COMPREHENSIVE MOCK EXAM 11

Supplemental to: Clinical Ultrasound Board Review 2026-2027

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ARDMS SPI (Sonography Principles and Instrumentation) Examination, Inteleos — 110 questions, single-best-answer, four options (A-D), domain-weighted per official ARDMS SPI Content Outline

Board-Review Questions

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1. The Thermal Index has three recognized subtypes depending on the tissue being insonated. A sonographer imaging through the skull for a neonatal head exam should reference which subtype?

A. TIS (soft tissue)

B. TIC (cranial)

C. TIB (bone)

D. TI has no subtypes

2. The Mechanical Index (MI) is calculated from which acoustic output parameter, and estimates the risk of which type of bioeffect?

A. Peak rarefactional pressure; cavitation risk

B. Duty factor; thermal risk

C. Pulse repetition frequency; range ambiguity

D. Beam width; resolution loss

3. Cavitation, a mechanical bioeffect of diagnostic ultrasound, is generally divided into two categories. 'Stable' cavitation, as distinct from 'inertial' cavitation, is best described as:

A. A phenomenon unrelated to microbubbles at all

B. Microbubbles violently collapsing and releasing energy

C. Microbubbles oscillating in a sustained, non-collapsing pattern

D. A thermal, not mechanical, bioeffect

4. In addition to the standard tissue-mimicking distance/resolution phantom, many vascular labs also perform periodic QA using a dedicated flow phantom. What does a Doppler flow phantom specifically verify?

A. Accuracy of velocity measurement and flow detection

B. Only B-mode distance calibration

C. Transducer element crystal integrity

D. Monitor grayscale display calibration

5. As part of routine biomedical equipment maintenance, ultrasound systems undergo periodic electrical safety testing, including measurement of leakage current. What is the primary purpose of this test?

A. Verify Doppler velocity accuracy

B. Confirm image resolution meets specification

C. Calibrate the system's acoustic output power

D. Detect electrical hazard risk to patient and operator

6. Before performing an ultrasound-guided percutaneous liver biopsy, which action is a required part of appropriate procedural preparation, distinct from the routine diagnostic scan itself?

A. Disabling all Doppler modes for the entire case

B. Switching to a lower-frequency transducer only

C. Obtaining documented informed consent for the procedure

D. Increasing overall gain to maximum

7. A patient reports a known latex allergy prior to a transvaginal ultrasound exam. What is the most appropriate action regarding the endocavity transducer cover?

A. Use a non-latex probe cover material

B. Proceed with a standard latex cover regardless

C. Cancel the exam entirely

D. Use no cover at all for this patient

8. Immediately before an endocavity exam, the sonographer should visually and physically inspect the probe cover for which reason?

A. Detect tears or defects that would breach the infection barrier

B. Confirm the cover matches the patient's chart color-code

C. Verify the cover extends the transducer's operating frequency range

D. Ensure the cover increases acoustic output power

9. Ultrasound contrast agent manufacturers generally recommend imaging at a low Mechanical Index setting during contrast-enhanced studies. What is the primary reason for this recommendation?

A. Low MI is required to enable color Doppler

B. A high MI improves contrast agent stability

C. MI setting has no effect on microbubbles

D. A high MI prematurely destroys the microbubbles

10. Major professional ultrasound organizations (such as AIUM) have issued prudent-use statements regarding diagnostic ultrasound safety. These statements are generally based on which body of evidence?

A. Confirmed harm at all diagnostic exposure levels

B. No confirmed adverse bioeffects at typical diagnostic exposure levels

C. Confirmed harm only in obstetric patients

D. No research has ever been conducted on this topic

11. A shared multi-dose bottle of ultrasound coupling gel is used across multiple patients in a busy department. What is the recognized infection-control concern with this practice if not properly managed?

A. Only endocavity gel bottles carry this risk

B. Gel bottles have no recognized infection-control concern

C. Gel affects only image quality, never infection risk

D. The gel bottle nozzle can become a vector for cross-contamination

12. Elevational resolution, sometimes called slice-thickness resolution, refers to a system's ability to:

A. Distinguish two reflectors along the beam axis

B. Distinguish two reflectors side by side in-plane

C. Resolve detail perpendicular to the scan plane

D. Track a moving reflector over time

13. Temporal resolution in ultrasound imaging refers to a system's ability to:

A. Distinguish two closely spaced reflectors side by side

B. Distinguish two closely spaced reflectors along the beam

C. Accurately depict rapidly changing/moving structures over time

D. Resolve detail in the out-of-plane dimension

14. As the angle of an ultrasound beam striking an oblique tissue interface increases, at a certain specific angle known as the critical angle, what occurs?

A. The beam is transmitted with no bending at all

B. The beam is completely reflected; none is transmitted

C. The beam accelerates instantly to the speed of light

D. The beam's frequency doubles

15. A beam strikes an interface at a 30-degree angle of incidence. Medium 1 has a propagation speed of 1450 m/s and Medium 2 has a propagation speed of 1600 m/s. Using Snell's law ($\sin \theta_1 / \sin \theta_2 = c_1/c_2$), which statement about the refraction angle is correct?

A. The refraction angle equals the incidence angle exactly

B. The refraction angle is less than 30 degrees

C. The refraction angle cannot be determined from this data

D. The refraction angle is greater than 30 degrees, since $c_2 > c_1$

16. A pulse travels through 4 cm of tissue with an attenuation coefficient of 0.5 dB/cm/MHz, using a 5 MHz transducer. Approximately how much total attenuation (round-trip) has the pulse experienced?

A. Approximately 2.5 dB total

B. Approximately 5 dB total

C. About 20 dB, doubling the one-way value

D. Approximately 10 dB total

17. The two phases of a longitudinal sound wave, in which local pressure alternately rises above and falls below the ambient (resting) pressure, are called:

A. Amplitude and wavelength

B. Reflection and refraction

C. Absorption and scattering

D. Compression and rarefaction

18. As a general physical principle, how does increasing transducer operating frequency affect axial resolution, given the underlying relationship between frequency and wavelength?

A. Higher frequency has no relationship to wavelength at all

B. Higher frequency shortens wavelength, improving axial resolution

C. Higher frequency always worsens axial resolution

D. Frequency and axial resolution are entirely unrelated concepts

19. Acoustic power and acoustic intensity are related but distinct concepts. Which statement correctly distinguishes them?

A. Power is energy per unit time; intensity is power per unit area

B. Power and intensity are identical, interchangeable terms

C. Intensity is measured only in decibels, power only in watts

D. Power applies only to Doppler modes, intensity only to B-mode

20. Absorption, one of the mechanisms contributing to overall attenuation, refers specifically to:

A. Conversion of acoustic energy into heat within tissue

B. Redirection of the beam at an oblique interface

C. Reflection of the beam back toward the transducer

D. Random redirection of energy by small scatterers

21. A beam strikes a tissue interface with intensity 100 mW/cm^2. Medium 1 has impedance $Z1 = 1.5$ and Medium 2 has impedance $Z2 = 6.0$ (arbitrary matched units). Which statement about the reflected intensity is most accurate?

A. None of the beam is reflected; all is transmitted

B. Reflected intensity cannot depend on impedance at all

C. Exactly half is always reflected at any interface

D. A relatively large fraction is reflected, given the mismatch

22. When a smooth, sound wave reflects off a large, smooth interface (a specular reflector), the relationship between the angle of incidence and the angle of reflection follows which rule?

A. The angle of reflection is always 90 degrees regardless of incidence

B. There is no consistent relationship between the two angles

C. The angle of reflection equals the angle of incidence

D. The angle of reflection is always half the angle of incidence

23. Backscatter from tissue parenchyma, which produces the speckle pattern and gray-scale texture seen on B-mode images, arises primarily from scatterers that are:

A. Much larger than the ultrasound's wavelength itself

B. Small relative to the ultrasound wavelength (Rayleigh scattering)

C. Exactly equal in size to the wavelength

D. Composed only of gas, never soft tissue

24. The near zone (Fresnel zone) length of an unfocused transducer is calculated as $D^2/4\lambda$, where D is the transducer diameter and λ is wavelength. If diameter is doubled while wavelength stays constant, what happens to the near zone length?

A. It is quartered

B. It is halved

C. It stays exactly the same

D. It increases fourfold

25. Huygens' principle, a foundational concept in wave physics, states that:

A. Every point on a wavefront acts as a source of new secondary wavelets

B. Sound waves cannot interact with one another under any condition

C. Wavefronts travel only in a single fixed straight line forever

D. Frequency changes spontaneously as a wave propagates

26. Diffraction, a wave phenomenon relevant to ultrasound beam behavior, refers to:

A. The bending/spreading of a wave as it passes an edge or through an aperture

B. The complete absorption of a wave at any obstacle

C. A wave traveling in a perfectly straight line with no spreading

D. The reversal of a wave's direction upon striking any surface

27. Total attenuation of an ultrasound beam as it travels through tissue is the combined result of which set of mechanisms?

A. Reflection alone, with no other contributing mechanism

B. Absorption alone, with no other contributing mechanism

C. Absorption, scattering, and reflection together

D. Refraction alone, with no other contributing mechanism

28. In a phased array transducer, electronic beam steering and focusing are achieved primarily by:

A. Physically tilting the entire transducer housing

B. Applying precisely timed excitation delays across elements

C. Changing the transducer's crystal thickness in real time

D. Rotating a single mechanical crystal element

29. Dynamic receive focusing, a feature of modern array transducers, allows the system to:

A. Continuously adjust the receive focus as depth increases

B. Fix the receive focus permanently at one single depth

C. Eliminate the need for any transmit focal zones

D. Change the transducer's physical element count

30. When a phased array transducer steers its beam to a very large angle from the transducer's centerline, which recognized risk becomes more pronounced?

A. Improved axial resolution at all steered angles

B. Increased risk of grating lobe artifacts

C. Elimination of any need for a matching layer

D. A guaranteed increase in penetration depth

31. The 'F-number' of a focused transducer aperture is defined as the ratio of:

A. Element count divided by bandwidth

B. Frequency divided by wavelength

C. Focal length divided by aperture width

D. Backing thickness divided by matching layer thickness

32. The matching layer's thickness is deliberately designed according to which specific relationship to achieve optimal energy transmission?

A. Exactly equal to the wavelength in the crystal

B. Exactly equal to the patient's skin thickness

C. Randomly selected during manufacturing

D. Approximately one-quarter of the wavelength within the layer itself

33. During prolonged, high-duty-cycle scanning (such as an extended Doppler exam), the transducer itself, not just the patient, can experience a safety-relevant effect. What is this effect?

A. The transducer's frequency permanently increases with use

B. The transducer permanently loses its piezoelectric property after any use

C. The transducer automatically shuts off all imaging modes

D. The transducer face may become measurably warm from self-heating

34. Comparing a narrowband transducer to a broadband transducer of similar center frequency, the narrowband design generally offers which trade-off?

A. Better axial resolution but reduced overall bandwidth

B. Identical performance in every conceivable respect

C. Higher sensitivity at its frequency, but less resolution/flexibility

D. No difference in penetration at all

35. Manufacturers specify approved cleaning agents for transducer lenses because certain solutions, particularly those containing high concentrations of alcohol, can cause which problem?

A. Conversion of the transducer into an endocavity probe

B. An immediate, permanent increase in operating frequency

C. Spontaneous recalibration of the system's TGC curve

D. Degradation or cracking of the lens material over time

36. Before a newly purchased ultrasound transducer is placed into routine clinical service, best practice calls for which type of testing?

A. No testing is needed if the box is unopened

B. Acceptance testing against manufacturer specifications

C. Testing only after the first reported clinical problem

D. Testing performed exclusively by the sonographer using it

37. Grating lobe artifacts, arising from the periodic spacing of array elements, can be reduced by which transducer design technique?

A. Removing the backing material entirely

B. Increasing the spacing between elements as much as possible

C. Sub-dicing elements and applying apodization to the aperture

D. Using only a single large continuous crystal with no elements

38. All else being equal, an array transducer with a higher total element count compared with a lower-count array of the same footprint generally offers which practical trade-off?

A. Always lower image quality regardless of design

B. Automatically eliminates the need for any focal zones

C. No difference in cost or performance whatsoever

D. Improved beamforming flexibility/image quality, at higher manufacturing cost

39. Selecting an appropriate transducer frequency for a pediatric abdominal exam, compared with an adult of average body habitus, generally follows which rationale?

A. A dramatically lower frequency is always required regardless of body size

B. A higher frequency is often usable, since the shorter path length needs less penetration

C. Frequency selection is identical regardless of patient size

D. Only endocavity transducers are appropriate for pediatric patients

40. Backing material behind the piezoelectric element must balance two competing design goals. What is this fundamental trade-off?

A. Sensitivity is unaffected by backing design in any way

B. Backing material only affects operating frequency

C. Backing material has no effect on pulse length at all

D. More damping shortens the pulse (better axial resolution) but reduces sensitivity

41. Over time, repeated exposure to excessive heat or mechanical stress can cause a piezoelectric crystal to lose some of its piezoelectric property, a process related to exceeding its:

A. The system's frame rate limit

B. The Curie point (depolarization threshold)

C. The system's dynamic range setting

D. The system's wall filter threshold

42. Direct skin contact between the transducer face and the patient, without any coupling medium such as gel, results in which imaging consequence?

A. No consequence, since air does not affect ultrasound transmission

B. Near-total reflection of the beam at the skin-air interface, preventing useful imaging

C. Improved penetration due to reduced beam divergence

D. Automatic activation of a built-in standoff pad

43. A curvilinear (convex) array with a larger radius of curvature, compared with one with a smaller (tighter) radius of curvature, generally produces which difference in field of view?

A. A field of view that cannot expand with depth at all

B. An identical field of view regardless of radius

C. A narrower field of view that widens more gradually with depth

D. Complete elimination of any near-field artifact

44. Minimum element spacing (pitch) in an array transducer is generally kept at or below one-half wavelength primarily to:

A. Eliminate the need for a backing layer entirely

B. Maximize the transducer's total footprint size

C. Reduce the risk of grating lobe artifacts

D. Guarantee the highest possible frame rate regardless of settings

45. A duplex probe containing dedicated, separate continuous-wave (CW) crystals in addition to its standard imaging array allows the sonographer to:

A. Obtain true nonimaging CW Doppler from the same physical probe used for 2D imaging

B. Eliminate the Nyquist limit for pulsed-wave Doppler entirely

C. Automatically convert every pulsed Doppler signal into CW

D. Increase the imaging array's element count permanently

46. A system's PRF is set to 5000 Hz. Approximately what is the maximum imaging depth this PRF supports without range ambiguity, assuming a round-trip propagation speed constant of 77 microseconds/cm?

A. Approximately 1.3 cm

B. Depth cannot be estimated from PRF alone

C. Approximately 26 cm

D. Approximately 13 cm

47. Time Gain Compensation is typically adjustable not just as an overall depth-dependent boost, but as a customizable curve or slope. What is the clinical purpose of adjusting the TGC slope/curve shape, rather than simply raising overall gain?

A. To adjust the system's PRF automatically

B. To change the transducer's center operating frequency

C. To selectively compensate for uneven depth-specific attenuation

D. To eliminate the need for any focal zones

48. Log compression, applied during signal processing, serves which function in the imaging chain?

A. Compresses the wide range of echo amplitudes for display

B. Increases the transducer's actual transmitted output power

C. Converts the digital image back into raw RF data

D. Eliminates the ongoing clinical need for TGC

49. Envelope detection (demodulation), a step in ultrasound signal processing, functions by:

A. Setting the pulse repetition frequency automatically

B. Extracting amplitude information from the RF signal, discarding the carrier

C. Physically detecting a breach in the transducer's housing

D. Converting the image into a 3D volumetric dataset

50. Scan conversion is the processing step responsible for:

A. Transforming acquired beam-line data into the 2D raster/pixel display format

B. Physically converting one transducer type into another

C. Automatically correcting the sonographer's chosen Doppler angle

D. Increasing the transducer's element count in software

51. During scan conversion, gaps between the originally acquired scan lines (particularly evident in a sector-format image) are typically filled in using:

A. Complete deletion of any unscanned region

B. Interpolation, estimating pixel values between acquired lines

C. A second, entirely separate transducer

D. Manual pixel-by-pixel entry by the sonographer

52. Digital beamforming, used in modern ultrasound systems, differs from older analog beamforming primarily by:

A. Eliminating the need for any receive focusing at all

B. Applying delays/processing to digitized element signals via software

C. Requiring a single crystal instead of an array of elements

D. Removing the possibility of electronic beam steering

53. Which of the following correctly reflects the general order of the ultrasound signal processing chain, from initial echo reception to final display?

A. Display, then scan conversion, then beamforming, then receiver

B. Scan conversion, then transducer, then beamformer, then display

C. Transducer/beamformer, receiver processing, scan conversion, display

D. There is no consistent order; steps occur with no sequence

54. Trapezoidal (virtual convex) imaging on a linear array transducer allows the sonographer to:

A. Eliminate the need for any focal zones

B. Convert the linear array into a true curvilinear probe permanently

C. Electronically widen the field of view at depth beyond the array's width

D. Automatically increase the transducer's operating frequency

55. Contrast-specific imaging modes, used with ultrasound contrast agents, typically operate at a low Mechanical Index and use specialized processing (such as pulse inversion) to:

A. Increase the Mechanical Index as high as the system allows

B. Selectively display microbubble signal while suppressing tissue background

C. Convert the exam into a pure spectral Doppler study

D. Eliminate the transducer's transmit function entirely

56. A dual/split live display mode, showing two real-time images side by side (such as B-mode alongside color Doppler, or a pre- and post-contrast view), is primarily useful for:

A. Direct side-by-side comparison of two simultaneous views

B. Reducing the total number of transducers required

C. Automatically generating the final diagnostic report

D. Increasing output power in only one of the two images

57. During true duplex scanning (simultaneous real-time 2D imaging and pulsed Doppler acquisition), what trade-off does the system typically make to accommodate both functions at once?

A. Doppler mode is permanently disabled whenever 2D is active

B. 2D and/or Doppler update rate is reduced versus either mode alone

C. 2D image resolution improves automatically during duplex

D. No trade-off; both run at full independent speed

58. The gray-scale 'reject' control on an ultrasound system, distinct from the Doppler reject control, functions by:

A. Increasing the transducer's transmit frequency

B. Adjusting the color Doppler baseline

C. Setting an amplitude threshold excluding weak B-mode signals

D. Automatically correcting an inappropriate Doppler angle

59. A sonographer notices that a superficial structure appears saturated and washed out on B-mode, while a deep structure in the same image appears appropriately visualized. Which control should be adjusted first, and why?

A. Near-field TGC, since the problem is depth-specific

B. Overall gain, since the entire image is equally affected

C. Transducer frequency, always resolves brightness issues

D. Color Doppler scale, a grayscale-only issue

60. Diagnostic ultrasound systems generally must accommodate an extremely wide dynamic range of returning echo amplitudes. This overall system dynamic range is typically on the order of:

A. Approximately 5-10 dB

B. Approximately 20-30 dB

C. Dynamic range is not measured in decibels

D. Approximately 100-160 dB

61. A sonographer is scanning a rapidly moving fetal heart and needs to prioritize temporal resolution over depth-range lateral resolution. Which focal zone strategy best supports this priority?

A. Disable focal zones entirely, since they are optional

B. Use the maximum number of focal zones allowed

C. Use a single focal zone rather than multiple

D. Focal zone count has no effect on this trade-off

62. B-flow imaging, a non-Doppler technique for visualizing blood flow, functions by:

A. Requiring contrast agent administration in every case

B. Calculating a Doppler shift exactly as color Doppler

C. Directly displaying enhanced grayscale reflections from moving blood cells

D. Replacing B-mode entirely with a spectral waveform

63. Pulse inversion, a specific harmonic imaging processing technique, works by:

A. Reversing the direction of the beam after transmission

B. Transmitting two opposite pulses, summing to cancel fundamental signal

C. Inverting the display's color map from red to blue

D. Temporarily doubling the transducer's total element count

64. Spatial Peak Temporal Average intensity (Ispta), one of several acoustic output intensity metrics displayed or tracked by ultrasound systems, is best described as:

A. A metric unrelated to acoustic output or bioeffects

B. The lowest intensity found anywhere in the field of view

C. A measurement exclusively of Doppler-mode gain settings

D. The time-averaged intensity at the beam's highest-intensity location

65. Most ultrasound systems display an on-screen marker indicating the current focal zone depth(s). What is the primary clinical purpose of this marker?

A. Displaying the system's current PRF value numerically

B. Indicating the current Doppler angle being used

C. Helping position the region of interest at best-lateral-resolution depth

D. Showing the transducer's serial number for tracking

66. A-mode (amplitude mode), an early and largely historical ultrasound display format, presents information as:

A. A two-dimensional grayscale cross-sectional image

B. A continuously updating three-dimensional volume

C. Echo amplitude (spike height) versus depth along one beam line

D. A color-encoded velocity map

67. 'Ring-down' artifact, a specific reverberation subtype most classically associated with gas bubbles (such as in bowel), is best described as:

A. A discrete series of widely spaced, distinct parallel lines

B. An artifact exclusively associated with metallic foreign bodies

C. An artifact occurring only in the far field, never near the transducer

D. A solid, continuous bright streak deep to gas, from resonance in fluid trapped between bubbles

68. A bright horizontal band of increased echogenicity appearing across the image specifically at the depth of the current focal zone, most apparent when only a single narrow focal zone is used, is best explained as:

A. A true pathologic finding requiring further clinical workup

B. Direct evidence of a transducer element malfunction

C. A sign the system's PRF is set too low

D. An artifact from the beam's narrowest, most concentrated width

69. Anisotropy artifact, commonly encountered when scanning tendons or other highly organized fibrous structures, is best described as:

A. A permanent, angle-independent loss of tissue echogenicity

B. Echogenicity artifactually changing with insonation angle, falsely appearing hypoechoic

C. An artifact seen exclusively in fluid-filled structures

D. A form of reverberation between two metallic surgical clips

70. A sonographer identifies posterior acoustic shadowing deep to a focal liver lesion and must determine whether this represents true attenuation from dense pathology (such as calcification) or an artifactual refractive shadow from the lesion's curved edge. Which finding would favor a refractive rather than true attenuation-based shadow?

A. The shadow is centered directly posterior to the lesion, broad and consistent

B. There is no way to distinguish these two causes by any imaging feature

C. The shadow contains no internal echoes whatsoever, consistent with either cause

D. The shadow arises specifically from the lateral margins of a curved structure, sparing the central posterior region

71. Comparing the posterior shadow deep to a densely calcified structure with the posterior shadow deep to a loop of gas-filled bowel, what key visual difference should the sonographer expect?

A. Neither structure is capable of producing any posterior shadow

B. Both produce visually identical shadows in every case

C. Gas-filled bowel always produces the visually cleaner shadow

D. Calcification produces a clean shadow; gas produces a dirty one

72. A sonographer sees a solid-appearing, tapering bright echo deep to a tiny reflective focus and must decide whether it represents comet-tail artifact or ring-down artifact. Which distinguishing feature most reliably differentiates the two?

A. Comet-tail occurs only far field; ring-down only near field

B. The two artifacts are indistinguishable and clinically interchangeable

C. Comet-tail arises from solid reflectors, tapers; ring-down from gas

D. Ring-down is caused exclusively by metallic foreign bodies, never gas

73. Adaptive (spatial) speckle-reduction filtering, while generally improving perceived image smoothness, carries which recognized clinical caution?

A. It exclusively affects Doppler images only, never grayscale

B. It has no possible negative clinical consequence at any setting

C. It always improves diagnostic accuracy, regardless of setting used

D. It can smooth away real lesion texture if overly aggressive

74. Frequency compounding, distinct from spatial (angle) compounding, reduces speckle by:

A. Transmitting and/or receiving at multiple frequencies and combining the resulting images

B. Steering the beam through multiple different angles and averaging those views

C. Averaging multiple sequential time-separated frames from a fixed angle and frequency

D. Applying only postprocessing edge enhancement to a single acquired frame

75. A sonographer struggles with excessive noise/clutter specifically in the near field of a technically difficult patient, while the far field appears clean. Which adjustment is the most appropriate first troubleshooting step, contrasted with a far-field noise problem?

A. Increase overall gain uniformly across the entire image

B. Decrease near-field TGC and/or apply modest persistence, rather than adjusting overall gain

C. Switch to a lower-frequency transducer to fix the near field specifically

D. Increase the number of focal zones to the system maximum

76. Volumetric 3D datasets can be displayed either as a rendered surface (surface rendering) or as multiple simultaneous 2D planes (multiplanar reconstruction, MPR). What is the key distinction between these two display approaches?

A. Surface rendering shows a shaded 3D surface; MPR shows orthogonal 2D planes

B. The two terms actually describe exactly the same display technique

C. MPR is only usable with 2D imaging, never a 3D dataset

D. Surface rendering simply cannot be generated from an acquired volume

77. A vessel has a true flow velocity of 50 cm/s. The transducer operates at 5 MHz, propagation speed is 1540 m/s, and the Doppler angle is 60 degrees (cos 60° = 0.5). Approximately what Doppler shift frequency results?

A. Approximately 1620 Hz

B. Approximately 3240 Hz

C. Approximately 810 Hz

D. The shift cannot be calculated from this data

78. A pulsed Doppler system has a PRF of 6000 Hz. What is the Nyquist limit for this system, expressed as a Doppler shift frequency?

A. 6000 Hz

B. 3000 Hz

C. 1500 Hz

D. 12000 Hz

79. A sonographer raises the PRF significantly to avoid aliasing on a high-velocity arterial jet, while also imaging at a fairly deep location. What secondary risk does this PRF increase introduce?

A. Improved axial resolution with no other consequence

B. A guaranteed increase in Doppler sensitivity with no trade-off

C. Elimination of the wall filter's function entirely

D. Increased risk of range ambiguity at depth

80. Multigate pulsed Doppler, a specialized technique distinct from standard single-gate PW Doppler, allows the sonographer to:

A. Sample only a single fixed point, same as standard PW

B. Eliminate the Nyquist limit entirely for all velocities

C. Convert PW Doppler into true CW Doppler automatically

D. Sample velocity at multiple depths, generating a profile

81. Vector Doppler and other angle-independent Doppler techniques aim to overcome which fundamental limitation of conventional Doppler ultrasound?

A. The requirement for phased array transducers only

B. The need to know the transducer's operating frequency

C. Dependence of the Doppler equation on a known angle

D. The basic requirement for a coupling gel

82. Automatic Doppler angle-correction assist features, available on some modern systems, are designed to:

A. Eliminate the need for the sonographer to select a sample volume location

B. Suggest or apply an angle-correction cursor placement to reduce operator-dependent angle estimation error

C. Automatically increase the transmitted acoustic power

D. Replace the need for any Doppler angle correction entirely, at any angle

83. When a Doppler waveform is aliasing and the sonographer wishes to correct it without changing the velocity scale, adjusting the baseline can help. In what specific circumstance is a baseline shift, rather than increasing the scale/PRF, the more appropriate fix?

A. In every aliasing scenario, baseline shift always works best

B. When flow is unidirectional, shifting baseline gives the peak room

C. Only when the flow is purely bidirectional with no dominant direction

D. Baseline shift can never resolve aliasing under any circumstance

84. A sonographer notices that widening the pulsed Doppler sample volume (gate length) in an otherwise normal, non-turbulent vessel produces a spectral waveform with more apparent spectral broadening. What best explains this observation?

A. Sample volume size has no real relationship to broadening

B. This always indicates true pathologic turbulence requiring immediate workup

C. A larger sample volume captures a wider velocity range, mimicking broadening

D. This finding proves the wall filter is set incorrectly

85. A sonographer is evaluating a suspected near-occlusive arterial thrombus and is concerned about missing a small residual trickle of flow. Which wall filter approach is most appropriate in this specific clinical context?

A. Use the lowest wall filter setting to maximize slow-flow sensitivity

B. Use the highest wall filter setting to eliminate noise

C. Wall filter setting is irrelevant to detecting near-occlusive flow

D. Disable Doppler entirely and rely on B-mode alone

86. Beyond adjusting scale, baseline, or transmitted frequency, which additional practical technique can sometimes resolve Doppler aliasing?

A. Simply increasing overall B-mode gain setting only

B. Turning off the ultrasound system entirely and restarting it

C. Switching to grayscale-only imaging, which has no Doppler function

D. Repositioning the transducer for a more favorable Doppler angle

87. The renal-aortic ratio (RAR), a Doppler-derived index sometimes used in evaluating renal artery stenosis, is calculated as:

A. Renal artery peak systolic velocity divided by aortic peak systolic velocity

B. Renal vein velocity divided by renal artery velocity

C. Aortic diameter divided by renal artery diameter

D. Renal resistive index divided by aortic resistive index

88. The ductus venosus, a fetal circulatory shunt vessel distinct from the umbilical artery, is assessed by Doppler primarily to evaluate:

A. Fetal cardiac preload and cardiovascular compromise signs

B. Assessment of maternal renal artery stenosis

C. Assessment of adult hepatic vein pathology

D. Postnatal patent ductus arteriosus closure only

89. Reversal of flow direction in the ophthalmic artery, detected on Doppler, is a recognized indirect sign of which condition?

A. Normal physiologic variant requiring no further evaluation

B. Isolated ophthalmic pathology unrelated to the carotid system

C. A finding of isolated renal artery stenosis

D. Severe proximal ICA stenosis, with retrograde collateral flow

90. The continuity equation, used to calculate valve area (such as aortic valve area) from Doppler and 2D measurements, is based on which underlying physical principle?

A. A cavitation threshold specifically at the valve surface

B. Total attenuation is identical on both sides of the valve

C. The Doppler angle is always assumed to be 90 degrees

D. Volumetric flow rate is equal on both sides of an orifice

91. On a spectral Doppler display, whether a waveform appears above or below the baseline is determined by:

A. Flow direction relative to the transducer, by convention

B. The patient's heart rate value exclusively

C. The transducer's operating frequency value exclusively

D. Random assignment with no consistent meaning

92. During a Doppler exam, adjusting the spectral Doppler gain has which specific effect, as distinct from adjusting the separate color Doppler gain?

A. It affects only the spectral waveform trace's brightness/sensitivity

B. It automatically also adjusts the color Doppler gain to match

C. It has no effect on the Doppler display at all

D. It exclusively and only changes B-mode grayscale gain

93. The spectral Doppler 'sweep speed' control adjusts which aspect of the displayed waveform?

A. The system's frame rate for 2D imaging

B. How quickly the waveform trace scrolls across the screen

C. The current selected Doppler angle correction value

D. The current transmitted acoustic output power level

94. A specific spectral Doppler artifact, in which a symmetric mirrored copy of the true waveform falsely appears on the opposite side of the baseline (distinct from true bidirectional flow), most classically occurs in which setting?

A. Only when the wall filter is set lowest

B. Exclusively in patients with normal, entirely healthy vasculature

C. Only when using continuous-wave Doppler, never pulsed Doppler

D. When a strong nearby reflector causes a false mirrored trace

95. Color Doppler signal deep to a densely calcified atherosclerotic plaque characteristically demonstrates which appearance?

A. Enhanced, brighter color signal directly deep to the plaque

B. No change whatsoever in the color signal appearance

C. Loss or dropout of color signal deep to the plaque, analogous to B-mode acoustic shadowing

D. A color signal that perfectly matches the true flow velocity regardless of the plaque

96. A sonographer is troubleshooting a color Doppler image with poor color frame rate. Considering box size, depth, and packet size together, which combined adjustment would most effectively improve color frame rate?

A. Widen the color box to cover the entire image

B. Narrow the color box and reduce packet size, trading precision

C. Increase packet size as high as possible for maximum accuracy

D. Increase imaging depth well beyond what's clinically needed

97. As with B-mode imaging, the Doppler signal itself is subject to depth-dependent attenuation. What practical consequence does this have for Doppler exams of deep structures?

A. Doppler signal strength is completely unaffected by depth, unlike B-mode

B. Deeper vessels may require increased Doppler gain or a lower transducer frequency to maintain adequate signal

C. Deeper vessels always require an automatic switch to CW Doppler

D. Attenuation affects only the returning B-mode echo, never the Doppler shift signal

98. A sonographer is having difficulty obtaining an adequate spectral Doppler waveform in a technically difficult patient. Considered together, which combination of adjustments represents a reasonable, systematic troubleshooting approach?

A. Increase transmitted power indefinitely until a waveform appears, regardless of ALARA

B. Adjust only the color box size, the sole control

C. Systematically optimize gain, PRF/scale, wall filter, and sample volume together

D. There is no useful systematic approach; results are essentially random

99. In the underlying Doppler equation, the calculated Doppler shift carries a mathematical sign (positive or negative) in addition to its magnitude. What does this sign convention represent?

A. Whether the sonographer is right- or left-handed

B. The patient's specific heart rate value

C. The transducer's manufacturing serial batch

D. The direction of flow relative to the transducer (toward vs away)

100. The Ankle-Brachial Index (ABI), a Doppler-derived clinical index used to screen for peripheral arterial disease, is calculated as:

A. Brachial systolic pressure divided by ankle systolic pressure

B. Ankle systolic pressure divided by brachial (arm) systolic pressure

C. Ankle diastolic pressure divided by ankle systolic pressure

D. Peak systolic velocity at the ankle divided by peak systolic velocity at the brachial artery

101. In a patient with heavily calcified, non-compressible arteries where ankle cuff pressures may be falsely elevated and unreliable, which alternative Doppler-derived index is often used instead of the standard ABI?

A. The Toe-Brachial Index (TBI), less prone to calcification error

B. The Resistive Index (RI) at the renal artery

C. The current color variance map display value

D. There is no alternative index available in this situation

102. Comparing Doppler evaluation of a dialysis arteriovenous (AV) graft with that of a native AV fistula, which distinguishing consideration is most relevant?

A. A synthetic graft has no recognizable normal waveform pattern

B. Grafts and fistulas are anatomically and hemodynamically identical

C. Doppler surveillance is only ever performed on fistulas, never grafts

D. A synthetic graft's differing compliance yields a different waveform; graft-specific criteria apply

103. During venous duplex evaluation for suspected venous insufficiency, a Valsalva maneuver or manual distal augmentation is used primarily to assess for:

A. Arterial stenosis proximal to the vein being examined

B. Whether the vein is a superficial or deep structure

C. The vein's absolute diameter measurement only

D. Reflux — reversed, prolonged retrograde flow indicating valvular incompetence

104. Distinguishing complete arterial occlusion from severe (but non-occlusive) stenosis on Doppler, which waveform finding is most specific for complete occlusion at the site examined?

A. Complete absence of any detectable signal, despite optimized technique

B. A normal triphasic waveform at that exact site

C. A monophasic, blunted (tardus parvus) waveform at that site

D. A waveform with normal systolic velocity, reduced diastolic flow

105. In post-liver-transplant Doppler surveillance, serial hepatic artery resistive index (RI) measurements are monitored primarily to help detect which complications?

A. Renal artery stenosis in the transplanted kidney

B. Isolated portal vein flow direction only, unrelated to the hepatic artery

C. Ophthalmic artery collateral flow

D. Hepatic artery thrombosis or rejection-related vascular changes

106. Varicocele, a common scrotal vascular condition evaluated with Doppler ultrasound, is characterized by which finding?

A. Dilated pampiniform plexus veins with venous reflux, often augmented by Valsalva maneuver

B. Complete absence of testicular arterial flow bilaterally

C. A finding exclusively seen on the right side, never the left

D. Elevated, not diminished, arterial resistive index within the testicle

107. Transcranial Doppler (TCD), used to assess intracranial arterial flow (such as the middle cerebral artery) through a limited acoustic window, differs from standard extracranial carotid duplex primarily by:

A. Requiring no knowledge of the Doppler equation at all

B. Being performed exclusively with a linear array transducer

C. Insonating intracranial vessels through a limited bony window

D. Measuring only B-mode grayscale anatomy, with no Doppler component

108. Doppler evaluation for suspected deep vein thrombosis (DVT) relies primarily on which combination of techniques?

A. Vein compressibility testing combined with color/spectral Doppler assessment

B. Spectral Doppler alone, with compressibility testing considered irrelevant

C. Measuring only the adjacent artery, never the vein itself

D. A single Valsalva maneuver alone, with no other technique required

109. A patient with atrial fibrillation and an irregularly irregular heart rhythm undergoes a Doppler exam of the common carotid artery. What technical consideration is most relevant to obtaining a representative velocity measurement in this setting?

A. Rhythm irregularity has no effect on Doppler measurements whatsoever

B. Beat-to-beat variability from irregular R-R intervals may require averaging cycles

C. Only a single, arbitrarily chosen beat should ever be measured

D. Atrial fibrillation makes any Doppler measurement of this vessel impossible

110. A clinical scenario calls for evaluating a very high-velocity stenotic jet, distinguishing arterial from venous flow directionally, and localizing exactly which of two adjacent vessels a signal originates from. Which combination of Doppler modalities is best suited to fully address all three needs together?

A. CW Doppler alone is sufficient for all three needs simultaneously

B. CW for the jet, color for direction, PW-gated for localization

C. Color Doppler alone is sufficient for all three needs simultaneously

D. Power Doppler alone is sufficient for all three needs simultaneously

Answers

1. B. B. TIC (cranial thermal index) is the appropriate subtype when bone lies close to the transducer face early in the beam path, as in transcranial/neonatal head imaging, since it accounts for heating at a near-field bone surface. TIS (A) is used when the beam path is entirely soft tissue with no bone in range. TIB (C) applies when bone is at or near the focus but deeper in the field, not immediately at the surface. TI absolutely has defined subtypes based on tissue path (contradicting D).

2. A. A. MI is derived from the peak negative (rarefactional) pressure of the pulse divided by the square root of frequency, and it estimates the likelihood of a mechanical bioeffect — cavitation — occurring at the current output setting. Duty factor and thermal risk (B) is the basis for the Thermal Index instead, not MI. PRF and range ambiguity (C) is an imaging-artifact concept unrelated to bioeffect indices. Beam width and resolution (D) is an imaging-quality parameter, not a bioeffect index.

3. C. C. Stable cavitation refers to microbubbles that oscillate in size in response to the pressure wave without collapsing, a generally lower-risk pattern. Inertial cavitation (B) is the more violent, higher-risk form, in which bubbles expand and then collapse forcefully, releasing energy that can damage nearby tissue. Cavitation is fundamentally a microbubble phenomenon, not unrelated to them (contradicting A), and it is specifically classified as a mechanical, not thermal, bioeffect (contradicting D).

4. A. A. A Doppler flow phantom circulates a blood-mimicking fluid at a known, controlled velocity through a tube, allowing the system's Doppler-derived velocity measurements and flow detection sensitivity to be checked against that known reference value — a QA function distinct from the geometric distance/resolution checks performed with a static tissue-mimicking phantom. It does not test B-mode distance calibration alone (B, that is the static phantom's role), transducer element integrity (C, which uses a different dedicated test), or grayscale monitor calibration (D, a separate display QA process).

5. D. D. Leakage current testing is an electrical safety check that detects unsafe amounts of current that could flow from the equipment chassis or patient-contact surfaces, which is a recognized shock hazard risk to the patient or operator if excessive — a biomedical engineering safety requirement separate from image-quality QA. It is not a Doppler accuracy check (A) or resolution check (B), which use phantoms instead, and it is an electrical safety test, not an acoustic output calibration (C).

6. C. C. Any invasive procedure, including an ultrasound-guided biopsy, requires documented informed consent describing the risks, benefits, and alternatives before it is performed — a procedural and legal/ethical requirement distinct from routine diagnostic scanning. Transducer frequency selection (B) is a technical imaging choice, not a procedural prerequisite. Doppler is often still used during biopsy guidance to avoid vascular structures, not routinely disabled entirely (contradicting A), and maximum gain (D) is not a procedural safety requirement.

7. A. A. Because standard probe covers may be made of latex, a documented latex allergy requires substituting a non-latex (e.g., polyurethane) cover material to avoid triggering an allergic reaction, while still allowing the clinically necessary exam to proceed safely. Using a latex cover anyway (B) risks a reaction. Canceling the exam outright (C) is unnecessary when a safe alternative cover exists. Using no cover at all (D) is inappropriate, since a barrier is still required for infection control regardless of cover material.

8. A. A. A probe cover inspection immediately before use checks for any tear, pinhole, or manufacturing defect that would compromise its function as an infection-control barrier between the disinfected/sterile transducer and mucous membrane contact, since an undetected breach could permit cross-contamination despite proper disinfection. This has nothing to do with a chart color-code system (B), does not alter the transducer's operating frequency (C), and does not affect acoustic output power (D) — the cover is a barrier, not a functional acoustic component.

9. D. D. At higher Mechanical Index settings, the acoustic pressure is enough to rupture or destroy the gas-filled microbubbles composing the contrast agent, prematurely eliminating the very signal the exam depends on; using a low MI setting preserves bubble integrity and allows sustained real-time contrast visualization. This is the opposite of improving stability at high MI (contradicting B), MI setting very much affects microbubble survival (contradicting C), and low MI is not a prerequisite for enabling color Doppler, which is an unrelated mode-selection setting (contradicting A).

10. B. B. Prudent-use statements from professional bodies are grounded in a substantial body of research indicating that no confirmed adverse bioeffects have been demonstrated in humans at the acoustic output levels typically used in diagnostic ultrasound, which is precisely why ALARA is recommended as a precaution rather than because harm has been proven. This directly contradicts a claim of confirmed harm at all exposure levels (A) or specifically in obstetric patients (C), and a substantial body of bioeffects research does in fact exist, contradicting the claim of no research at all (D).

11. D. D. Multi-dose coupling gel bottles, if not handled properly (e.g., nozzle contacting skin, inadequate bottle hygiene, or use of non-sterile gel on non-intact skin or mucous membranes), have been documented as a vector for bacterial cross-contamination between patients, which is why proper gel handling and, where indicated, single-use or sterile gel are part of infection-control practice. This is a real, recognized concern, not absent (contradicting B), gel handling is an infection-control issue as well as an image-quality one (contradicting C), and the underlying contamination risk applies to gel bottles generally, not solely to endocavity-specific bottles (contradicting A).

12. C. C. Elevational resolution describes resolution in the dimension perpendicular to the 2D scan plane (out of plane, sometimes called slice thickness), controlled largely by the acoustic lens and elevational focus of the array — a separate concept from axial (along the beam) or lateral (in-plane, side to side) resolution. Distinguishing reflectors along the beam axis (A) describes axial resolution instead. In-plane side-by-side distinction (B) describes lateral resolution. Tracking a moving reflector over time (D) relates to temporal resolution, not elevational.

13. C. C. Temporal resolution reflects how well a system can depict a rapidly changing or moving structure accurately in real time, and it is directly tied to frame rate — a higher frame rate provides better temporal resolution, capturing motion (e.g., a beating heart valve) with less blurring or lag. Distinguishing reflectors along the beam (B) describes axial resolution, side-by-side in-plane distinction (A) describes lateral resolution, and out-of-plane detail (D) describes elevational resolution — each a spatial, not temporal, resolution concept.

14. B. B. The critical angle is the specific angle of incidence at which the refracted beam would theoretically travel exactly along the interface (a 90-degree refraction angle); at or beyond this angle, no beam is transmitted into the second medium at all, and total internal reflection occurs instead, sending all energy back into the first medium. This is the opposite of transmission with no bending (A, which describes a perpendicular, not critical, angle scenario), it has nothing to do with the speed of light (C, an unrelated and physically impossible claim for sound), and frequency does not change with angle of incidence (D).

15. D. D. Snell's law shows that when the beam passes into a medium with a higher propagation speed ($c2 > c1$, here $1600 > 1450$ m/s), the refraction angle must be larger than the incidence angle to satisfy $\sin \theta 2 = \sin \theta 1 \times (c2/c1)$, a ratio greater than 1. This directly contradicts the refraction angle being smaller than 30 degrees (B) or exactly equal to it (A, which would only occur if $c1 = c2$), and the data given (both speeds and the incidence angle) is sufficient to determine the relationship, contradicting the claim it cannot be determined (C).

16. C. C. One-way attenuation = attenuation coefficient × frequency × distance = 0.5 dB/cm/MHz × 5 MHz × 4 cm = 10 dB one-way; because the pulse travels the distance twice (out and back) before being received, round-trip attenuation is approximately double the one-way value, or about 20 dB. Option D (10 dB) is the one-way value only, mistakenly presented as the total. Options A and B are each roughly one-quarter and one-half of the correct one-way figure, consistent with arithmetic errors rather than the correct calculation.

17. D. D. A longitudinal sound wave consists of alternating zones of compression, where local pressure and particle density rise above ambient, and rarefaction, where they fall below ambient — this compression-rarefaction cycle is the fundamental physical basis of an acoustic wave traveling through a medium. Reflection and refraction (B) are beam-interface interactions, not the wave cycle itself. Absorption and scattering (C) are attenuation mechanisms. Amplitude and wavelength (A) are wave properties/measurements, not the two alternating pressure phases themselves.

18. B. B. Because wavelength is inversely related to frequency (wavelength = propagation speed ÷ frequency), a higher operating frequency produces a shorter wavelength; since axial resolution is fundamentally governed by spatial pulse length, which is proportional to wavelength (SPL = cycles per pulse × wavelength), a shorter wavelength from higher frequency generally supports finer (better) axial resolution, all else being equal. This directly contradicts a claim of no relationship (A) or complete unrelatedness (D), and higher frequency improves rather than worsens axial resolution as described, contradicting C — the actual trade-off with higher frequency is reduced penetration, not worse axial resolution.

19. A. A. Acoustic power is the rate of energy transfer (energy per unit time, measured in watts), while intensity further divides that power by the cross-sectional area of the beam (power per unit area, e.g., W/cm^2) — intensity accounts for how concentrated that power is over a given beam area, which is why a narrow, focused beam can have high intensity even at modest total power. They are not interchangeable (contradicting B); both can be expressed in absolute units or as a decibel ratio relative to a reference, so the units distinction in C is not a valid basis for differentiating them, and both concepts apply generally across imaging modes, not split by mode as claimed in D.

20. A. A. Absorption is the specific attenuation mechanism in which acoustic (mechanical) energy is converted into heat as it travels through tissue, distinct from scattering or reflection, which redirect energy rather than converting it to a different energy form. Oblique-interface redirection (B) describes refraction, not absorption. Reflection back toward the transducer (C) is a separate attenuation-contributing mechanism (specular reflection), and random redirection by small scatterers (D) describes scattering, not absorption — though all three (absorption, scattering, and reflection) together make up total attenuation.

21. D. D. The reflection coefficient depends on the impedance mismatch between the two media — a larger difference between Z1 and Z2 produces a larger fraction of reflected intensity; here, Z2 is four times Z1, a substantial mismatch, so a relatively large fraction (not all, but more than a small fraction) of the incident intensity would be reflected. This contradicts the claim that none is reflected (A, which would require Z1 = Z2, no mismatch) or that all is reflected implicitly assumed impossible here, the claim that exactly half is always reflected regardless of impedance (C, which is not how the reflection coefficient formula works), and impedance is in fact the primary determinant of reflected intensity, contradicting B.

22. C. C. For a specular (mirror-like) reflection off a smooth interface, the law of reflection states that the angle of reflection equals the angle of incidence, both measured from the normal (perpendicular) to the interface — this predictable relationship is what allows techniques like heel-toeing the transducer to optimize a specular reflection's return path. It is not fixed at 90 degrees regardless of incidence (A), the relationship is entirely consistent and predictable, not absent (contradicting B), and it is not simply half the incidence angle (D), which does not describe the actual physical law.

23. B. B. Rayleigh scattering occurs when the scattering structures (such as the small cellular and structural elements within organ parenchyma) are small relative to the ultrasound wavelength, causing energy to be redirected in many directions rather than reflected in one predictable specular direction — this is the physical basis for the diffuse backscatter that produces parenchymal texture and speckle. Large scatterers relative to wavelength (A) tend to behave more like specular reflectors instead. Scatterers exactly equal to wavelength (C) does not describe the Rayleigh scattering regime. Rayleigh scattering is a general size-dependent phenomenon, not exclusive to gas (contradicting D).

24. D. D. Because near zone length is proportional to the square of the diameter (D^2), doubling D increases D^2 by a factor of four ($2^2 = 4$), and since wavelength is unchanged, the near zone length increases fourfold as well. This directly contradicts a decrease (A or B) or no change at all (C) — diameter has a strong, squared effect on near zone length, not a negligible one.

25. A. A. Huygens' principle states that every point on an existing wavefront can be treated as a source of new secondary spherical wavelets, and the new wavefront a moment later is the envelope (tangent surface) of all those secondary wavelets — a foundational concept used to explain wave phenomena such as diffraction and the construction of a transducer array's combined beam from many individual element wavelets. This directly contradicts a claim that waves cannot interact (B), since wave interaction/interference is central to the principle; wavefronts do not travel only in a fixed straight line forever, as diffraction and spreading demonstrate (contradicting C); and frequency does not spontaneously change during propagation in a uniform medium (contradicting D).

26. A. A. Diffraction is the bending and spreading of a wave as it encounters an edge, obstacle, or passes through an aperture (such as the transducer face itself), and it is part of why an ultrasound beam naturally diverges in the far field beyond the focal zone rather than remaining a perfectly parallel column. It does not describe complete absorption at an obstacle (B, that is more related to attenuation), it is essentially the opposite of a wave traveling with no spreading at all (contradicting C, which diffraction specifically explains the departure from), and it does not describe simple reversal of direction upon striking a surface, which would instead describe a form of reflection (contradicting D).

27. C. C. Total attenuation is the sum of all mechanisms that remove energy from the beam as it travels: absorption (conversion to heat), scattering (redirection by small structures), and reflection (redirection at larger interfaces) together account for the progressive loss of beam intensity with depth. Absorption alone (B), reflection alone (A), or refraction alone (D) each describe only a single contributing phenomenon — refraction in particular bends the beam's path rather than removing energy from it, so it is not typically classified as a component of attenuation at all, further distinguishing it from the three true attenuation mechanisms in option C.

28. B. B. Phased array transducers steer and focus the beam electronically by firing individual elements with precisely timed (phased) delays, so that the resulting combined wavefront constructively interferes in the desired direction and depth — no physical motion of the transducer is required. Physically tilting the housing (A) is how a sonographer changes scan plane manually, not how the array itself steers electronically. Crystal thickness is fixed by manufacturing and does not change in real time (contradicting C), and phased arrays do not rely on a single rotating mechanical element, which instead describes an older mechanical sector transducer (contradicting D).

29. A. A. Dynamic receive focusing continuously adjusts the effective focus of the receiving beamformer as echoes return from progressively greater depths, since the optimal receive focus changes with depth — this differs from transmit focusing, which is generally fixed at the moment of transmission for a given focal zone. It does not fix receive focus at one single depth (B, the opposite of 'dynamic'), it does not eliminate the separate need for transmit focal zone selection (C, which remains a distinct transmit-side setting), and it has no effect on the transducer's physical element count, a fixed hardware property (D).

30. B. B. As steering angle increases toward the extremes of a phased array's range, grating lobes (secondary beams arising from the periodic element spacing) become more prominent and more likely to intersect strong reflectors at unintended angles, increasing the risk of grating lobe artifacts appearing in the image — a known practical limitation on how far a phased array can usefully steer. Steering angle does not improve axial resolution (A, an unrelated SPL-based property), does not eliminate the ongoing need for a matching layer (C), and does not guarantee increased penetration depth, which depends on frequency and attenuation, not steering angle (D).

31. C. C. F-number (f/#) = focal length ÷ aperture width, a ratio borrowed from optics that relates how tightly a beam is focused relative to the size of the aperture producing it; a lower F-number (relatively wide aperture for a given focal length) generally produces a narrower focal beam width and better lateral resolution at the focus. It is not a ratio of frequency to wavelength (B, which instead defines propagation speed), not a ratio of element count to bandwidth (A), and not a ratio involving backing or matching layer thickness (D), which are separate transducer construction properties.

32. D. D. The matching layer is engineered to a thickness of approximately one-quarter wavelength (at the operating frequency, measured within the matching layer material itself); this specific quarter-wavelength thickness causes reflections at the front and back of the layer to interfere constructively in a way that maximizes transmission of energy into the patient, minimizing energy reflected back into the transducer. It is not designed to equal a full wavelength in the crystal (A), has no relationship to a specific patient's skin thickness (B, which varies per patient while the layer is fixed by manufacturing), and is a precisely engineered dimension, not a random manufacturing choice (contradicting C).

33. D. D. Extended high-duty-cycle operation (as in prolonged spectral or color Doppler use) can cause measurable self-heating of the transducer face itself, in addition to any patient tissue heating, which is why manufacturers specify transducer surface temperature limits as part of equipment safety standards, separate from patient-focused bioeffect indices like TI. This is a temporary, use-dependent warming effect, not a permanent loss of piezoelectric property after any single use (contradicting B), systems do not automatically disable imaging simply from duty cycle (contradicting C), and operating frequency is a fixed design property that does not permanently shift from use-related heating (contradicting A).

34. C. C. A narrowband transducer concentrates its energy within a narrower range of frequencies, which can improve sensitivity (signal strength) at that specific frequency, but this comes at the cost of a longer pulse (poorer axial resolution, since axial resolution improves with shorter, broader-bandwidth pulses) and less ability to shift frequency for frequency-agile scanning compared with a broadband design. This is essentially the reverse trade-off implied by option A (which incorrectly assigns better axial resolution to the narrowband design), the two designs are not identical in performance (contradicting B), and the bandwidth difference does have real downstream imaging consequences, contradicting a claim of no difference in D.

35. D. D. Repeated or prolonged exposure to non-approved cleaning agents, especially high-concentration alcohol or other harsh solvents, can degrade, crack, or otherwise damage the lens/acoustic window material over time, compromising both the acoustic performance and the infection-control integrity of the probe — which is why manufacturers publish an approved list of compatible cleaning and disinfecting agents. This is a material-degradation concern, not a frequency change (B), a TGC recalibration effect (C), or something that changes what type of probe it fundamentally is (A).

36. B. B. Acceptance testing — verifying that a newly received transducer meets manufacturer specifications for element function, image uniformity, and other baseline performance parameters — is a recommended best practice before a probe is placed into routine clinical use, establishing a documented performance baseline and catching any defect before patient use. Simply trusting an unopened box (A) does not verify actual functional performance. Waiting until a clinical problem is reported (C) means patients may already have been scanned with a defective probe. Acceptance testing is typically performed by qualified biomedical/clinical engineering staff following a defined protocol, not left solely to an individual sonographer's informal judgment (contradicting D).

37. C. C. Grating lobes can be reduced by sub-dicing each array element into smaller sub-elements (effectively reducing the periodic spacing that creates grating lobes) and by apodization — tapering the drive amplitude across the aperture's edge elements rather than driving all elements equally — both of which reduce the constructive interference that forms grating lobes at off-axis angles. Increasing element spacing (B) would worsen, not reduce, grating lobes, since grating lobe angle depends on how large the spacing is relative to wavelength. Removing backing material (A) affects axial resolution/damping, not grating lobes. Using a single large continuous crystal (D) would eliminate array-based electronic steering/focusing altogether, which is not how modern diagnostic array transducers function.

38. D. D. A higher element count generally allows finer electronic control over focusing and steering (more independent channels to phase and apodize), which can improve image quality and beamforming flexibility, but manufacturing, cabling, and electronics for a higher channel count add real cost to the system — a genuine engineering and cost trade-off manufacturers must balance. This is the opposite of a claim that more elements always mean lower quality (A), cost and performance are not unaffected by element count (contradicting C), and focal zone selection remains a necessary imaging parameter regardless of element count (contradicting B).

39. B. B. Because pediatric patients are generally smaller, with a shorter distance from the skin surface to the structures of interest, a higher-frequency transducer can often be used than would be appropriate in a larger adult, since the reduced penetration requirement is offset by the shorter path length — allowing the sonographer to take advantage of the improved resolution that comes with higher frequency. This is the opposite of always requiring a much lower frequency regardless of size (A), frequency selection is very much tailored to patient size/body habitus, not identical across patients (contradicting C), and standard external transducers, not solely endocavity probes, are the norm for pediatric abdominal imaging (contradicting D).

40. D. D. Backing material absorbs energy directed backward and damps the crystal's ringing; more heavily damped (highly absorptive) backing shortens the pulse, which improves axial resolution, but that same damping also absorbs some of the crystal's vibrational energy that could otherwise contribute to the transmitted/received signal, reducing sensitivity — a genuine engineering trade-off manufacturers must balance for a given clinical application. This directly contradicts a claim that backing has no effect on sensitivity (A) or on pulse length (C), and operating frequency is set by crystal thickness, not backing material, contradicting B.

41. B. B. Every piezoelectric ceramic has a Curie point — a specific temperature above which the material's internal dipole alignment (polarization) is disrupted, permanently degrading or eliminating its piezoelectric property; exceeding this temperature through excessive heat exposure (such as improper sterilization methods) is a recognized cause of transducer failure over time. Frame rate (A) is an unrelated imaging display parameter. Dynamic range (C) is a display/processing setting, not a transducer material property. Wall filter (D) is a Doppler signal-processing control, also unrelated to the crystal's physical polarization state.

42. B. B. Air has an enormous acoustic impedance mismatch relative to soft tissue and the transducer face, so any air gap between the transducer and skin (from inadequate coupling gel) causes near-total reflection of the beam at that interface, preventing meaningful transmission into the patient and rendering the exam essentially non-diagnostic in that area. This is very much a consequence, not a non-issue (contradicting A), it degrades rather than improves penetration (contradicting C), and transducers do not have any automatic mechanism that activates a physical standoff pad on their own (contradicting D) — coupling gel or a manually applied standoff pad must be used deliberately.

43. C. C. A larger radius of curvature (a flatter curve) produces a narrower divergence angle and a field of view that widens more gradually with depth, while a smaller (tighter) radius of curvature diverges more sharply, producing a wider trapezoidal field of view sooner at shallower depths — a genuine geometric design trade-off among curvilinear probe models for different clinical applications. This contradicts a claim of no difference between radii (B), curvilinear arrays specifically are defined by their expanding field of view with depth, contradicting a claim it cannot expand at all (A), and radius of curvature does not eliminate near-field artifact, which arises from separate causes such as reverberation (contradicting D).

44. C. C. Keeping element spacing (pitch) at or below approximately one-half wavelength is a design principle that helps suppress grating lobes, since grating lobes arise from the periodic spacing of discrete elements and their angle of appearance is directly related to how large that spacing is relative to wavelength — tighter spacing pushes any grating lobes to angles steep enough to fall outside the clinically relevant field of view. This spacing rule is not primarily about maximizing footprint size (B, an unrelated design goal), it does not eliminate the ongoing need for backing material (A), and it does not by itself guarantee the highest frame rate, which depends on separate factors like depth, line count, and focal zones (D).

45. A. A. A duplex probe with dedicated CW crystals allows a sonographer to obtain genuine continuous-wave Doppler — which requires physically separate, continuously transmitting and continuously receiving elements rather than a single pulsed array — from the same handheld probe otherwise used for standard 2D imaging, avoiding the need to switch to an entirely separate nonimaging pencil probe for high-velocity CW measurements. This dedicated CW capability does not change the Nyquist limit that still applies to the probe's separate pulsed-wave Doppler function (contradicting B), it does not automatically convert PW signals into CW — the two remain distinct acquisition modes selected by the user (contradicting C), and it has no effect on the imaging array's own separate element count (contradicting D).

46. D. D. Pulse repetition period = 1/PRF = 1/5000 = 200 microseconds; using the standard round-trip rule of thumb (approximately 13 microseconds of round-trip travel per cm of depth), maximum unambiguous depth is approximately 200 µs ÷ 13 µs/cm ≈ 15 cm, closest in order of magnitude to the 13 cm answer among the choices. The key relationship tested is that PRF and maximum depth are inversely related through round-trip travel time, which is calculable from PRF (directly contradicting B), and the correct order of magnitude is roughly 13-15 cm, not the much smaller 1.3 cm (A) or much larger 26 cm (C).

47. C. C. Unlike overall gain, which applies uniformly across the whole image, the TGC curve/slope can be shaped to selectively boost or reduce amplification at specific depth zones, compensating for uneven attenuation patterns (for example, a fatty layer causing extra attenuation at one particular depth range) more precisely than a single uniform gain adjustment could achieve. TGC has no effect on the transducer's operating frequency, a separate hardware-driven parameter (contradicting B), does not adjust PRF, a timing parameter unrelated to receiver amplification (contradicting A), and does not remove the separate need for focal zone selection (contradicting D).

48. A. A. The range of returning echo amplitudes (from very weak to very strong) is far wider than a standard display's grayscale range can directly show; log compression mathematically compresses that wide dynamic range down into a smaller range of values that map onto the available display gray shades, preserving relative differences while making the full range visible. It does not affect the transducer's transmitted power, a transmit-side setting (contradicting B), it moves toward a displayable image rather than back to raw RF data (contradicting C), and TGC (a depth-based amplification step) remains a separate and still-necessary part of the processing chain (contradicting D).

49. B. B. Envelope detection (also called demodulation or rectification) extracts the amplitude envelope of the received radiofrequency signal — the information that actually corresponds to echo strength — while discarding the underlying high-frequency oscillation (carrier), simplifying the signal for further processing such as log compression and scan conversion. It has no role in setting PRF, a transmit-timing parameter (contradicting A), it is a signal-processing step with no relation to physically detecting a housing breach (contradicting C, a maintenance/inspection concept), and it does not itself create a 3D volumetric dataset, which requires separate volumetric acquisition hardware/software (contradicting D).

50. A. A. Scan conversion takes the acquired data, which is organized along the individual scan lines the beam actually traveled (often not in a simple rectangular grid, especially for sector or curved formats), and maps/interpolates it into the standard 2D raster (pixel-based) format that a display monitor can show as a conventional rectangular image. It does not physically alter transducer hardware (contradicting B), it has no role in Doppler angle correction, a separate user-adjustable measurement tool (contradicting C), and it cannot increase the transducer's actual physical element count, a fixed hardware property (contradicting D).

51. B. B. Because acquired scan lines, especially in a diverging sector format, become more widely spaced from one another at increasing depth, scan conversion uses interpolation — mathematically estimating pixel values in the gaps between actual acquired lines based on the surrounding real data — to produce a visually continuous, smoothly filled image rather than leaving visible gaps. It does not simply delete unscanned regions, which would leave visible dropout (contradicting A), does not require a second transducer (C), and is an automated computational process, not a manual pixel-by-pixel task performed by the sonographer (contradicting D).

52. B. B. Digital beamforming converts each element's received signal to a digital format early in the processing chain and applies the necessary timing delays, apodization, and summing computationally in digital circuitry/software, offering more flexibility and precision than older analog beamforming, which applied analog delay lines directly to the raw electrical signals. It does not eliminate receive focusing, which remains essential and is in fact often improved by digital dynamic focusing (contradicting A), it still relies on a multi-element array, not a single crystal (contradicting C), and it fully supports, rather than removes, electronic beam steering (contradicting D).

53. C. C. The general processing sequence begins with the transducer receiving echoes and the beamformer combining element signals, followed by receiver-side processing (amplification/TGC, envelope detection, log compression), then scan conversion to arrange the data into a displayable raster format, and finally the display itself shows the completed image — a logical pipeline from raw acoustic signal to viewable image. Reversing this order to start with display (A) or to place scan conversion before the transducer/beamformer stage (B) does not reflect how the actual data flow works, and while modern systems process at high speed, there is a genuine logical/temporal sequence to these steps, contradicting the claim of no consistent order in D.

54. C. C. Trapezoidal or virtual convex imaging steers the outer scan lines of a linear array outward electronically, widening the effective field of view at depth into a trapezoid shape beyond what the array's physical width alone would produce with parallel scan lines — useful for visualizing structures that extend beyond the probe's straight footprint. This is a software/steering feature applied to the existing linear array, not a permanent physical conversion into a different probe type (contradicting B), it does not eliminate the need for focal zone selection (A), and it has no effect on the transducer's operating frequency (D).

55. B. B. Contrast-specific imaging modes are engineered to selectively detect and display the strong nonlinear harmonic signal produced by oscillating contrast microbubbles while suppressing the comparatively weaker, more linear signal from surrounding normal tissue, maximizing the conspicuity of contrast-enhanced structures against a relatively dark background. This deliberately uses a low, not high, Mechanical Index to avoid destroying the microbubbles (contradicting A), it remains a grayscale/harmonic imaging mode, not a conversion to spectral Doppler (contradicting C), and the transducer's transmit function is very much still active and essential to generate the insonating pulses (contradicting D).

56. A. A. Dual/split live display allows the sonographer or interpreting physician to directly compare two simultaneously updating views side by side — for example, correlating anatomic B-mode detail with color flow information, or observing a structure before and after contrast injection — which is more informative for real-time comparison than switching back and forth between two separate full-screen displays. It has no bearing on the number of transducers needed for a given exam, since it is a display feature of one active probe's data (contradicting B), it does not generate a diagnostic report (C, an interpreting physician's task), and it does not selectively alter acoustic output power for just one of the two displayed panels (D).

57. B. B. Because the system must interleave the pulses needed for 2D image formation with the pulses needed for pulsed Doppler sampling within the same overall time budget, true simultaneous duplex scanning generally results in a reduced update rate for one or both functions compared with running either mode alone — a genuine real-time processing trade-off sonographers learn to anticipate. This is the opposite of Doppler being entirely disabled during 2D (A, duplex specifically means both run together, just at a cost), 2D resolution does not automatically improve during duplex scanning (C, an unrelated and incorrect claim), and there is a real, not absent, trade-off in update rate (contradicting D).

58. C. C. The gray-scale reject control sets an amplitude threshold below which weak B-mode signals (often representing low-level noise rather than genuine tissue echo) are excluded from the displayed image, functioning analogously to — but as a separate control from — the amplitude-based reject function sometimes available in Doppler processing. It does not adjust the color Doppler baseline, an unrelated Doppler display control (contradicting B), does not change transmit frequency, a separate transducer-driving parameter (contradicting A), and has no role in Doppler angle correction, a distinct measurement tool (contradicting D).

59. A. A. Because the problem described is localized to the superficial (near) field while the deep structure looks appropriate, a depth-selective adjustment — lowering near-field TGC — is the correct first step, rather than a whole-image change like overall gain, which would also inappropriately darken the already well-visualized deep structure. Overall gain (B) is not depth-selective and would affect the entire image, not just the affected region. Changing transducer frequency (C) is a more disruptive step not specifically indicated for a simple, correctable near-field TGC issue, and color Doppler scale (D) has no relevance to a grayscale-only near-field saturation problem, since it is not even the control category implicated here.

60. D. D. The overall dynamic range a diagnostic ultrasound system must handle, from the weakest detectable echo to the strongest specular reflection, spans an extremely wide range, typically on the order of 100 to 160 dB — far greater than a display alone could show without compression, which is precisely why log compression is a necessary processing step. This is far larger than the modest 5-10 dB (A) or 20-30 dB (B) ranges, which would represent only a small fraction of the true physiologic echo amplitude range, and dynamic range is in fact conventionally expressed in decibels, a logarithmic ratio unit well suited to such a wide range (contradicting C).

61. C. C. Because each additional focal zone requires its own full set of transmitted and received scan lines, using a single focal zone (rather than several) minimizes the total pulses needed per frame, maximizing frame rate/temporal resolution — an appropriate trade-off when imaging a fast-moving structure like a beating fetal heart, at some cost to lateral resolution across the full depth range. Using the maximum number of focal zones (B) would instead prioritize lateral resolution at the direct cost of frame rate, the opposite of what is needed here. Focal zones are a real, adjustable imaging parameter, not something that can simply be 'disabled' as optional with no consequence (A), and focal zone count very much affects this specific trade-off, contradicting D.

62. C. C. B-flow imaging uses specialized processing (such as coded excitation and digital signal enhancement) to directly visualize the grayscale reflectivity of moving blood cells within the vessel lumen in real time, distinguishing it from color or power Doppler, which instead calculate and color-encode a Doppler frequency shift; B-flow can show flow and vessel wall detail simultaneously in a single grayscale image without angle-dependence concerns tied to a Doppler shift calculation. This directly contradicts a claim that it calculates a Doppler shift the same way color Doppler does (B), it does not require contrast agent administration to function, unlike contrast-specific imaging (contradicting A), and it does not replace B-mode with a spectral waveform, remaining fundamentally a grayscale display technique (contradicting D).

63. B. B. Pulse inversion transmits two successive pulses that are exact inverted (180-degree phase-shifted) copies of one another; when the two received echo signals are summed, the linear (fundamental-frequency) components cancel each other out, since they are also inverted copies, while the nonlinear (harmonic) components — which do not simply invert in the same linear fashion — reinforce and survive the summation, isolating harmonic signal without needing a separate receive filter alone. It does not physically reverse the beam's travel direction (A, a nonsensical description of the technique), it is unrelated to the color Doppler directional color map (C), and it does not physically alter the transducer's element count (D) — pulse inversion is a transmit-sequence and signal-processing technique, not a hardware change.

64. D. D. Ispta refers to the intensity at the spatial location within the beam where intensity is highest, averaged over time (accounting for the pulsed, not continuous, nature of transmission) — it is one of several standardized intensity metrics (along with others such as Isppa) used in characterizing a system's acoustic output and is relevant to thermal bioeffect considerations. It does not describe the lowest intensity anywhere in the field (B, the opposite spatial extreme), it is not a Doppler gain setting, which is a receiver amplification control unrelated to this output intensity metric (contradicting C), and it is directly related to acoustic output/bioeffect characterization, not unrelated to it (contradicting A).

65. C. C. The on-screen focal zone marker shows the sonographer exactly which depth (or depths) the beam is currently focused at — the location of narrowest beam width and therefore best lateral resolution — allowing the sonographer to reposition that focal marker to align with the specific structure of clinical interest for optimal image quality. It is not a Doppler angle indicator, a separate on-screen measurement tool (contradicting B), it does not itself display a numeric PRF value, though PRF may be shown elsewhere on screen as a separate readout (contradicting A), and it has no relationship to equipment inventory tracking information such as a serial number (contradicting D).

66. C. C. A-mode displays echo information as a simple one-dimensional graph along a single beam line, with spike height representing echo amplitude/strength and horizontal position representing depth — a format now largely superseded clinically by B-mode's two-dimensional grayscale cross-sectional display, though A-mode's underlying amplitude data is still conceptually part of how B-mode brightness values are ultimately derived. It is not itself a 2D grayscale cross-sectional image, which describes B-mode instead (contradicting A), it is not a real-time 3D volumetric display (B), and it is not a color-encoded velocity map, which describes color Doppler (D).

67. D. D. Ring-down artifact is a specific reverberation-family artifact classically seen deep to small gas collections, in which sound resonates within a thin layer of fluid trapped between adjacent gas bubbles, producing a continuous, solid-appearing bright streak (rather than discrete separate lines) extending deep to the gas — visually and mechanistically distinct from the discrete, individually resolvable parallel lines of classic reverberation. It does not appear as widely spaced discrete lines (A, that better describes classic reverberation), it is not restricted to only the far field (C, it characteristically occurs adjacent to superficial or any-depth gas collections), and it is specifically associated with gas, not metallic foreign bodies, which instead classically produce comet-tail artifact (contradicting B).

68. D. D. Focal banding/enhancement artifact arises because the beam is narrowest — and acoustic energy most concentrated — at the focal zone depth, which can produce a band of relatively brighter appearance at that specific depth even in otherwise uniform tissue; this is a known technical artifact of focusing, not a true tissue finding. It is not evidence of pathology requiring workup, since it is a predictable, technique-dependent phenomenon rather than a tissue-based finding (contradicting A). It does not indicate a transducer element malfunction, which would instead typically produce a dropout band rather than a focal brightness band (contradicting B). It is unrelated to PRF, a Doppler/frame-timing parameter with no direct bearing on this focal-depth brightness effect (contradicting C).

69. B. B. Anisotropy occurs because highly organized, parallel fibrous tissue (such as tendon) reflects sound strongly back toward the transducer only when the beam strikes it close to perpendicular; even a modest deviation from perpendicular can cause the same true tissue to appear falsely hypoechoic (dark), mimicking pathology such as tendinosis or a tear when none exists — a recognized angle-dependent artifact, not a true, permanent tissue change. It is not a permanent, angle-independent effect, since re-angling the transducer characteristically restores normal echogenicity (contradicting A), it is specifically associated with organized fibrous tissue like tendon, not fluid-filled structures (contradicting C), and it has no relationship to reverberation between metallic clips, an unrelated artifact mechanism (contradicting D).

70. D. D. Refractive edge-shadowing classically arises from the lateral margins of a curved structure, where the beam obliquely bends away from a straight return path, while the central posterior region directly behind the structure remains relatively unaffected — a pattern distinct from a broad, centrally located shadow directly posterior to a densely attenuating structure like calcification, which would produce true attenuation-based shadowing across the width of the structure rather than sparing its center. A broad, centrally consistent shadow (A) is more typical of true attenuation than refraction. A clean shadow with no internal echoes (C) alone does not reliably distinguish the two causes, since both can appear anechoic. There are, in fact, recognizable imaging clues (such as shadow location relative to the structure's margins versus its center) that can help distinguish the two, contradicting the claim in B that no distinguishing feature exists.

71. D. D. A densely calcified structure attenuates the beam strongly and relatively uniformly, producing a clean, sharply defined acoustic shadow (a true acoustic void) deep to it, whereas gas at a tissue-gas interface reflects and scatters the beam chaotically, producing a 'dirty' shadow filled with indistinct, low-level reverberation echoes rather than a clean void — a genuinely useful visual distinction for identifying the likely cause of a given shadow. This directly contradicts a claim the two are visually identical (B) or that gas characteristically produces the cleaner-appearing shadow of the two (C, which reverses the actual pattern), and both structure types are, in fact, well-recognized causes of posterior shadowing, contradicting A.

72. C. C. Comet-tail artifact classically arises from a small, strongly reflective solid structure (metallic fragment, cholesterol crystal) and appears as a tapering, narrowing bright tail, while ring-down artifact classically arises from gas bubbles with fluid trapped between them and tends to appear as a more uniform, non-tapering continuous streak — a genuinely useful distinguishing feature given their overlapping general appearance as bright posterior streaks. This is not indistinguishable/interchangeable, since their differing appearance and underlying cause are clinically useful to recognize (contradicting B), neither artifact is restricted to only the far or near field specifically as its defining feature (contradicting A), and ring-down is specifically a gas-related phenomenon, not caused by metallic foreign bodies, which instead classically cause comet-tail (contradicting D).

73. D. D. Because adaptive speckle-reduction algorithms cannot perfectly distinguish random speckle noise from genuine, subtle textural differences within true pathology, applying this filtering too aggressively risks smoothing away real diagnostic texture along with the noise it is intended to reduce, potentially masking a subtle lesion or altering its apparent characteristics — a real trade-off sonographers should be aware of rather than assuming the feature is purely beneficial. This directly contradicts a claim of no possible negative consequence (B) or that it always improves diagnostic accuracy regardless of setting (C), and it is a grayscale (B-mode) image-processing feature, not something exclusive to Doppler images (contradicting A).

74. A. A. Frequency compounding acquires image information using multiple frequencies (often exploiting a broadband transducer's range) and combines the resulting images; because speckle pattern varies somewhat with frequency while true anatomic structure remains consistent, combining these frequency-diverse images reduces speckle in a manner analogous to, but mechanistically distinct from, spatial (angle) compounding. Steering through multiple angles (B) describes spatial compounding instead, a different compounding technique. Averaging sequential frames from a fixed angle and frequency (C) describes persistence, not frequency compounding. Applying only postprocessing edge enhancement to a single frame (D) is an unrelated single-frame processing step, not a multi-acquisition compounding technique.

75. B. B. Because the described problem is specifically localized to the near field while the far field is already clean, the appropriate first step is a depth-selective adjustment — decreasing near-field TGC and/or applying modest persistence — rather than a uniform whole-image change like overall gain, which would also degrade the already-acceptable far field. Increasing overall gain (A) would worsen, not fix, a near-field clutter problem and would also inappropriately affect the clean far field. Switching to a lower frequency (C) is the wrong direction for a near-field-specific issue and would primarily trade away resolution rather than address near-field clutter. Adding more focal zones (D) targets lateral resolution and slows frame rate, not the depth-selective near-field noise issue described.

76. A. A. Surface rendering processes a 3D dataset to display an externally shaded, 3D-appearing surface (useful, for example, for fetal facial imaging), while multiplanar reconstruction (MPR) instead displays several simultaneous 2D slice planes (typically three orthogonal planes) cut through the same acquired volume, letting the viewer examine internal cross-sectional detail rather than an external surface — two genuinely different ways of visualizing the same underlying volumetric data. This directly contradicts a claim that the two are identical (B), MPR is specifically a way of viewing an acquired 3D volume as 2D planes, not a 2D-imaging-only technique (contradicting C), and surface rendering is, in fact, generated directly from an acquired 3D volumetric dataset, contradicting D.

77. B. B. Doppler shift = (2 × transmit frequency × velocity × cos θ) ÷ propagation speed = (2 × 5,000,000 Hz × 0.5 m/s × 0.5) ÷ 1540 m/s ≈ 3,247 Hz, closest to the 3240 Hz answer. Option C is roughly half this value (consistent with omitting the factor of 2 for round-trip shift), and Option A is roughly half of B as well; the data provided (frequency, velocity, angle, propagation speed) is fully sufficient to calculate the shift using the standard Doppler equation, directly contradicting D.

78. B. B. The Nyquist limit is defined as one-half the PRF; with PRF = 6000 Hz, the Nyquist limit is 6000 ÷ 2 = 3000 Hz — any true Doppler shift exceeding this value will alias rather than being sampled correctly. Option A repeats the PRF value itself rather than halving it. Option C is one-quarter of PRF rather than one-half. Option D doubles the PRF rather than halving it, each reflecting a miscalculation of the PRF/2 relationship rather than the correct value.

79. D. D. Raising PRF shortens the pulse repetition period, meaning less time is available for a pulse to travel to a deep structure and return before the next pulse is sent; at sufficient depth, this risks range ambiguity, where a late-returning deep echo is misattributed to the next pulse cycle and displayed at an incorrect (falsely shallow) depth — a genuine trade-off between avoiding Doppler aliasing (high PRF) and avoiding range ambiguity at depth (which favors lower PRF). This has no effect on axial resolution, an SPL-based property unrelated to PRF (contradicting A), does not guarantee improved sensitivity without any trade-off (contradicting B), and does not eliminate the wall filter's separate, unrelated function (contradicting C).

80. D. D. Multigate pulsed Doppler uses multiple range-gated sample volumes positioned simultaneously across the vessel's diameter (rather than the single sample volume of standard PW Doppler), allowing the system to construct a velocity profile across the lumen at one moment — useful for research and certain specialized clinical applications requiring detailed flow-profile information rather than a single representative velocity. It remains a pulsed technique still subject to the Nyquist limit, not exempt from it (contradicting B), it does not convert into true CW Doppler, which requires distinct continuously transmitting/receiving hardware (contradicting C), and its defining feature is precisely that it samples multiple points rather than the single point of standard PW (contradicting A).

81. C. C. Conventional Doppler velocity calculation depends on an accurate estimate of the angle between the beam and the direction of flow, and error grows sharply as that angle approaches 90 degrees; angle-independent techniques such as vector Doppler use multiple simultaneous beam directions or other approaches to estimate true flow velocity and direction without relying on a single manually estimated angle, addressing this specific accuracy limitation. This has nothing to do with a requirement for phased array transducers specifically (A), it does not remove the (still necessary) knowledge of operating frequency built into the underlying physics (contradicting B), and it does not address a coupling gel requirement, an unrelated basic acoustic coupling need (contradicting D).

82. B. B. Automatic angle-correction assist features use image analysis (such as detected vessel wall orientation) to suggest or apply an appropriately aligned angle-correction cursor, reducing the variability and potential error introduced by a sonographer manually eyeballing the vessel's angle — a workflow aid rather than a replacement for the underlying physics requirement. It does not eliminate the separate need to position the sample volume, a distinct manual step (contradicting A), it has no effect on transmitted acoustic power, an unrelated output parameter (contradicting C), and correct angle correction remains necessary regardless of this assist feature, particularly at larger angles where error is more significant (contradicting D).

83. B. B. Baseline shift is most useful when flow is predominantly in one direction and the display's opposite-direction range is largely unused; shifting the baseline toward the dominant flow direction effectively extends the available display range for that direction without needing to raise PRF/scale (which can reduce sensitivity to slower flow). This is not universally better than a scale change in every scenario, since scale increases remain necessary when true velocity genuinely exceeds the available Nyquist limit even after baseline shift (contradicting A). It is specifically most helpful for predominantly unidirectional, not purely bidirectional, flow, since bidirectional flow needs range on both sides of the baseline (contradicting C), and baseline shift is a genuinely useful, not useless, tool in the appropriate circumstance (contradicting D).

84. C. C. Because a wider sample volume captures signal from a larger cross-section of the vessel, including the naturally slower-flowing laminar layers near the vessel wall in addition to the faster central stream, the resulting waveform can show an apparent widening (technique-induced spectral broadening) even in a vessel with entirely normal, non-turbulent flow — an important technical pitfall to recognize before concluding true turbulence is present. This is not automatically pathologic, since a technical cause exists and should be excluded first (contradicting B), sample volume size very much affects this appearance, contradicting A, and the finding does not specifically implicate the wall filter, an unrelated frequency-threshold control rather than a gate-size issue (contradicting D).

85. A. A. Because a small residual trickle of flow around a near-occlusive thrombus is characteristically very low-velocity, using the lowest appropriate wall filter setting minimizes the risk of inadvertently filtering out that genuine slow-flow signal along with wall-motion clutter — directly analogous to the low-wall-filter approach used for slow venous flow, but applied here to a critical arterial patency question. A high wall filter setting (B) would risk missing exactly the subtle residual flow signal the exam is trying to detect. Wall filter setting is highly relevant, not irrelevant, to this specific clinical question (contradicting C), and Doppler assessment, appropriately optimized, adds important information beyond B-mode alone rather than being abandoned in this scenario (contradicting D).

86. D. D. Because Doppler shift magnitude depends on the cosine of the insonation angle, repositioning the transducer or adjusting the sample volume approach to achieve a smaller, more favorable angle (closer to parallel with flow) reduces the calculated shift for the same true velocity in some geometric configurations, which can help bring a borderline-aliasing signal back within the Nyquist limit — an additional practical technique alongside the more commonly cited scale/baseline/frequency adjustments. Restarting the system (B) is not a recognized technique for resolving aliasing. Switching to grayscale-only imaging (C) abandons the Doppler assessment entirely rather than resolving the technical issue. Increasing B-mode gain (A) has no effect on the separate Doppler shift/Nyquist relationship.

87. A. A. The renal-aortic ratio (RAR) is calculated as the renal artery's peak systolic velocity divided by the aortic peak systolic velocity measured at a standard reference level, with an elevated ratio supporting a diagnosis of renal artery stenosis — a specific, named clinical index analogous in concept to other stenosis-grading velocity ratios used elsewhere in vascular ultrasound. It is not a renal vein-to-artery ratio (B), not a diameter-based ratio (C, which is a different type of measurement entirely), and not a resistive-index-based ratio (D) — RAR is specifically a peak-systolic-velocity comparison between two named arterial sites.

88. A. A. The ductus venosus shunts a portion of oxygenated umbilical venous blood toward the fetal heart, and its Doppler waveform (normally showing forward flow throughout the cardiac cycle) is used as an indicator of fetal cardiac preload and function; an abnormal waveform, such as absent or reversed flow during atrial contraction, can be an important sign of fetal cardiovascular compromise, distinct from the umbilical artery waveform, which instead reflects placental resistance. It is unrelated to maternal renal artery assessment (B), it is a fetal vessel entirely distinct from the postnatal adult hepatic vein (C), and it is a fetal vessel present before birth, not the same structure as the postnatal ductus arteriosus (D).

89. D. D. The ophthalmic artery normally carries flow away from the internal carotid artery toward the eye; in the setting of severe proximal ICA stenosis or occlusion, collateral flow can reverse this direction, with blood instead flowing retrograde through the ophthalmic artery from the external carotid system to help supply the compromised intracranial circulation — a recognized indirect Doppler sign of significant carotid disease. This is not a normal physiologic variant (A), it specifically reflects carotid system pathology rather than being isolated to the eye itself (contradicting B), and it has no relationship to renal artery stenosis, an entirely different vascular territory (contradicting C).

90. D. D. The continuity equation relies on conservation of volumetric flow rate: because the same volume of blood must pass through two different cross-sectional areas in series (e.g., the left ventricular outflow tract and a stenotic aortic valve) in the same time, $\text{area}_1 \times \text{velocity}_1 = \text{area}_2 \times \text{velocity}_2$, allowing an unknown valve area to be calculated from a known reference area and the two respective velocities. It is unrelated to cavitation, a bioeffect concept (A), it does not assume a fixed 90-degree Doppler angle — accurate angle correction is, if anything, essential to obtaining valid velocities for this calculation (contradicting C), and it is not based on attenuation being equal on both sides, an unrelated acoustic property (contradicting B).

91. A. A. By display convention, flow moving toward the transducer is generally plotted above the baseline and flow moving away is plotted below (or the reverse, depending on the system's configurable convention), consistently reflecting the direction of flow relative to the transducer — analogous to, and generally matched with, the red/blue directional convention used in color Doppler. Heart rate (B) affects waveform timing/shape, not baseline position, which is a directional indicator rather than a rate indicator. Transducer frequency (C) affects the magnitude of the Doppler shift, not which side of the baseline the waveform appears on. This positioning is a defined, consistent convention, not a random assignment (contradicting D).

92. A. A. Spectral Doppler gain is a separate, independently adjustable control from color Doppler gain, affecting only the sensitivity/brightness of the spectral waveform trace itself (how visible the trace and its noise floor appear), even though both a spectral trace and a color image might be displayed simultaneously in duplex/triplex mode; each gain control must generally be optimized independently for its respective display. It does not automatically synchronize with or change the separate color gain setting (contradicting B), it clearly does affect the spectral display, not nothing at all (contradicting C), and it is distinct from B-mode grayscale gain, a third separate control (contradicting D).

93. B. B. Sweep speed controls how quickly the spectral waveform trace scrolls horizontally across the display over time; a faster sweep speed spreads each cardiac cycle's waveform out over more horizontal screen space (useful for detailed morphology assessment), while a slower sweep speed compresses more cycles into the same screen width (useful for observing beat-to-beat or respiratory variation) — a distinct display timing parameter from imaging frame rate. It does not control 2D imaging frame rate, a separate parameter governing the B-mode image update rate (contradicting A), it has no relationship to angle correction, an unrelated measurement tool (contradicting C), and it does not adjust transmitted acoustic power, an output-side parameter unrelated to this display timing control (contradicting D).

94. D. D. Doppler mirror-image artifact can occur when a strong nearby reflector (such as a bone surface or another highly reflective interface) causes part of the beam to reflect in a way that produces a symmetric, mirrored copy of the true spectral waveform on the opposite side of the baseline — an artifact rather than genuine bidirectional flow, and one that typically resolves with a change in transducer angle or position relative to the reflective structure. This is not exclusive to healthy vasculature, since the artifact depends on local reflector geometry rather than the vessel's health status (contradicting B), it is not restricted to CW Doppler only, since PW Doppler can also be affected by strong nearby reflectors (contradicting C), and it is not specifically caused by a low wall filter setting, an unrelated frequency-threshold control (contradicting A).

95. C. C. Just as dense calcification produces posterior acoustic shadowing on grayscale B-mode by strongly attenuating the beam, that same attenuation prevents adequate signal from reaching or returning from the region directly deep to the plaque on color Doppler, producing a corresponding dropout or loss of color signal in that shadowed zone — an important pitfall, since this artifactual color dropout should not be mistaken for a genuine flow-limiting lesion at that specific location without correlating with the B-mode shadow. This is the opposite of enhanced signal deep to the plaque (A, which would instead be expected deep to a fluid structure, not calcification), the appearance is meaningfully affected, not unchanged (contradicting B), and the color signal in this shadowed zone is specifically degraded/lost, not an accurate reflection of the true flow velocity present in that vessel segment (contradicting D).

96. B. B. Because color frame rate is reduced by a larger color box (more scan lines), greater imaging depth (longer listening time per line), and larger packet size (more pulses per line for velocity estimation), the most effective way to improve a sluggish color frame rate is to narrow/shorten the box to only the clinically relevant region and reduce packet size, accepting a modest trade-off in velocity-estimate precision/sensitivity in exchange for a more responsive real-time image. Widening the box (A) would further reduce, not improve, frame rate. Maximizing packet size (C) would further slow frame rate in pursuit of accuracy, the opposite of the stated goal. Increasing depth beyond what is clinically necessary (D) would also further reduce frame rate rather than improve it.

97. B. B. The Doppler signal, like any returning echo, is subject to attenuation as it travels through tissue, so deeper vessels may present with a weaker returning signal; sonographers compensate by increasing Doppler gain appropriately or, when feasible, selecting a lower transducer frequency (which attenuates less per centimeter) to maintain adequate signal-to-noise for a diagnostic waveform or color display. This directly contradicts a claim that Doppler signal is entirely unaffected by depth (A), a deep vessel does not automatically require switching to CW Doppler, since PW Doppler with appropriate gain/frequency adjustment often remains entirely adequate (contradicting C), and attenuation affects the Doppler-shifted signal just as it affects any other returning acoustic energy, not exclusively B-mode echoes (contradicting D).

98. C. C. Because several interacting controls affect Doppler signal quality — gain (signal amplification), PRF/scale (appropriate for the expected velocity range), wall filter (appropriately low if slow flow is suspected), and sample volume/focus placement (correctly positioned within the vessel) — a systematic approach adjusting each appropriately, rather than fixating on a single control, is the most effective troubleshooting strategy for a technically difficult Doppler exam. Color box size alone (B) is not the sole relevant control and does not address spectral Doppler signal quality specifically. Increasing power indefinitely without regard to ALARA (A) is not an appropriate or safe troubleshooting approach. A systematic, physics-based approach is available and effective, contradicting the claim of randomness in D.

99. D. D. The sign of the calculated Doppler shift (positive or negative) reflects the direction of flow relative to the transducer — conventionally, flow toward the transducer produces a positive shift and flow away produces a negative shift (or the reverse, by system convention) — which is the underlying mathematical basis for the red/blue color-flow direction display and above/below-baseline spectral display, both of which are simply visual representations of this sign. It has no relationship to sonographer handedness (A), the patient's heart rate, which instead affects waveform timing/shape rather than shift sign (B), or the transducer's manufacturing batch, an unrelated logistical detail (C).

100. B. B. ABI is calculated as the higher of the two ankle systolic pressures (obtained using a Doppler probe and blood pressure cuff) divided by the higher of the two brachial (arm) systolic pressures; a reduced ratio indicates reduced perfusion pressure to the leg consistent with peripheral arterial disease, with the severity generally correlating with how low the ratio falls below normal. It is not calculated as the inverse ratio (A), it does not use diastolic pressure at all in the standard calculation (C), and it is a pressure-based ratio using cuff-measured systolic pressures at each site (with Doppler used only to detect the pulse, not to measure velocity for this particular index), not a direct peak-systolic-velocity ratio (D).

101. A. A. In patients with heavily calcified, poorly compressible arteries (common in diabetes and advanced renal disease), ankle cuff pressures can be falsely elevated, making the standard ABI unreliable; the Toe-Brachial Index (TBI), using toe systolic pressure instead of ankle pressure, is often used as an alternative, since digital arteries are less prone to this specific calcification-related measurement error. The renal artery Resistive Index (B) is an entirely different clinical index used for a different vascular territory and purpose, not an ABI alternative. The color variance map (C) is a color Doppler display mode, not a numeric limb-perfusion index. A genuine, recognized alternative does exist in this situation, contradicting D.

102. D. D. Because a synthetic AV graft is a prosthetic conduit rather than a native, compliant vessel, its normal waveform characteristics and the specific velocity criteria used to detect a developing stenosis differ somewhat from those used for a native AV fistula, and dedicated graft-surveillance protocols/criteria are generally applied to account for this difference. A graft does have a recognizable, characteristic normal waveform pattern, not none at all (contradicting A), grafts and fistulas are not hemodynamically identical, given their differing compliance and construction (contradicting B), and Doppler surveillance is a standard, recommended practice for both grafts and fistulas, not fistulas exclusively (contradicting C).

103. D. D. Provocative maneuvers such as Valsalva (increasing intra-abdominal pressure) or manual augmentation (compressing and releasing the limb distal to the sample volume) are used to assess venous valve competence: in a normal, competent vein, any reversed flow triggered by these maneuvers is brief, while an incompetent (refluxing) valve allows a pathologically prolonged period of reversed retrograde flow — the key diagnostic finding in venous insufficiency evaluation. This is not an assessment of arterial stenosis, an unrelated vascular territory and question (contradicting A), it is not primarily a diameter-measurement technique, though diameter may also be recorded separately (contradicting C), and it does not determine whether a vein is superficial or deep, which is instead assessed by its anatomic location and compressibility pattern (contradicting B).

104. A. A. Complete occlusion at the examined site produces a complete absence of any detectable arterial Doppler signal there, despite confirming optimized technique (appropriate gain, scale, angle, and wall filter) to rule out a technical cause for the absent signal — this is distinct from severe but non-occlusive stenosis, which characteristically still shows some detectable, though markedly abnormal (monophasic, blunted, tardus parvus), flow signal at or through the narrowed segment. A normal triphasic waveform (B) would argue against significant disease at that site altogether. A monophasic, blunted tardus parvus waveform (C) is actually more typical of severe stenosis with preserved (if diminished) flow, not complete occlusion, which is essentially the finding the question distinguishes it from. A waveform with preserved normal peak systolic velocity (D) would not be consistent with either severe stenosis or occlusion at that site.

105. D. D. Serial hepatic artery RI monitoring after liver transplantation helps detect vascular complications such as hepatic artery thrombosis (which can dramatically alter or abolish the arterial signal) or rejection-related changes in downstream vascular resistance, both of which can meaningfully affect graft viability and prompt further urgent evaluation if a significant trend or acute change is identified. This is a hepatic ARTERY-focused surveillance parameter, not specifically about portal vein flow direction, a related but separate transplant Doppler assessment (contradicting B), it has no relationship to ophthalmic artery collateral flow, an entirely different vascular territory (contradicting C), and it is unrelated to a transplanted kidney's renal artery, a different organ and transplant type altogether (contradicting A).

106. A. A. Varicocele is characterized on Doppler by dilated, tortuous pampiniform plexus veins surrounding the testicle, with retrograde venous flow (reflux) that becomes more apparent or is specifically elicited with a Valsalva maneuver, reflecting incompetent venous valves in that plexus — a venous, not arterial, finding. It does not typically present as bilateral absence of testicular arterial flow, which would instead suggest an entirely different, more urgent process such as torsion (contradicting B). While varicocele is in fact more common on the left side anatomically, it is not exclusively a right-sided finding as stated, and the reverse claim in C misstates the typical laterality. It is fundamentally a venous reflux condition, not primarily characterized by an elevated testicular arterial resistive index (contradicting D).

107. C. C. TCD assesses intracranial vessels, such as the middle cerebral artery, by insonating through a relatively limited acoustic window where the skull is thin enough to permit adequate beam transmission (such as the temporal bone window), a technically more challenging approach than standard extracranial carotid duplex, which images superficial neck vessels without a significant bony barrier. TCD is generally performed with a lower-frequency phased/sector-style transducer suited to penetrating the temporal window, not a standard linear array optimized for superficial imaging (contradicting B). It relies on the same fundamental Doppler equation and angle considerations as any other Doppler application, not an exemption from them (contradicting A), and it is specifically a Doppler-based flow assessment technique, not a grayscale-only anatomic study (contradicting D).

108. A. A. DVT evaluation combines direct compression of the vein with transducer pressure (a normal vein fully compresses; a vein containing thrombus characteristically does not compress, or compresses incompletely) with color and/or spectral Doppler assessment of flow (absent, reduced, or non-phasic flow can further support the diagnosis) — the two techniques together provide more diagnostic confidence than either alone. Compressibility testing is, in fact, a central and highly relevant part of DVT evaluation, not irrelevant as claimed in B. The suspected vein itself, not merely an adjacent artery, is the primary structure examined (contradicting C), and while Valsalva or augmentation maneuvers can contribute supporting information, they are not by themselves a complete substitute for compressibility and flow assessment together (contradicting D).

109. B. B. Because atrial fibrillation produces an irregularly irregular R-R interval, individual cardiac cycles can have meaningfully different stroke volumes and resulting peak velocities; obtaining a representative velocity measurement in this setting generally benefits from averaging measurements across several cardiac cycles rather than relying on a single, potentially unrepresentative beat, an important technical consideration distinct from measurement technique in a patient with a regular rhythm. This directly contradicts a claim that rhythm irregularity has no effect at all (A), relying on only a single arbitrarily chosen beat (C) is specifically the less reliable approach in this setting, and while more technically challenging, a Doppler measurement remains obtainable and clinically useful in atrial fibrillation, not impossible as claimed in D.

110. B. B. No single Doppler modality optimally satisfies all three needs at once, since each has a specific strength and limitation: CW Doppler has no Nyquist limit and is best for accurately capturing a very high-velocity jet without aliasing (but lacks range resolution), color Doppler provides an efficient overview of flow direction (toward/away) across a field of view, and PW Doppler's range gating allows the sonographer to isolate signal specifically to one of two adjacent vessels at a chosen depth — using them together, each for its respective strength, addresses the full scenario. CW Doppler alone (A) cannot localize between adjacent vessels, since it lacks range resolution entirely. Color Doppler alone (C) would alias on a very high-velocity jet, since it is a pulsed technique. Power Doppler alone (D) does not provide directional or precise velocity information at all, and also lacks range resolution to distinguish two adjacent vessels along the same beam line the way PW Doppler's gating can.