# COMPREHENSIVE MOCK EXAM 6

Supplemental to: Ultrasound Physics 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 principle of using the lowest possible acoustic output and shortest exposure time necessary to obtain a diagnostic image is known as:

**A.** The Spaulding disinfection classification system

**B.** ALARA, or As Low As Reasonably Achievable

**C.** The AIUM Prudent Use Statement document

**D.** FDA Track 3 acoustic output labeling

**2.** The Mechanical Index (MI) estimates the likelihood of one bioeffect, while the Thermal Index (TI) estimates the likelihood of another. Which pairing is correct?

**A.** MI: infection; TI: thermal injury

**B.** MI: cavitation; TI: infection

**C.** MI: thermal injury; TI: cavitation

**D.** MI: cavitation; TI: thermal injury

**3.** Under the Spaulding classification, a transducer used for an endocavity exam that contacts intact mucous membranes is classified as:

**A.** Noncritical, requiring low-level disinfection

**B.** Semicritical, requiring high-level disinfection

**C.** Critical, requiring sterilization

**D.** Exempt from disinfection requirements

**4.** Standard precautions, applied to every patient regardless of known infection status, differ from transmission-based precautions in that transmission-based precautions:

**A.** Completely replace the need for standard precautions

**B.** Apply only to sonographers, and never to physicians

**C.** Are used only within a hospital's operating rooms

**D.** Are added on top of standard precautions for known infections

**5.** Valid informed consent for an invasive ultrasound-guided procedure must include an explanation of the procedure, its risks and benefits, and:

**A.** The sonographer's credentials

**B.** The cost of the procedure

**C.** Reasonable alternatives to the procedure

**D.** The exact needle gauge to be used

**6.** Sustained scanning with a pinch grip, extended reach, and awkward wrist positioning places sonographers at increased risk for:

**A.** An increased risk of hearing loss

**B.** An increased risk of contrast reactions

**C.** Work-related musculoskeletal strain disorders

**D.** An increased risk of thermal bioeffects

**7.** When a sonographer identifies a highly suspicious finding during a routine exam, the appropriate action is to:

**A.** Inform the patient of the likely diagnosis directly

**B.** Document the finding objectively and refer interpretation to the physician

**C.** Repeat the exam until the finding resolves

**D.** Omit the finding from the worksheet to avoid alarming the patient

**8.** Routine QA testing using a tissue-mimicking phantom evaluates system performance parameters such as:

**A.** Overall patient satisfaction survey scores

**B.** Axial/lateral resolution, penetration, and dead zone

**C.** Departmental billing accuracy rates overall

**D.** Sonographer certification status only

**9.** Cavitation-related bioeffects are most directly associated with which acoustic output index?

**A.** TIB

**B.** TIS

**C.** TIC

**D.** MI

**10.** Before beginning an ultrasound-guided invasive procedure, confirming patient identity, procedure, and site with at least two identifiers is part of the:

**A.** Spaulding classification

**B.** Time-out/Universal Protocol process

**C.** ALARA principle

**D.** HIPAA minimum necessary standard

**11.** If a patient develops signs of an anaphylactoid reaction during ultrasound contrast agent administration, the sonographer's first responsibility is to:

**A.** Continue the exam to gather diagnostic data

**B.** Stop the exam and initiate the facility's emergency response protocol

**C.** Document the reaction only after the exam is finished

**D.** Administer additional contrast to confirm the reaction

**12.** The wavelength of a 4 MHz transducer operating in soft tissue (propagation speed 1540 m/s) is closest to:

**A.** 0.15 mm

**B.** 0.62 mm

**C.** 1.54 mm

**D.** 0.39 mm

**13.** Total attenuation of an ultrasound beam as it travels through tissue results from the combined effects of absorption, scattering, and:

**A.** Refraction

**B.** Diffraction

**C.** Reflection

**D.** Interference

**14.** Axial resolution is defined as the minimum separation between two reflectors along the beam's path that can still be displayed as two distinct echoes, and is primarily determined by:

**A.** The beam's overall width

**B.** The system's current frame rate

**C.** The pulse's spatial pulse length

**D.** The image's line density setting

**15.** Duty factor is defined as the fraction of time that a pulsed ultrasound system is actively:

**A.** Transmitting

**B.** Receiving

**C.** Processing

**D.** Displaying

**16.** Snell's law describes the relationship between the angle of incidence and the angle of refraction at a boundary where:

**A.** Propagation speeds are equal in both media

**B.** Propagation speeds differ between the two media

**C.** Impedances are equal in both media

**D.** The interface is perpendicular to the beam

**17.** Acoustic impedance of a medium is calculated as the product of its density and its:

**A.** Propagation speed

**B.** Attenuation coefficient

**C.** Wavelength

**D.** Frequency

**18.** The fraction of incident intensity reflected at a boundary, known as the reflection coefficient, depends primarily on the:

**A.** The frequency of the incident beam

**B.** The angle of incidence alone

**C.** The impedance mismatch at the boundary

**D.** The overall beam intensity level

**19.** Period, the time required to complete one cycle, is related to frequency by the equation:

**A.** Period = frequency x wavelength

**B.** Period = 1/frequency

**C.** Period = frequency/2

**D.** Period = propagation speed/frequency

**20.** The decibel is a logarithmic unit used to express:

**A.** Absolute intensity in watts

**B.** Frequency ratios

**C.** Relative ratios of intensity or power

**D.** Absolute distance in centimeters

**21.** Acoustic intensity is defined as:

**A.** Power per unit area

**B.** Power per unit time

**C.** Energy per unit volume

**D.** Pressure per unit area

**22.** A transducer with a high Q-factor (narrow bandwidth, long pulse) is best suited for applications prioritizing:

**A.** Axial resolution

**B.** Broad tissue penetration variety

**C.** Doppler sensitivity

**D.** Harmonic imaging

**23.** The near zone (Fresnel zone) of an unfocused transducer is the region where the beam is:

**A.** Diverging outward from the source

**B.** At its widest possible point

**C.** Converging to a point narrower than the aperture

**D.** Entirely undefined by any formula

**24.** Scattering from a red blood cell, which is much smaller than the ultrasound wavelength, is classified as:

**A.** Specular scattering

**B.** Rayleigh scattering

**C.** Forward scattering only

**D.** Coherent reflection

**25.** Pulse repetition frequency (PRF) and pulse repetition period (PRP) are related as:

**A.** PRF equals one divided by PRP

**B.** PRF equals PRP multiplied by two

**C.** PRF and PRP share no relationship

**D.** PRF equals PRP divided by frequency

**26.** As imaging depth increases, maximum achievable frame rate:

**A.** Increases, since more tissue is sampled

**B.** Is completely unaffected by depth

**C.** Decreases, since each cycle takes longer

**D.** Doubles for every added centimeter

**27.** Ultrasound systems calculate depth assuming a standard soft-tissue propagation speed of:

**A.** 1450 m/s

**B.** 4080 m/s (bone)

**C.** 331 m/s (air)

**D.** 1540 m/s

**28.** The piezoelectric effect used by ultrasound transducers to convert electrical energy into mechanical (acoustic) energy, and vice versa, relies on which type of material?

**A.** Purely metallic conductive materials only

**B.** Simple dielectric insulating materials alone

**C.** Ferromagnetic metal alloys exclusively

**D.** Crystalline or ceramic materials such as PZT

**29.** The backing material behind the piezoelectric element is designed primarily to:

**A.** Focus the transmitted beam

**B.** Match impedance to the patient's skin

**C.** Dampen element vibration, shortening the pulse

**D.** Generate the electrical drive signal

**30.** The primary purpose of the acoustic matching layer is to:

**A.** Reduce impedance mismatch between element and skin

**B.** Increase the transducer's operating frequency

**C.** Provide simple electrical insulation

**D.** Protect the element from mechanical damage

**31.** A curvilinear (convex) array transducer is most commonly selected for:

**A.** Superficial vascular access sites

**B.** Cardiac imaging through a narrow window

**C.** General abdominal imaging needing a wide field

**D.** Intracavitary transvaginal or transrectal imaging

**32.** A phased (sector) array transducer, with its small footprint and electronically steered beam, is best suited for:

**A.** Routine general abdominal imaging

**B.** Cardiac imaging through a narrow window

**C.** Superficial small-parts structure imaging

**D.** Standard transrectal prostate imaging

**33.** Increasing transducer frequency generally results in:

**A.** Improved penetration and improved resolution

**B.** Reduced penetration and reduced resolution

**C.** No change in either penetration or resolution

**D.** Improved resolution but reduced penetration

**34.** Bandwidth refers to the range of frequencies contained within the ultrasound pulse, and is generally:

**A.** Wider for a shorter, more heavily damped pulse

**B.** Wider for a longer, less damped pulse

**C.** Unrelated to pulse length

**D.** Fixed regardless of transducer design

**35.** The Curie point of a piezoelectric material is the temperature above which the material:

**A.** Becomes more efficient at converting energy

**B.** Permanently loses its piezoelectric properties (depoles)

**C.** Generates higher-frequency output

**D.** Requires re-calibration only, with no lasting damage

**36.** Apodization is a technique that reduces the drive amplitude of the outer elements in an array relative to the central elements, primarily to:

**A.** Increase overall output power

**B.** Reduce side lobes and improve image contrast

**C.** Increase the operating frequency

**D.** Extend transducer lifespan

**37.** Dynamic aperture automatically increases the number of active elements as imaging depth increases, primarily to:

**A.** Increasing frame rate at depth

**B.** Reducing power consumption overall

**C.** Maintaining consistent lateral resolution

**D.** Eliminating the need for focusing

**38.** An annular array transducer, composed of concentric ring-shaped elements, allows for:

**A.** Electronic steering in both planes at once

**B.** Dynamic focusing in both planes, with mechanical steering

**C.** Linear sequential element firing only

**D.** No need for any matching layer

**39.** Endocavity transducers typically operate at higher frequencies than general abdominal transducers primarily because:

**A.** Higher frequency reduces discomfort

**B.** Higher frequency is needed for Doppler only

**C.** The probe housing requires it structurally

**D.** Closer targets tolerate higher frequency without excess loss

**40.** A phased array transducer steers its beam electronically by:

**A.** Physically rotating the entire transducer housing

**B.** Using a single large element with a mechanical lens

**C.** Applying small, sequential timing delays to the firing of each element

**D.** Changing the transducer's operating frequency

**41.** A continuous-wave (CW) Doppler probe typically uses:

**A.** Two crystals, one transmitting and one receiving

**B.** A single crystal alternating transmit and receive

**C.** A full phased array of elements

**D.** No piezoelectric material used at all

**42.** Tissue harmonic imaging relies on the transducer receiving primarily at:

**A.** The same frequency it transmitted

**B.** Twice the transmitted (fundamental) frequency

**C.** Half the transmitted frequency

**D.** A randomly selected frequency band

**43.** A standoff pad or gel pad placed between the transducer and a very superficial structure is used primarily to:

**A.** Increase the operating frequency

**B.** Reduce the need for gel

**C.** Improve Doppler sensitivity

**D.** Move the target out of the dead zone

**44.** Compared with a standard 1D array, a 1.5D array adds a limited number of additional rows of elements in the elevational direction primarily to allow:

**A.** Full elevational steering like a 2D matrix

**B.** A higher operating frequency

**C.** Mechanical 3D sweep capability

**D.** Some electronic elevational focus control

**45.** A linear sequential array, producing a rectangular field of view, is most commonly used for:

**A.** Deep abdominal organ imaging depth

**B.** Superficial structures such as thyroid or breast

**C.** Standard transvaginal pelvic imaging use

**D.** Standard cardiac chamber imaging use

**46.** Time gain compensation (TGC) is used to:

**A.** Compensate for attenuation at increasing depth

**B.** Increase the overall frame rate

**C.** Change the operating frequency

**D.** Adjust the displayed color map

**47.** Unlike TGC, which adjusts amplification at specific depths, overall gain:

**A.** Affects only color, not grayscale

**B.** Compensates only for depth-dependent loss

**C.** Cannot be adjusted by the operator

**D.** Uniformly amplifies the signal at every depth

**48.** As imaging depth increases, the maximum usable pulse repetition frequency must:

**A.** Increase to keep up with the depth

**B.** Decrease, allowing time for each pulse to return

**C.** Remain entirely unchanged regardless of depth

**D.** Become completely random with no pattern

**49.** Narrowing the dynamic range setting on a system will:

**A.** Increase the number of gray shades

**B.** Improve penetration at depth

**C.** Reduce gray shades, increasing contrast

**D.** Have no effect on the image

**50.** Persistence, or frame averaging, reduces image noise (speckle) primarily by:

**A.** Increasing pulse repetition frequency

**B.** Reducing beam divergence overall

**C.** Narrowing the dynamic range

**D.** Averaging data across consecutive frames

**51.** Spatial compounding combines image data acquired from multiple different beam-steering angles to:

**A.** Increasing the frame rate

**B.** Increasing penetration depth only

**C.** Sharpening axial resolution specifically

**D.** Reducing speckle by averaging multiple views

**52.** A key clinical benefit of tissue harmonic imaging is:

**A.** Reduced near-field artifact and improved contrast resolution

**B.** Increased penetration compared with fundamental imaging

**C.** Increased frame rate compared with fundamental imaging

**D.** Elimination of the need for TGC

**53.** M-mode (motion mode) displays tissue motion along a single scan line over time, and is most commonly used for:

**A.** Evaluating rapid cardiac valve motion

**B.** Measuring total organ volume

**C.** Three-dimensional volume reconstruction

**D.** Correcting the Doppler angle

**54.** Write zoom, applied before an image is frozen, differs from read zoom (applied after freezing) in that write zoom:

**A.** Only magnifies pixels already stored

**B.** Reacquires data at higher line density

**C.** Cannot be used with calipers

**D.** Is identical to read zoom

**55.** Range ambiguity artifact occurs when a second pulse is transmitted before all echoes from the first pulse have returned, most often as a result of:

**A.** Excessive overall gain

**B.** A narrow dynamic range setting

**C.** An excessively high PRF for the depth

**D.** Insufficient TGC compensation

**56.** Reverberation artifact, appearing as multiple equally spaced parallel echoes, results from:

**A.** Refraction at a curved interface

**B.** An excessively low PRF setting

**C.** Beam divergence in the far field

**D.** Sound bouncing between two reflectors

**57.** Mirror image artifact occurs when the ultrasound beam reflects off a strong, curved reflector (such as the diaphragm) and creates a duplicate image:

**A.** Far side of the reflector, at a false depth

**B.** At the exact same true depth

**C.** Only in color Doppler mode

**D.** Only with a linear array probe

**58.** Posterior enhancement, appearing as increased brightness deep to a structure, occurs because that structure:

**A.** Has extremely high attenuation, like bone

**B.** Reflects nearly all the incident beam

**C.** Lies outside the field of view

**D.** Attenuates less, so TGC over-amplifies it

**59.** Clean acoustic shadowing, with a sharply defined edge and no internal echoes deep to the structure, is typically caused by:

**A.** A simple fluid-filled structure

**B.** A gas-filled bowel loop

**C.** A strongly attenuating stone-like structure

**D.** A random speckle noise pattern

**60.** Speckle, the granular texture seen in ultrasound images, results from:

**A.** Electronic system noise alone

**B.** Patient motion artifact alone

**C.** Incorrect system calibration alone

**D.** Interference from sub-resolution scatterers

**61.** Grating lobe artifact, seen as duplicated or smeared structures displaced from their true position, is most associated with:

**A.** Single-element mechanical transducers only

**B.** Arrays with spacing over half a wavelength

**C.** Low-frequency imaging exclusively

**D.** TGC miscalibration alone

**62.** Side lobe artifact occurs when off-axis energy from the main beam strikes a strong reflector and is displayed as if it originated:

**A.** Along the main axis, wrong lateral position

**B.** At exactly twice the true depth

**C.** Only in Doppler imaging mode

**D.** Only with phased array probes

**63.** Refraction artifact causes structures to be displayed in an incorrect lateral position because:

**A.** The beam reflects, not bends

**B.** Attenuation differs between structures

**C.** The beam bends at an oblique interface

**D.** The transducer frequency is too high

**64.** A comet tail artifact, a tapering series of closely spaced reverberation echoes, is classically associated with:

**A.** A simple fluid-filled cyst

**B.** Uniform tissue with no interfaces

**C.** A strongly attenuating shadow

**D.** Small, highly reflective metal deposits

**65.** Thin, clean acoustic shadows arising from the curved edges of a rounded structure (such as a cyst or vessel wall) are caused by:

**A.** High attenuation at the edge

**B.** Simple posterior acoustic enhancement

**C.** Refraction bending the beam away

**D.** Reverberation between two close surfaces

**66.** In B-mode (brightness mode) imaging, the brightness of each displayed pixel corresponds to:

**A.** The depth of the reflector

**B.** The amplitude of the returning echo

**C.** The frequency of the returning echo

**D.** The Doppler shift at that location

**67.** Coded excitation improves signal-to-noise ratio by transmitting a longer, uniquely coded pulse and then:

**A.** Simply amplifying the received signal

**B.** Applying a matched filter on receive

**C.** Discarding half the returning data

**D.** Doubling the transmit frequency

**68.** Extended field-of-view (panoramic) imaging is created by:

**A.** Increasing the physical footprint

**B.** Compounding a single static frame

**C.** Stitching sequential frames into one image

**D.** Doubling the acquisition frame rate

**69.** Real-time 3D imaging, often called 4D imaging, differs from static 3D imaging in that 4D imaging:

**A.** Requiring an external sensor always

**B.** Being unusable for fetal imaging

**C.** Using only mechanical transducers

**D.** Continuously updating the volume over time

**70.** DICOM is the standardized format used to store and transmit ultrasound images so they can be accessed through a facility's:

**A.** A facility's PACS system

**B.** An EMR billing module exclusively

**C.** A crash cart inventory system

**D.** A transducer calibration log

**71.** A cine loop allows the sonographer to review a short sequence of recently acquired frames retrospectively, which is especially useful for:

**A.** Selecting the best frame for measurement

**B.** Increasing overall frame rate

**C.** Permanently deleting unwanted images

**D.** Recalibrating the transducer itself

**72.** Accurate on-screen caliper measurement depends most directly on:

**A.** The color Doppler settings

**B.** The patient's body mass alone

**C.** Precise caliper placement on a good image

**D.** The transducer's serial number

**73.** The body marker icon displayed on the image, showing transducer orientation and position, is used primarily to:

**A.** Help the physician orient the anatomy

**B.** Calculate organ volume automatically

**C.** Adjust TGC automatically for depth

**D.** Trigger automatic Doppler angle correction

**74.** Facility and accreditation-body documentation standards for a complete ultrasound exam typically require, at minimum:

**A.** Only a single image per organ

**B.** Verbal report with no stored images

**C.** Images with no patient identification

**D.** Images of all required structures, labeled

**75.** Increasing persistence (frame averaging) to reduce noise comes at the cost of:

**A.** Reduced temporal resolution from blurred motion

**B.** Reduced spatial axial resolution

**C.** Increased overall frame rate

**D.** Reduced overall penetration depth

**76.** The dead zone is the region closest to the transducer face where structures cannot be reliably imaged because:

**A.** TGC being disabled there

**B.** The beam not reaching focus yet

**C.** Attenuation being too high there

**D.** The transducer's initial ring-down period

**77.** The Doppler equation used to calculate blood flow velocity includes all of the following variables EXCEPT:

**A.** The Doppler frequency shift

**B.** The angle of insonation

**C.** The reflector's physical size

**D.** The propagation speed of sound in tissue

**78.** The Nyquist limit, the maximum Doppler shift that can be unambiguously measured, is equal to:

**A.** The full PRF

**B.** One-half the PRF

**C.** Twice the PRF

**D.** The transmit frequency

**79.** Aliasing occurs on spectral Doppler when the Doppler shift exceeds the Nyquist limit, causing the waveform to:

**A.** Disappear entirely from view

**B.** Shift to a lower baseline

**C.** Become perfectly flat

**D.** Wrap around as reversed flow

**80.** By the standard BART convention, flow moving toward the transducer is displayed as:

**A.** Displayed as blue

**B.** Always displayed as green

**C.** Displayed as red

**D.** Always displayed as black

**81.** Compared with conventional color Doppler, power Doppler is more sensitive to slow, low-volume flow primarily because it displays:

**A.** Signal amplitude, and it isn't subject to aliasing

**B.** Only arterial flow, never venous

**C.** Flow direction with greater precision

**D.** A narrower color box setting

**82.** Spectral broadening, or filling-in of the normally clear window beneath a spectral waveform, is most often associated with:

**A.** A properly angle-corrected, laminar flow pattern

**B.** An excessively low wall filter setting

**C.** Venous flow exclusively

**D.** Turbulent or disturbed flow, such as at a stenosis

**83.** The wall filter (or high-pass filter) is used to eliminate low-frequency, high-amplitude Doppler signals originating from:

**A.** Fast-moving blood cells directly

**B.** The transducer itself only

**C.** Slowly moving vessel wall tissue

**D.** Turbulent flow jets specifically

**84.** In pulsed-wave spectral Doppler, the sample volume (gate) is positioned to:

**A.** Select the location for Doppler sampling

**B.** Automatically correct the insonation angle

**C.** Filter out low-velocity venous signals

**D.** Automatically increase the system's PRF

**85.** Increasing the Doppler scale (velocity range) setting on a system corresponds to:

**A.** Decreasing the overall PRF

**B.** Applying a lower wall filter

**C.** Raising the PRF and Nyquist limit

**D.** Narrowing the sample volume automatically

**86.** For the most accurate Doppler velocity measurement, the angle of insonation should be:

**A.** As close to 90 degrees as possible

**B.** Irrelevant, since the system compensates

**C.** As close to 0 degrees as possible

**D.** Exactly 45 degrees in every case

**87.** Unlike pulsed-wave Doppler, continuous-wave Doppler can measure very high velocities without aliasing, but at the cost of:

**A.** Reduced sensitivity to slow flow

**B.** An inability to detect direction

**C.** Requiring a phased array only

**D.** Range ambiguity from a continuous beam

**88.** Resistive index (RI) is calculated as:

**A.** PSV minus EDV, divided by PSV

**B.** EDV divided by PSV

**C.** PSV divided by EDV

**D.** Mean velocity divided by PSV

**89.** Pulsatility index (PI) is calculated as:

**A.** PSV divided by EDV

**B.** EDV divided by mean velocity

**C.** Resistive index multiplied by two

**D.** PSV minus EDV, over mean velocity

**90.** A normal resting peripheral (extremity) arterial Doppler waveform is typically described as:

**A.** Monophasic and continuous, like venous flow

**B.** Triphasic, reflecting high peripheral resistance

**C.** Absent during diastole entirely, with no exceptions

**D.** Always low-resistance with continuous forward diastolic flow

**91.** Normal lower-extremity venous Doppler flow is expected to show phasicity with respiration and augmentation with distal compression; absence of either finding raises concern for:

**A.** Elevated cardiac output

**B.** Normal arterial supply

**C.** A technically inadequate angle

**D.** Venous obstruction proximal to the site

**92.** Duplex grading of internal carotid artery stenosis relies primarily on measured:

**A.** Resistive index alone

**B.** Peak systolic and end diastolic velocity

**C.** Vessel diameter by grayscale

**D.** Color Doppler gain settings

**93.** The primary grayscale technique for diagnosing lower-extremity deep venous thrombosis is:

**A.** Measuring peak systolic velocity

**B.** Evaluating waveform phasicity only

**C.** Direct compression to assess coaptation

**D.** Simply measuring the vessel's diameter

**94.** A normal main renal artery Doppler waveform is characterized by:

**A.** A monophasic venous-type pattern

**B.** Rapid upstroke with forward diastolic flow

**C.** Completely absent diastolic flow

**D.** Fully reversed diastolic flow

**95.** The normal hepatic vein Doppler waveform is:

**A.** Triphasic, reflecting cardiac pressure changes

**B.** Simply monophasic and continuous

**C.** Completely absent under normal conditions

**D.** Identical to the portal vein waveform

**96.** Normal portal vein flow is directed:

**A.** Away from the liver, hepatofugal

**B.** Toward the liver, hepatopetal

**C.** In a to-and-fro pattern

**D.** Absent until after a meal

**97.** Normal umbilical artery Doppler in a healthy pregnancy shows continuous forward flow throughout the cardiac cycle, including:

**A.** Reversed flow at end-diastole normally

**B.** A triphasic arterial pattern

**C.** Absent flow during systole

**D.** Forward end-diastolic flow

**98.** A normal fetal heart rate, as assessed by M-mode or Doppler, generally falls within the range of:

**A.** 60 to 80 beats per minute

**B.** About 110 to 160 beats per minute

**C.** 250 to 300 beats per minute

**D.** 40 to 60 beats per minute

**99.** Normal intratesticular arterial Doppler waveforms are typically:

**A.** Absent at rest

**B.** Identical to epididymal waveforms in every case

**C.** High-resistance with absent diastolic flow always

**D.** Low-resistance, with continuous forward diastolic flow

**100.** Normal ovarian stromal blood flow on Doppler is typically:

**A.** Never detectable in a healthy ovary

**B.** Always high-resistance with no diastolic flow

**C.** Variable, fluctuating with the cycle

**D.** Identical pre- and post-ovulation

**101.** When spectral or color Doppler aliasing occurs, appropriate corrective steps include all of the following EXCEPT:

**A.** Increasing the velocity scale (PRF)

**B.** Increasing the Doppler angle toward 90 degrees

**C.** Shifting the baseline

**D.** Switching to a lower transducer frequency

**102.** In a linear array, steering the color Doppler box to angle the beam relative to a horizontally running vessel is done primarily to:

**A.** Achieve a usable Doppler angle

**B.** Increase the frame rate

**C.** Reduce wall filter artifact

**D.** Automatically correct for depth

**103.** Color Doppler gain that is set too high will produce:

**A.** An underfilled vessel lumen

**B.** Complete loss of color signal

**C.** Improved spatial resolution

**D.** Color bleeding outside the vessel wall

**104.** If the Doppler scale (PRF) is set too low for the actual velocities present, the resulting artifact is:

**A.** An underfilled color box

**B.** Aliasing of the Doppler signal

**C.** Complete signal loss

**D.** Excessive spectral broadening only

**105.** Doppler color assignment (e.g., red vs blue) reflects flow direction relative to the transducer, meaning that in a single image, a vein and an adjacent artery with flow in opposite directions relative to the probe will:

**A.** Always both display as red

**B.** Always both display as blue

**C.** Display in different colors from each other

**D.** Cannot be told apart by color

**106.** Color persistence, or frame averaging applied to the color Doppler signal, improves the appearance of color fill but can:

**A.** Increase overall spatial resolution

**B.** Eliminate aliasing entirely

**C.** Increase the frame rate

**D.** Blur rapidly changing flow

**107.** A 'triplex' Doppler mode simultaneously displays:

**A.** Two separate spectral traces from two vessels

**B.** Grayscale (B-mode), color Doppler, and spectral Doppler together

**C.** Color Doppler and spectral Doppler only, without grayscale

**D.** Grayscale and spectral Doppler only

**108.** High pulse repetition frequency (HPRF) Doppler mode is used to measure high velocities beyond the standard PW Nyquist limit by:

**A.** Switching to continuous-wave transmission

**B.** Reducing the sample volume to zero

**C.** Doubling the transducer frequency

**D.** Firing an extra pulse before the first returns

**109.** The audible Doppler signal heard through the system's speakers is generated because Doppler shift frequencies for typical blood flow velocities fall within:

**A.** The ultrasonic imaging frequency range (2-15 MHz)

**B.** The range of human hearing (roughly 20 Hz-20 kHz)

**C.** The infrasound range, below 20 Hz

**D.** A range that must always be electronically shifted up before it becomes audible

**110.** Continuous-wave Doppler, when used with a nondirectional (single-channel) system, cannot distinguish:

**A.** High velocity from low velocity

**B.** Flow toward vs away from the probe

**C.** Arterial from venous timing patterns

**D.** Systole from diastole precisely

**Answers**

**1. B.** ALARA is the guiding principle of using the minimum acoustic output and exposure time needed to obtain a diagnostic-quality image, distinct from disinfection classification (Spaulding), the AIUM Prudent Use Statement (a related but separate document), or FDA output labeling tracks.

**2. D.** MI estimates the likelihood of mechanical bioeffects such as cavitation, while TI estimates the likelihood of thermal bioeffects (tissue heating); the two indices track fundamentally different physical mechanisms.

**3. B.** Devices contacting mucous membranes (but not entering sterile tissue) fall under Spaulding's semicritical category, requiring high-level disinfection, distinct from noncritical (intact skin only) or critical (sterile tissue/bloodstream) categories.

**4. D.** Standard precautions apply universally to all patients; transmission-based precautions (contact, droplet, airborne) are added on top of standard precautions specifically when a known or suspected transmissible infection is present.

**5. C.** Valid informed consent requires disclosure of the procedure, its risks and benefits, and reasonable alternatives so the patient can make an informed choice; sonographer credentials, cost, and needle gauge are not required consent elements.

**6. C.** Repetitive, awkward postures and sustained gripping during scanning are well-documented causes of work-related musculoskeletal disorders among sonographers, distinct from hearing loss, contrast reactions, or thermal bioeffects.

**7. B.** Sonographers document objective findings and defer diagnostic interpretation and disclosure to the interpreting physician, remaining within their scope of practice rather than diagnosing, omitting findings, or repeating exams unnecessarily.

**8. B.** Phantom-based QA testing directly measures objective system performance metrics like axial/lateral resolution, penetration depth, and dead zone, not administrative metrics like satisfaction or billing.

**9. D.** MI is specifically designed to estimate the likelihood of mechanical (cavitation-related) bioeffects, while TIB, TIS, and TIC all relate to thermal, not mechanical, bioeffects in different tissue paths.

**10. B.** The time-out, a core element of the Universal Protocol, confirms correct patient, procedure, and site immediately before an invasive procedure begins, distinct from disinfection classification, ALARA, or HIPAA privacy rules.

**11. B.** Patient safety takes priority: the exam is stopped and the facility's emergency protocol for an allergic/anaphylactoid reaction is initiated immediately, rather than continuing to scan, delaying documentation, or giving more contrast.

**12. D.** Wavelength = propagation speed / frequency = 1540 m/s / 4,000,000 Hz = 0.385 mm, which rounds to approximately 0.39 mm.

**13. C.** Total attenuation is the sum of all mechanisms that reduce beam intensity with distance, including absorption, scattering, and reflection; refraction, diffraction, and interference affect beam direction or pattern rather than contributing directly to attenuation in this standard grouping.

**14. C.** Axial resolution is governed by spatial pulse length (the physical length of the pulse along its direction of travel); shorter pulse length allows finer discrimination of closely spaced reflectors along the beam axis.

**15. A.** Duty factor is the fraction of time the system is transmitting relative to the total pulse repetition period, distinguishing pulsed systems (low duty factor) from continuous-wave systems (duty factor of 1).

**16. B.** Refraction, governed by Snell's law, only occurs at an oblique interface where the propagation speeds of the two media differ; if speeds are equal, the beam continues straight through without bending.

**17. A.** Acoustic impedance (Z) equals density (rho) multiplied by propagation speed (c): Z = rho x c, a fundamental relationship distinct from attenuation, wavelength, or frequency.

**18. C.** The reflection coefficient at a boundary is determined by the degree of acoustic impedance mismatch between the two media; a larger mismatch produces a larger fraction of reflected intensity, largely independent of frequency or beam intensity for a normal-incidence reflection.

**19. B.** Period and frequency are reciprocals of each other: period (T) = 1/frequency (f), a basic relationship distinct from wavelength or propagation-speed-based formulas.

**20. C.** The decibel is a logarithmic scale expressing a ratio between two intensity or power values (such as transmitted vs received), not an absolute unit of intensity, frequency, or distance.

**21. A.** Intensity is formally defined as power per unit area (typically expressed in W/cm^2 or mW/cm^2), distinguishing it from power alone, energy, or pressure.

**22. C.** A high-Q, narrow-bandwidth, longer-pulse design favors Doppler applications, where sustained, narrowband energy improves velocity/frequency discrimination, at the cost of the axial resolution favored by short, broadband pulses.

**23. C.** In the near zone of an unfocused transducer, the beam actually converges somewhat before reaching its narrowest point at the near zone/far zone boundary, rather than diverging as it does in the far zone.

**24. B.** Rayleigh scattering describes scattering from reflectors much smaller than the wavelength, such as red blood cells, distinguishing it from specular reflection off large, smooth interfaces.

**25. A.** PRF and PRP are reciprocals of one another: PRF = 1/PRP, analogous to the relationship between frequency and period for individual cycles.

**26. C.** Greater depth requires a longer wait for each pulse's echoes to return before the next pulse can be safely sent, which lowers the maximum usable PRF and therefore reduces achievable frame rate.

**27. D.** Ultrasound systems universally assume an average soft-tissue propagation speed of 1540 m/s for depth calculation, which is why measurement errors occur in tissues (such as fat) whose actual speed differs from this assumption.

**28. D.** The piezoelectric effect depends on crystalline or ceramic materials with a specific internal structure (such as PZT) that generates or responds to an electrical charge when mechanically deformed, unlike ordinary conductors, insulators, or ferromagnetic alloys.

**29. C.** Backing material absorbs and dampens the element's vibration after each pulse, shortening the pulse and improving axial resolution, rather than focusing the beam or generating the electrical signal itself.

**30. A.** The matching layer's quarter-wavelength design minimizes the large impedance mismatch between the piezoelectric element and skin, maximizing the fraction of energy transmitted into the patient rather than reflected back into the probe.

**31. C.** The curvilinear array's wide, divergent field of view at depth makes it well suited to general abdominal imaging, unlike the small footprint of a sector array or the superficial focus of a linear array.

**32. B.** The phased array's small footprint fits between rib spaces and its electronic steering allows rapid sector-shaped imaging, making it the standard choice for cardiac imaging through a narrow intercostal window.

**33. D.** Higher frequency shortens wavelength, improving spatial resolution, but is attenuated more rapidly by tissue, reducing penetration depth -- the fundamental resolution-versus-penetration trade-off in transducer selection.

**34. A.** A shorter, more heavily damped pulse contains a broader range of frequency components (wider bandwidth), while a longer, less damped pulse is more narrowband, an inverse relationship between pulse length and bandwidth.

**35. B.** Exceeding the Curie point permanently disrupts the crystal's internal dipole alignment, causing irreversible loss of piezoelectric properties (depoling), which is why transducers must be protected from excessive heat, such as during certain sterilization methods.

**36. B.** Apodization tapers the drive amplitude toward the edges of the active aperture, which reduces the side lobe energy that would otherwise create artifact and improves overall image contrast.

**37. C.** As depth increases, dynamic aperture activates more elements to keep the effective aperture size (and therefore lateral resolution) more consistent across the field, compensating for the natural degradation of lateral resolution with depth.

**38. B.** An annular array's concentric ring elements allow true dynamic focusing in both the azimuthal and elevational planes simultaneously, but because the rings alone cannot steer the beam electronically, real-time scanning requires mechanical motion of the array.

**39. D.** Because endocavity structures are imaged at much shallower depths, the higher attenuation associated with higher frequency is not a limiting factor, allowing endocavity probes to use higher frequencies than general abdominal probes for improved resolution.

**40. C.** Phased array beam steering is achieved by applying incrementally timed electronic firing delays across the array's elements, causing the resulting wavefront to travel in a chosen direction without any physical movement of the transducer.

**41. A.** A CW Doppler probe uses two separate, dedicated crystals -- one continuously transmitting and one continuously receiving -- allowing it to detect very high velocities without the pulsing (and resulting Nyquist limit) of pulsed systems.

**42. B.** Tissue harmonic imaging exploits nonlinear propagation, which generates a second-harmonic component at twice the transmitted fundamental frequency; the system is designed to selectively receive at this harmonic frequency for improved image quality.

**43. D.** A standoff device physically increases the distance between the transducer face and a very superficial structure, moving that structure out of the near-field dead zone and into a region where the beam is better focused.

**44. D.** A 1.5D array's limited additional element rows provide some electronic control over elevational focusing and slice thickness, an intermediate step between a fixed-lens 1D array and a full 2D matrix capable of complete elevational steering.

**45. B.** The linear array's flat, rectangular field of view and typically higher operating frequency make it well suited to superficial structures like the thyroid, breast, and peripheral vessels, rather than deep abdominal or cardiac imaging.

**46. A.** TGC selectively amplifies returning echoes based on their arrival time (depth), compensating for the progressively greater attenuation experienced by deeper echoes so that similar tissues appear similarly bright throughout the image.

**47. D.** Overall gain applies a uniform amplification across the entire received signal regardless of depth, unlike TGC, which selectively adjusts amplification at specific depths to counteract depth-dependent attenuation.

**48. B.** Because each pulse-echo cycle takes longer to complete at greater depth (more time for the pulse to travel down and the echo to return), the maximum PRF that avoids range ambiguity must decrease as imaging depth increases.

**49. C.** Narrowing dynamic range compresses the range of echo amplitudes mapped to visible gray shades, reducing the number of distinguishable shades and producing a higher-contrast, more black-and-white-appearing image.

**50. D.** Persistence averages data across several consecutive frames over time, smoothing out random speckle variation between frames while real anatomic structures, which are consistent frame to frame, remain visible.

**51. D.** By combining views of the same tissue acquired from several different steering angles, spatial compounding averages out speckle and certain angle-dependent artifacts that don't repeat consistently across all the angles used.

**52. A.** Because harmonic signals are generated as the beam travels through tissue rather than at the transducer face, near-field reverberation and clutter are reduced, improving contrast resolution compared with fundamental-frequency imaging.

**53. A.** M-mode's very high temporal resolution along a single line makes it ideal for capturing and measuring rapid, repetitive motion such as cardiac valve opening/closing or wall motion, which 2D imaging alone cannot resolve as precisely over time.

**54. B.** Write zoom, applied before freezing, causes the system to reacquire fresh scan-line data concentrated within the magnified region, genuinely improving resolution there, unlike read zoom, which simply enlarges pixels already stored in a frozen image.

**55. C.** If the PRF is set too high for the chosen imaging depth, a new pulse can be transmitted before all echoes from the prior pulse have returned, causing late-arriving deep echoes to be misassigned to the wrong (shallower) location -- range ambiguity.

**56. D.** Reverberation occurs when sound repeatedly bounces back and forth between two strong, closely spaced reflectors (such as the transducer face and a superficial interface), each round trip producing an additional equally spaced echo at increasing depth.

**57. A.** When a strong curved reflector like the diaphragm redirects the beam, structures beyond it can be imaged via this indirect path and displayed as a duplicate, falsely positioned deeper on the far side of the true reflector.

**58. D.** Because the overlying structure attenuates the beam less than the system's TGC curve assumes for that depth, the TGC over-amplifies the genuinely weaker echoes returning from below it, producing an artifactually bright band.

**59. C.** A strongly attenuating or strongly reflecting structure, such as a gallstone, blocks most of the beam from reaching deeper tissue, producing a sharply defined, echo-free shadow directly behind it.

**60. D.** Speckle arises from the constructive and destructive interference of echoes returning from numerous scatterers smaller than the system's resolution, producing a textured pattern that does not correspond to actual discrete anatomic structures.

**61. B.** When element spacing in an array exceeds roughly half a wavelength, the array behaves like a diffraction grating, generating grating lobes of significant off-axis energy that can produce duplicated, displaced artifacts from strong reflectors.

**62. A.** Side lobe energy travels off the main beam axis but, when it strikes a strong reflector, the returning echo is processed by the system as if it came from directly along the main beam, placing the resulting artifact at the correct depth but an incorrect lateral position.

**63. C.** When the beam crosses an oblique interface between media with different propagation speeds, it bends according to Snell's law; the system, unaware of this bending, plots the resulting echo along its originally assumed straight path, misplacing the structure laterally.

**64. D.** Small, highly reflective objects such as metal fragments or calcium/crystal deposits cause intense, closely spaced internal reverberation that tapers with depth, producing the classic comet tail appearance.

**65. C.** At the tangential, curved edge of a rounded structure, the beam strikes at an oblique angle and refracts away, effectively removing that portion of the beam from continuing straight through, which produces a thin, clean shadow distinct from attenuation-based shadowing.

**66. B.** In B-mode, echo amplitude (the strength of the returning signal) is mapped directly to pixel brightness, while depth is represented by vertical position on the screen, not brightness itself.

**67. B.** Coded excitation transmits a longer pulse with a unique internal code, allowing more total energy to be sent without sacrificing resolution; on receive, a matched filter compresses that coded signal back down into an effectively short pulse, improving signal-to-noise ratio.

**68. C.** Extended field-of-view imaging tracks the transducer's motion as the operator sweeps across the patient and digitally stitches successive frames together into one continuous, elongated composite image beyond the physical footprint of a single frame.

**69. D.** 4D imaging is simply 3D imaging updated continuously and rapidly enough to display volumetric change over time in real time, distinguishing it from a single static 3D acquisition.

**70. A.** DICOM (Digital Imaging and Communications in Medicine) is the standard format that allows ultrasound images to be stored, retrieved, and shared consistently through a facility's PACS, distinct from billing systems or equipment logs.

**71. A.** A cine loop lets the sonographer scroll back through recently captured frames to find the single best-timed image of a moving structure, such as a specific cardiac phase, which would be difficult to capture live in a single freeze.

**72. C.** Measurement accuracy depends fundamentally on correct caliper placement at true anatomic landmarks on a well-optimized image; poor image quality or incorrect landmark identification introduces error regardless of the system's other settings.

**73. A.** The body marker icon indicates transducer position and orientation on the patient, allowing the interpreting physician to correctly understand right/left and anatomic orientation of the structures displayed in the image.

**74. D.** Documentation standards require stored images that adequately demonstrate all required anatomic structures for the exam type, correctly labeled with patient and exam identifying information, supporting both clinical interpretation and the medical-legal record.

**75. A.** Because persistence averages several consecutive frames together, motion occurring between those frames becomes blurred, effectively reducing the system's ability to resolve rapid change over time (temporal resolution), even though spatial noise is reduced.

**76. D.** The transducer element continues to vibrate briefly (ring down) after transmitting before it can reliably switch to receiving mode; this initial period corresponds to the near-field dead zone where returning echoes cannot yet be accurately detected.

**77. C.** The Doppler equation relates frequency shift to the transmit frequency, propagation speed, reflector velocity, and the cosine of the angle of insonation; it does not include the physical size of the reflector.

**78. B.** The Nyquist limit is defined as one-half the pulse repetition frequency; any Doppler shift exceeding this value cannot be correctly displayed and will alias.

**79. D.** When the true Doppler shift exceeds the Nyquist limit, the system cannot represent it correctly and instead wraps the signal around to the opposite end of the velocity scale, displaying it as if it were reversed flow.

**80. C.** Under the standard BART (Blue Away, Red Toward) convention, flow moving toward the transducer is assigned red and flow moving away is assigned blue, though the operator can invert this map -- the question specifies the standard, unaltered convention.

**81. A.** Power Doppler displays the total amplitude (power) of the Doppler signal rather than the mean frequency shift used by conventional color Doppler, making it more sensitive to weak, low-volume flow and immune to the aliasing that affects mean-shift-based color Doppler.

**82. D.** Turbulent or disturbed flow, such as occurs at a stenosis, contains a wide range of simultaneous velocities and directions, which fills in the normally clear spectral window beneath the waveform -- distinct from a technical setting issue like wall filter.

**83. C.** The wall filter is specifically designed to remove the low-frequency, high-amplitude 'clutter' signal produced by moving vessel walls and adjacent slowly moving tissue, which would otherwise obscure the much weaker blood flow signal.

**84. A.** The sample volume (gate) defines the specific depth and location within the vessel from which the pulsed-wave system collects Doppler data, distinguishing it from unrelated functions like angle correction or wall filtering.

**85. C.** The Doppler scale setting is directly tied to PRF; raising the scale raises the PRF (and thus the Nyquist limit), allowing higher velocities to be measured without aliasing.

**86. C.** Because the Doppler equation includes the cosine of the insonation angle, accuracy degrades sharply as the angle approaches 90 degrees (where cosine approaches zero); angles kept close to 0 degrees, and generally no greater than about 60 degrees, minimize this error.

**87. D.** Because CW Doppler continuously transmits and receives along the entire beam path rather than gating a specific depth, it cannot isolate the signal to one location, meaning it cannot distinguish which depth along the beam a given velocity came from.

**88. A.** Resistive index is calculated as (peak systolic velocity minus end diastolic velocity) divided by peak systolic velocity, a ratio that increases as diastolic flow decreases, reflecting higher downstream resistance.

**89. D.** Pulsatility index is calculated as (peak systolic velocity minus end diastolic velocity) divided by mean velocity, a related but distinct formula from resistive index that uses mean rather than peak systolic velocity in the denominator.

**90. B.** A normal resting peripheral arterial waveform is triphasic, with forward systolic flow, a brief reversal, and a small forward diastolic component, reflecting the high resistance of the downstream resting muscle bed.

**91. D.** Loss of normal respiratory phasicity or of augmentation with distal compression suggests an obstruction somewhere between the point of compression/respiration and the sampled site, prompting further evaluation for venous thrombosis or other obstruction.

**92. B.** Standard carotid duplex stenosis grading criteria are based on measured peak systolic and end diastolic velocity thresholds (often alongside a velocity ratio), not on resistive index, diameter alone, or color gain.

**93. C.** Direct probe compression to assess whether the vein walls fully coapt is the primary grayscale diagnostic technique for DVT; failure of the vein to compress indicates thrombus, independent of Doppler findings.

**94. B.** A normal main renal artery shows a rapid systolic upstroke followed by continuous, low-resistance forward flow throughout diastole, reflecting the kidney's normally low vascular resistance.

**95. D.** The normal hepatic vein waveform is triphasic, directly reflecting the pressure changes of the cardiac cycle transmitted back through the right atrium and IVC into the hepatic veins.

**96. B.** Normal portal venous flow travels toward the liver (hepatopetal) with gentle respiratory undulation, distinguishing it from the reversed (hepatofugal) flow seen in portal hypertension.

**97. D.** A healthy umbilical artery waveform maintains forward flow throughout the entire cardiac cycle, including during diastole; loss or reversal of end-diastolic flow is an abnormal finding, not the normal baseline.

**98. B.** A normal fetal heart rate generally falls in the range of approximately 110 to 160 beats per minute, substantially faster than typical adult resting heart rates.

**99. D.** Normal intratesticular arteries are low-resistance vessels supplying an organ with continuous metabolic demand, showing continuous forward flow throughout diastole rather than the high-resistance, diastole-absent pattern seen in some other vascular beds.

**100. C.** Ovarian stromal flow resistance is not fixed; it varies with hormonal changes across the menstrual cycle, generally remaining low-to-moderate resistance rather than following a single fixed pattern.

**101. B.** Increasing the angle of insonation toward 90 degrees worsens, rather than corrects, aliasing risk in most practical scenarios because the true velocity component measured falls, but the correct standard remedies are raising the scale/PRF, shifting the baseline, or using a lower frequency, not increasing the angle.

**102. A.** Because a linear array's natural beam is perpendicular to a horizontally running superficial vessel (yielding a poor, near-90-degree Doppler angle), steering the color box angles the beam so a usable, non-perpendicular angle of insonation can be achieved.

**103. D.** Excessive color gain causes the system to display color signal from noise and low-level clutter outside the true vessel lumen, producing a speckled, bleeding appearance beyond the actual vessel walls.

**104. D.** A PRF (scale) set too low for the true velocities present cannot represent the full range of Doppler shifts, causing the signal to alias and wrap around the display, the same underlying phenomenon as Nyquist-limit aliasing generally.

**105. C.** Color assignment reflects flow direction relative to the transducer, not vessel type; an artery and an adjacent vein with genuinely opposite flow directions relative to the probe will correctly display in different colors even though both are functioning normally.

**106. A.** Because color persistence averages the color signal across several consecutive frames, it can make gradual or steady flow appear more complete, but it also reduces the apparent frame rate and blurs rapidly changing or pulsatile flow patterns.

**107. B.** Triplex mode combines all three data streams -- grayscale anatomy, color flow mapping, and spectral waveform analysis -- displayed together, giving the most complete simultaneous picture of anatomy and flow.

**108. D.** HPRF mode fires additional pulses before the echoes from the prior pulse have fully returned, effectively raising the achievable PRF (and Nyquist limit) beyond the standard single-pulse limit, at the cost of introducing potential range ambiguity from multiple simultaneous sample gates.

**109. B.** Doppler shift frequencies produced by typical blood flow velocities fall within the audible range of human hearing, which is why systems can output an audible Doppler signal directly through speakers without needing to shift the frequency.

**110. A.** A simple nondirectional CW system detects the magnitude of the Doppler shift but not its sign, so it cannot distinguish whether flow is moving toward or away from the transducer without additional directional processing.