenuation of amplitude occurs as $1/R$ with distance along the direction of propagation.
 [*imaging0273.mcq*]

28. Which of the following affects the intensity of a pixel in an ultrasound image ?

- I. changes in acoustic impedance of the tissue at the pixel location.
- II. the particular configuration of scatterers smaller than the resolution of the ultrasound within the pixel's resolution cell.
- III. attenuation, reflection, or scattering between the transducer and the pixel location.

- A. I, II, and III.
- B. I and II.
- C. I and III.
- D. II and III.
- E. None of the other answers

Explanation: All are true. Answer two describes speckle. Answer III effects the ultrasound energy reaching the location and thus the strength of the echo.

[*imaging0274.mcq*]

29. The following are true about the waves used in clinical ultrasound imaging, *except*

- A. The frequency of reflected ultrasound waves is independent of the velocity of moving target in the tissue.
- B. Velocity of ultrasound waves in soft tissue (not air or bone) is fairly constant at around 1540 meters/second ($< \pm 10\%$).
- C. They are primarily compression rather than shear waves.
- D. Distance to a target is determined by time of flight.
- E. Absorption in biological tissue is roughly proportional to frequency.

Explanation: Answer A is false, because otherwise Doppler would not work.

[*imaging0275.mcq*]

30. Which of the following statements is (are) *true* about the pulse-echo mode of operation in a phased array ultrasound scanner?

- I. The transmit beam is steered and focussed by controlling the relative timing of the transmit pulses to the elements of the array.
- II. The receive beam pattern can be changed even after the transmit pulse has been sent.
- III. Grating lobes result if the spacing between transducer elements is too large.

- A. I, II, and III.
- B. I and II.
- C. II and III.
- D. I and III.
- E. None of the others is correct.

Explanation: The receive and transmit beams are both steered by changing the relative delay for each of the elements of the array, and the receive beam can be dynamically focussed during the reception phase. Grating lobes result when the wave from one transducer element can be 180 degree behind that of its neighbor.

[*imaging0276.mcq*]

31. Which of the following statements is *false* about Doppler in ultrasound (or all of the others are true)?

- A. Motion orthogonal to the ultrasound beam results in Doppler shift to a lower frequency.
- B. In continuous-wave Doppler, discrete pulses of ultrasound are not used, but rather a continuous sinusoid is transmitted, received, and shifted by the transmit frequency down to the audio range, where motion may simply be heard as a “whooshing” sound.
- C. All of the others are true
- D. In Color Doppler, pulses of ultrasound are analyzed as to their phase shift over the period between pulses, and therefore aliasing can result if enough phase shift occurs.
- E. Power Doppler delivers a more sensitive measure of absolute motion but cannot determine the direction of that motion.

Explanation: Motion away from the transducer results in a shift to a lower frequency, but motion orthogonal to the ultrasound beam results in no Doppler shift.

[*imaging0277.mcq*]

32. Ultrasound is commonly used in adults for non-invasive imaging of all of the following, it except:

- A. Brain
- B. Liver
- C. Fetus
- D. Heart
- E. Kidney

Explanation: Ultrasound does not penetrate bone and thus is not normally used to image the adult brain, although in the fetus it can be seen through the softer thinner skull.

[*imaging0278.mcq*]

33. Which of the following statements is (are) *true* about resonance in an ultrasound transducer?

- I. The resonant frequency is largely determined by the thickness of the transducer and the speed of sound within it.
- II. The longer the resonance lasts for a given transmit pulse, the better the resolution in the range direction of the resulting image .
- III. Resonant energy is primarily and intentionally lost out the back of the transducer.

- A. I and III.
- B. I and II.
- C. II and III.
- D. I, II, and III.
- E. None of the others is correct.

Explanation: Longer resonance means a longer transmit envelope and poorer resolution in the range direction. Therefore the resonance is intentionally lost, primarily by using damping material behind the transducer.

[*imaging0279.mcq*]

34. Which of the following statements is *false* about the Fraunhofer zone? (or all are true)

- A. There are null points due to destructive interference along the axis in this zone.
- B. It is also known as the “far field”.
- C. The field pattern is basically a function of angle off the axis.
- D. The lateral resolution in this zone falls off linearly with distance to the transducer.
- E. All are true.

Explanation: Null points on the axis only occur in the Fresnel zone.

[*imaging0293.mcq*]

35. Which of the following statements is (are) *true* about the pulse-echo mode of operation in a phased array ultrasound scanner?

- I. Grating lobes are possible with phased arrays, but not with single array transducers.
- II. The transmit beam as well as the receive field pattern is steered by changing the relative timing between the elements of the array.
- III. Dynamic focusing is possible during the reception of echos from a given ultrasound pulse, but not during its transmission.

- A. I, II, and III.
- B. I and II.
- C. II and III.
- D. I and III.
- E. II

Explanation: All are true.

[*imaging0294.mcq*]