SIMULATION EXAM 13 — QUESTIONS 1–100

1. A conference room has a reverberation time (RT60) of 1.8 seconds at 1 kHz. The room is primarily used for speech communication. The most appropriate acoustic response is:

A. Increase loudspeaker volume to overcome the reverberation

B. Add more microphones to the room

C. Add absorptive treatment to reduce RT60 toward the 0.5–0.7 second range appropriate for speech

D. Upgrade the DSP processing

2. The formula relating reverberation time, room volume, and absorption is:

A. Sabine's equation: RT60 = 0.161 × V / A (metric)

B. Ohm's Law applied to acoustics

C. Snell's Law of refraction

D. The decibel calculation formula

3. The NC (Noise Criteria) rating for a typical conference room should target:

A. NC-55 or higher for cost efficiency

B. NC-45 as an industry default

C. No specific target is needed

D. Approximately NC-30 to NC-35 for good speech communication

4. The Speech Transmission Index (STI) or STIpa measurement provides:

A. A measure of room volume in cubic meters

B. A quantitative scale from 0 to 1 rating speech intelligibility, with 0.6 generally considered good

C. The room's total reflective surface area

D. The direct sound pressure level at the listener

5. A room with parallel hard-surface walls and a flat hard ceiling will most likely exhibit:

A. Excellent speech intelligibility without treatment

B. Ideal acoustic performance for all uses

C. Flutter echoes and standing wave room modes requiring acoustic treatment

D. Uniform sound coverage across all frequencies

6. Loudspeaker coverage pattern symmetry is specified in manufacturer documentation as:

A. The loudspeaker's color

B. Only the power rating

C. Only the manufacturer's suggested retail price

D. Horizontal and vertical coverage angles, typically at −6 dB points

7. The nominal distance at which a loudspeaker's SPL specification is typically measured is:

A. At the listener's ear regardless of distance

B. At the loudspeaker grille

C. One meter from the loudspeaker

D. Ten meters from the loudspeaker

8. Room modes are most problematic at:

A. Low frequencies where room dimensions match sound wavelengths

B. High frequencies above 10 kHz

C. All frequencies equally

D. Frequencies above human hearing range

9. A ceiling loudspeaker with 90-degree conical coverage mounted at 10 feet produces a coverage circle of approximately:

A. 5 feet in diameter

B. 20 feet in diameter at the listener's ear level

C. 100 feet in diameter

D. No predictable coverage pattern

10. Loudspeaker coverage uniformity is addressed by AVIXA standard:

A. ANSI/AVIXA V202.01

B. ISO 9001

C. NEC Chapter 9

D. ANSI/AVIXA A102.01

11. The gain-before-feedback margin in a sound reinforcement system is typically designed to be:

A. At the threshold of feedback

B. Zero for maximum volume

C. 6 dB or more below the feedback threshold

D. Unlimited

12. Sound absorption coefficients are measured per ASTM C423 and range from:

A. 0.00 to 1.00, where 1.00 represents complete absorption

B. −1 to +1 on a linear scale

C. 0 to infinity with no upper bound

D. Only integer values from 1 to 10

13. The inverse square law states that sound pressure level decreases by approximately:

A. 3 dB per doubling of distance in a reverberant field

B. 10 dB per halving of distance

C. Any amount depending on the room

D. 6 dB per doubling of distance in free field

14. A linear array loudspeaker system is most appropriate for:

A. Small rectangular conference rooms

B. Large venues requiring controlled vertical coverage across long throws

C. Small broom closets

D. Automotive audio systems

15. Acoustic treatment targeting reverberation control typically uses:

A. Reflective hard surfaces throughout

B. Vibration damping on the floor only

C. Porous absorption panels sized to the intended frequency range

D. More loudspeakers instead of treatment

16. The critical distance in a room is the distance from the source at which:

A. Direct sound level equals reverberant sound level

B. Sound stops propagating entirely

C. The room mode peak is loudest

D. The loudspeaker breaks up

17. Feedback in a sound reinforcement system occurs when:

A. The amplifier produces excessive harmonic distortion

B. The loudspeaker fails entirely

C. The DSP processes signals too slowly

D. The loop gain from microphone to loudspeaker back to microphone exceeds unity

18. A room measuring 30 feet long, 20 feet wide, and 10 feet high has a volume of:

A. 300 cubic feet

B. 6,000 cubic feet

C. 60 cubic feet

D. 60,000 cubic feet

19. Bass traps are acoustic treatments designed to:

A. Increase bass frequencies in a room

B. Reflect low frequencies

C. Absorb low-frequency energy, typically in corners where bass builds up

D. Block mid-frequency sounds

20. The Schroeder frequency is the frequency above which:

A. A room's acoustic behavior transitions from modal to statistical behavior

B. Feedback always occurs

C. Speakers always distort

D. The room becomes perfectly absorbent

21. A loudspeaker rated for 90 dB SPL at 1 watt, 1 meter produces what SPL at 1 meter with 100 watts input?

A. 92 dB SPL

B. 95 dB SPL

C. 105 dB SPL

D. 110 dB SPL

22. For speech reinforcement, an even coverage specification typically targets:

A. Maximum variation of 10 dB across the listener area

B. Coverage uniformity within ±3 dB across the listener area at the frequency of interest

C. Only the front row of seats

D. Only uniform loudness at very low frequencies

23. The minimum ceiling loudspeaker count for a given room is determined by:

A. The integrator's preferred number

B. The budget available

C. Coverage geometry using the loudspeaker's dispersion pattern, ceiling height, and target listener plane

D. The client's aesthetic preference

24. Reverberation time varies significantly by frequency because:

A. Absorption coefficients of room materials vary with frequency

B. Sound velocity changes with frequency

C. Loudspeakers are frequency-dependent

D. Microphones only pick up specific frequencies

25. Acoustic panels rated NRC 0.85 absorb approximately what percentage of incident sound?

A. 5%

B. 15%

C. 50%

D. 85%

26. The direct-to-reverberant ratio improves as:

A. The room becomes more reverberant

B. The listener moves farther from the source

C. Absorption decreases in the room

D. The listener moves closer to the source or the room becomes less reverberant

27. Axial room modes are caused by sound waves reflecting between:

A. Floor and ceiling randomly

B. Multiple walls in complex patterns

C. A single pair of parallel surfaces

D. No surfaces at all

28. Professional acoustic measurements for a conference room typically use:

A. A calibrated sound level meter and RTA or similar measurement tools with appropriate calibration

B. A consumer-grade smartphone app only

C. The integrator's subjective impression

D. A decibel chart from a textbook only

29. The primary purpose of acoustic treatment in a conference room is to:

A. Increase total SPL available

B. Manage reverberation and reflections for improved speech intelligibility

C. Reduce equipment costs

D. Replace the need for a DSP

30. Diffusion differs from absorption in that diffusion:

A. Absorbs sound completely

B. Reflects sound energy back in a focused way

C. Eliminates all room modes

D. Scatters reflected sound energy across a wide area, reducing specific reflections without removing total energy

31. The speed of sound in air at 20°C (68°F) is approximately:

A. 343 m/s or 1,125 ft/s

B. 186,000 m/s

C. 50 ft/s

D. 10,000 m/s

32. A conference room with excessive low-frequency buildup at specific locations is likely experiencing:

A. Microphone failures

B. DSP malfunction

C. Standing waves from room modes

D. Amplifier clipping

33. Dispersion patterns of loudspeakers are typically plotted as:

A. Linear graphs only

B. Polar plots showing coverage angle at various frequencies

C. Spectrograms exclusively

D. Waveform displays only

34. A room's acoustic design should consider:

A. Only the aesthetic of the walls

B. Only the height of the ceiling

C. Only the floor material

D. Volume, surface materials, shape, HVAC noise, and intended use

35. The 1/3 octave band is used in acoustic analysis because:

A. It provides meaningful frequency resolution for human hearing and room acoustic analysis

B. It is the only available bandwidth setting

C. It requires the least processing power

D. It is always the correct choice for everything

36. Mounting acoustic panels with an air gap behind them:

A. Reduces their effectiveness at all frequencies

B. Has no effect on performance

C. Improves low-frequency absorption compared to mounting directly to the wall

D. Only affects high-frequency absorption

37. A distributed loudspeaker ceiling grid typically uses:

A. Single loudspeakers spaced very far apart

B. Overlapping coverage circles with spacing calculated for target SPL uniformity

C. Random placement without design analysis

D. Placement only at the room's center

38. For conference rooms, the typical target RT60 for good speech intelligibility is:

A. Several seconds to emphasize room presence

B. Not specified in any guidelines

C. Zero seconds (completely dead)

D. Approximately 0.5 to 0.7 seconds, depending on room size and use

39. The SPL contribution from adding a second identical loudspeaker producing the same signal is:

A. Approximately 3 dB increase

B. 6 dB increase

C. 10 dB increase

D. Indeterminate

40. Speech intelligibility is most strongly affected by:

A. The visual aesthetic of the room

B. The color of the walls only

C. The signal-to-noise ratio and reverberation characteristics of the listening environment

D. The brand of the microphone

41. The −3 dB point on a loudspeaker's polar plot represents:

A. The loudest axis of radiation

B. The half-power angle where output is 3 dB below the on-axis level

C. The lowest frequency reproduction

D. The angle where the loudspeaker stops producing sound

42. Acoustic impact of HVAC systems on rooms is measured using:

A. Only room volume

B. Only wall material

C. Only carpet thickness

D. NC (Noise Criteria) or RC (Room Criteria) ratings of background sound

43. A line array's directivity increases with:

A. Array length and frequency

B. Array color

C. Array weight

D. Shorter arrays only

44. The speaker-to-listener distance affects SPL according to:

A. The inverse cube law

B. A linear relationship

C. The inverse square law in the direct field, with less variation in the reverberant field

D. Random variation

45. An acoustic designer can verify speech intelligibility through:

A. Visual appearance of the room only

B. STIpa measurements and/or C50 calculations in the occupied space

C. Amplifier output wattage

D. Microphone manufacturer reputation

46. Reverberation time is primarily controlled in a room by:

A. Painting the walls different colors

B. Changing the room's decor

C. Adding more loudspeakers only

D. The total absorption (surface area × absorption coefficient) of surfaces

47. A loudspeaker's sensitivity rating in dB SPL/W/m reveals:

A. The loudspeaker's manufacturing date

B. The loudspeaker's model lineup position

C. The loudspeaker's color scheme

D. The SPL produced at 1 meter with 1 watt of input power

48. A conference room needs to accommodate both speech and light background music. The acoustic design should:

A. Target a RT60 of 0.8–1.0 seconds as a compromise for both uses

B. Prioritize only music reproduction

C. Balance slightly higher absorption to favor speech intelligibility while allowing acceptable music reproduction

D. Skip acoustic design entirely

49. The Haas effect describes:

A. The way human hearing localizes sound to the first-arriving wavefront

B. Feedback in microphone systems

C. Bass buildup in corners

D. The color of loudspeakers

50. A loudspeaker with a 60-degree conical pattern mounted at 10 feet above the listener creates a coverage circle approximately how large at the listener's ear height (assume ear at 4 feet above floor)?

A. 2 feet in diameter

B. 10 feet in diameter

C. 30 feet in diameter

D. Approximately 7 feet in diameter

51. Porous absorber thickness influences:

A. Only the absorber's weight

B. Only the color of the absorber

C. The low-frequency limit at which absorption becomes effective

D. The absorber's price only

52. A sound reinforcement system's PAG (Potential Acoustic Gain) is limited by:

A. The listener's hearing

B. Only the amplifier power

C. Only the microphone quality

D. Room acoustics and microphone-loudspeaker-listener geometry

53. Acoustic diffusers designed using prime-number sequences (e.g., Schroeder diffusers) provide:

A. Complete absorption of all frequencies

B. Broadband scattering of sound with mathematically determined dispersion characteristics

C. Pure reflection with no scatter

D. Signal amplification

54. The law of reflection for sound waves states:

A. The angle of incidence equals the angle of reflection from a smooth surface

B. Sound cannot reflect from any surface

C. Reflection occurs only at 90-degree angles

D. Sound reflections are random

55. The difference between an absorber and a bass trap is:

A. Absorbers are wireless; bass traps are wired

B. Absorbers use electricity; bass traps don't

C. An absorber addresses mid-to-high frequencies; a bass trap targets low-frequency absorption, typically with greater depth or corner placement

D. They are the same device with different names

56. Constructive and destructive interference between multiple loudspeakers produces:

A. Only uniform coverage without variation

B. Coverage variations (peaks and nulls) at specific frequencies and locations

C. Pure signal amplification

D. No audible effect

57. A properly designed conference room audio system for a 30×20 foot room typically uses:

A. A grid of ceiling loudspeakers selected and placed for uniform coverage

B. A single large loudspeaker at the front wall

C. Wireless consumer speakers

D. No loudspeakers at all

58. Speech frequencies important for intelligibility include:

A. Only the 30–60 Hz range

B. Mid-range frequencies approximately 500 Hz to 4 kHz

C. Only sub-bass below 50 Hz

D. Only ultrasonic frequencies above 20 kHz

59. Room ratios are important in acoustic design because:

A. They determine the room's purchase price

B. They affect the decorator's choices

C. They determine only the ceiling color

D. Specific ratios minimize pronounced room mode concentrations

60. Loudspeaker aim is typically expressed as:

A. The angle from horizontal or vertical reference, indicating where the loudspeaker's primary axis points

B. The loudspeaker's color direction

C. The manufacturer's suggested retail position

D. An arbitrary direction without specification

61. The Fresnel region is:

A. A geographic location in Europe

B. A brand of loudspeaker

C. The near-field region where sound wavefronts have not yet formed into coherent spherical waves

D. The loudspeaker's far-field region

62. Adequate headroom above the feedback threshold in a sound reinforcement system should be:

A. At least 6 dB, preferably more, below the feedback threshold

B. At or above the feedback threshold for maximum gain

C. Zero dB for efficiency

D. Any arbitrary value

63. A ceiling height of 12 feet and a required floor coverage area determines:

A. The loudspeaker's brand

B. The loudspeaker's purchase price

C. The carpet type

D. The required coverage pattern angle and therefore the loudspeaker type selection

64. The primary cause of feedback in sound reinforcement is:

A. The amplifier's internal feedback

B. Insufficient distance between microphones and loudspeakers, causing loop gain to exceed unity

C. Insufficient microphone quality

D. The DSP's processing speed

65. Professional acoustic design uses software that models:

A. Only the room's dimensions

B. Only the loudspeaker brand

C. Only the wall color

D. Room geometry, surface absorption, and loudspeaker polar data to predict coverage and RT60

66. The audible frequency range for humans is typically:

A. 1 Hz to 100 Hz only

B. Only 500 Hz to 1 kHz

C. Approximately 20 Hz to 20 kHz with age-related reductions

D. Only above 20 kHz

67. Baffles and banners in a room serve primarily to:

A. Decorate the ceiling aesthetically

B. Add absorption in vertical or suspended configurations, typically for reverberation reduction

C. Replace acoustic panels entirely

D. Support HVAC ductwork

68. A room's first-reflection points are:

A. Locations where direct sound cancels completely

B. The loudspeaker grille

C. The microphone itself

D. Locations where early reflections reach the listener from the loudspeaker-to-wall-to-listener path

69. Loudspeaker placement behind architectural elements like scrim or fabric:

A. May attenuate high frequencies and must consider acoustic transparency of the material

B. Has no impact on performance

C. Improves all aspects of performance

D. Is always required in professional installations

70. A flutter echo is:

A. A pleasant musical effect

B. Required for proper room acoustics

C. A rapid repeating echo between parallel reflective surfaces that audibly degrades speech

D. Only a visual phenomenon

71. The dynamic range of a sound reinforcement system is the ratio between:

A. The cheapest and most expensive equipment

B. The system's noise floor and its maximum output SPL before distortion

C. The loudspeaker weight and amplifier weight

D. Only the cabinet dimensions

72. Acoustic panel placement for conference rooms typically focuses on:

A. Decoration only

B. Corners exclusively

C. Random placement for installer convenience

D. Primary reflection surfaces and areas contributing to reverberation and standing waves

73. A compression driver versus a cone driver in loudspeaker design:

A. Provides higher sensitivity and efficiency, typically used in horn-loaded high-frequency applications

B. Cannot reproduce high frequencies

C. Is only for consumer applications

D. Has no practical differentiation

74. A microphone's polar pattern affects:

A. Only the microphone's weight

B. Only the microphone's color

C. Its rejection of off-axis sound and susceptibility to feedback and ambient noise

D. The loudspeaker's performance

75. The primary measurement of a room's acoustic character for speech is:

A. The room's total square footage

B. Reverberation time (RT60) and intelligibility metrics like STIpa or C50

C. The average paint color

D. The purchase cost of the room

76. A sound system's signal-to-noise ratio is critical because:

A. Low S/N ratio produces distortion; high S/N ratio enables quiet passages to be heard clearly without masking by system noise

B. It determines the room's color scheme

C. It only affects the price

D. It has no practical impact

77. A room resonance at a specific frequency will produce:

A. Uniform response across all frequencies

B. Perfect reproduction at that frequency

C. No audible effect

D. Emphasized or peaked response at that frequency at specific locations in the room

78. Aiming loudspeakers to minimize reflections and maximize direct sound at listeners:

A. Is an important practice called loudspeaker alignment or aiming

B. Is irrelevant to system performance

C. Only applies to consumer systems

D. Is performed by the manufacturer only

79. Dynamic compression in audio processing:

A. Reduces the dynamic range, typically making program material more consistent in level

B. Increases dynamic range

C. Has no impact on audio

D. Is only for video signals

80. A 3 dB loss in sound pressure level represents:

A. A doubling of sound pressure

B. Approximately half the acoustic power (a 3 dB decrease is a halving of power)

C. A 100x increase in level

D. No change in level

81. An anechoic room has reverberation time of:

A. Several minutes

B. Several seconds

C. Exactly one second

D. Effectively zero, for acoustic measurement purposes

82. Professional acoustic analysis considers intelligibility as a function of:

A. Signal level, background noise, and reverberation characteristics together

B. Signal level alone

C. Microphone model alone

D. The room's paint color

83. An array of loudspeakers can be configured in a line or cluster to:

A. Reduce system complexity only

B. Only reduce cost

C. Control coverage pattern and delivery of direct sound to the listener area

D. Eliminate the need for design analysis

84. The Sound Pressure Level (SPL) unit decibel (dB):

A. Is a linear measurement unit

B. Is a logarithmic ratio of measured pressure to a reference pressure (typically 20 μPa)

C. Has no specific definition

D. Is only used in engineering calculations

85. Bass traps in room corners are most effective because:

A. Corners are visually appealing

B. Corners contain no acoustic energy

C. Corners have no special properties

D. Low frequencies build up in corners where three room surfaces intersect, making corner placement effective

86. The Schroeder model of room acoustics considers:

A. Only the decorative elements

B. Only the loudspeaker manufacturer

C. Statistical (reverberant) behavior in rooms above a critical frequency defined by room volume and RT

D. Only the microphone sensitivity

87. Primary reflections from walls should be:

A. Reflected multiple times for pleasant room ambience

B. Addressed through absorption or diffusion at reflection points

C. Amplified to improve clarity

D. Ignored in all acoustic design

88. A conference room's acoustic design should consider:

A. Only the table size

B. Only the chair color

C. Only the lighting fixtures

D. Occupied state acoustic behavior (people, furnishings affect absorption)

89. Loudspeaker-to-loudspeaker interaction at overlap regions causes:

A. Uniform SPL enhancement always

B. Pure amplification only

C. Comb filtering where specific frequencies constructively or destructively interfere

D. No audible effect

90. Reverberation time decay measurement typically measures the time for sound level to decrease by:

A. 60 dB, from which RT60 is calculated

B. 10 dB

C. 3 dB

D. No specific measurement

91. A conference room's acoustic design must consider HVAC-generated noise because:

A. It affects only the building's financial bottom line

B. HVAC noise directly impacts signal-to-noise ratio and speech intelligibility

C. HVAC is purely mechanical and unrelated to acoustics

D. HVAC noise has no practical effect

92. A large auditorium's loudspeaker design typically requires:

A. A single central loudspeaker

B. Consumer-grade equipment

C. Array design with dispersion analysis to ensure coverage across the seating area with controlled direct-to-reverberant ratio

D. No specific design approach

93. Absorption of low frequencies requires:

A. Thicker or specialized materials, such as membrane or corner-placed bass traps

B. Thin acoustic panels only

C. Reflective surfaces

D. No specific treatment

94. Background noise affects speech intelligibility through:

A. Aesthetic considerations only

B. Only visual effects

C. Only cost implications

D. Masking of speech frequencies, reducing the signal-to-noise ratio

95. The 4:1 rule for microphones states:

A. Microphones should be 1/4 the distance of the listener to the source

B. If two microphones are used, the distance between them should be at least 4 times the distance from microphone to source

C. Microphones should be 4 times the size of the source

D. The 4:1 rule is not used in audio

96. Speech intelligibility decreases significantly when:

A. Reverberation time exceeds approximately 1 second or signal-to-noise ratio is low

B. Only at temperatures below freezing

C. Only at high altitudes

D. Only with specific microphone brands

97. A loudspeaker's efficiency rating relates to:

A. The manufacturer's marketing score

B. The loudspeaker's color consistency

C. The percentage of electrical input power converted to acoustic output power

D. Only the warranty duration

98. Coherent wave addition requires:

A. Different signal sources at different frequencies

B. No signal at all

C. Microphones at every seat

D. Multiple loudspeakers producing the same signal in phase

99. A conference room with highly reflective surfaces causes:

A. Improved speech intelligibility in all cases

B. Reduced speech intelligibility due to excessive reverberation and masking by reflections

C. Better sound in all cases

D. No acoustic impact

100. The primary purpose of acoustic design in AV installations is to:

A. Create an acoustic environment supporting the intended use, balancing absorption, diffusion, and geometry

B. Only to reduce costs

C. Only for aesthetic purposes

D. To eliminate all sound reflections

SIMULATION EXAM 13 — ANSWER KEY AND FULL EXPLANATIONS

1. C — Add absorptive treatment to reduce RT60 toward the 0.5–0.7 second range appropriate for speech. Excessive reverberation masks consonants and degrades speech intelligibility; speech-focused rooms benefit from RT60 in the 0.5–0.7 second range. Absorptive treatment addresses the acoustic root cause, while volume, microphone count, or DSP processing only mask the underlying room problem.

2. A — Sabine's equation: $RT60 = 0.161 \times V / A$ (metric). This is the foundational equation of architectural acoustics — reverberation time is proportional to room volume (V) and inversely proportional to total absorption (A). The 0.161 coefficient applies in metric units; the imperial equivalent uses 0.049. Ohm's Law, Snell's Law, and decibel formulas address different phenomena.

3. D — Approximately NC-30 to NC-35 for good speech communication. NC-30 to NC-35 represents the background noise level at which speech communication is reliably supported without raised voices. Higher NC ratings (55, 45) reduce intelligibility; designing to these levels fails conference room acoustic goals.

4. B — A quantitative scale from 0 to 1 rating speech intelligibility, with 0.6 generally considered good. STI/STIpa provides objective, measurement-based intelligibility assessment — 0.6 is the generally accepted threshold for good speech communication. Values above 0.75 are excellent; below 0.45 are poor. This quantitative metric guides acoustic design verification.

5. C — Flutter echoes and standing wave room modes requiring acoustic treatment. Parallel hard surfaces create repeating reflections (flutter echoes) and standing waves that degrade audio quality. Treatment — absorption, diffusion, or both — addresses these acoustic anomalies. Untreated parallel hard surfaces produce predictable acoustic problems.

6. D — Horizontal and vertical coverage angles, typically at −6 dB points. Loudspeaker coverage is specified by the horizontal and vertical angular coverage at the −6 dB points, defining the useful coverage cone. This is a fundamental specification for coverage design calculations and loudspeaker selection.

7. C — One meter from the loudspeaker. The nominal reference distance for loudspeaker SPL specifications is 1 meter (1W/1m), providing a standardized comparison point across manufacturers and models. SPL at other distances follows the inverse square law in free field.

8. A — Low frequencies where room dimensions match sound wavelengths. Room modes occur when sound wavelengths relate to room dimensions — at low frequencies (with long wavelengths

comparable to room dimensions), modal peaks and nulls produce pronounced bass buildup and cancellation. High frequencies have wavelengths small enough that modes are densely packed and statistically smooth.

9. B — 20 feet in diameter at the listener's ear level. For a 90° conical loudspeaker, coverage diameter at the listener's ear plane equals twice the distance from the loudspeaker to the ear plane. With 10 feet vertical distance, coverage diameter is 2 × 10 = 20 feet. This geometric relationship drives ceiling loudspeaker spacing calculations.

10. D — ANSI/AVIXA A102.01. This is the Audio Coverage Uniformity in Listener Areas standard, which specifies permissible SPL variation across a listening space and the measurement methodology for verifying compliance. V202.01 addresses display image size; ISO 9001 is quality management; NEC addresses electrical installation.

11. C — 6 dB or more below the feedback threshold. Sound reinforcement design maintains 6 dB or greater margin below the feedback threshold to provide stable, usable gain before feedback under varying conditions. Zero margin produces immediate feedback; unlimited margin isn't achievable due to acoustic loop constraints.

12. A — 0.00 to 1.00, where 1.00 represents complete absorption. Sabine absorption coefficients range from 0.00 (complete reflection) to 1.00 (complete absorption), with an NRC value averaging performance across four octave bands. This scale enables quantitative absorption calculation for acoustic design.

13. D — 6 dB per doubling of distance in free field. In the free field (direct field, away from boundaries), sound pressure level decreases by 6 dB per doubling of distance as sound spreads spherically from the source. In reverberant conditions, less variation occurs due to the reverberant sound field contribution.

14. B — Large venues requiring controlled vertical coverage across long throws. Linear arrays use multiple closely-spaced drivers to control vertical coverage and extend throw distance, making them suitable for large venues and long auditoriums. Small conference rooms, closets, or automotive applications don't require or benefit from line array directivity.

15. C — Porous absorption panels sized to the intended frequency range. Porous absorbers provide broadband sound absorption through viscous losses in the porous material. Thickness determines low-frequency cutoff — thicker absorbers work at lower frequencies. Reflective surfaces, floor damping, or adding loudspeakers don't address the reverberation challenge.

16. A — Direct sound level equals reverberant sound level. Critical distance (or room radius) is the distance from the source at which the direct sound and reverberant sound levels are equal — beyond this distance, reverberant field dominates. This is a key metric in sound system design for reverberant spaces.

17. D — The loop gain from microphone to loudspeaker back to microphone exceeds unity. Feedback occurs when the audio loop (microphone → amplifier → loudspeaker → back to microphone) achieves gain greater than 1 at any frequency, causing oscillation. This is purely a system gain phenomenon, not due to amplifier distortion, loudspeaker failure, or DSP speed.

18. B — 6,000 cubic feet. Volume = length × width × height = 30 × 20 × 10 = 6,000 cubic feet. This room volume is the input to Sabine's equation for calculating reverberation time and determining appropriate acoustic treatment.

19. C — Absorb low-frequency energy, typically in corners where bass builds up. Bass traps are specialized absorbers optimized for low frequencies (below 300 Hz typically), often placed in corners where low-frequency energy accumulates. They address the low-frequency reverberation and modal issues that thin broadband absorbers miss.

20. A — A room's acoustic behavior transitions from modal to statistical behavior. The Schroeder frequency is a transition point above which a room's acoustic response becomes sufficiently dense with overlapping modes to be described statistically. Below Schroeder, individual modes dominate; above, statistical models like Sabine's equation apply.

21. D — 110 dB SPL. Each doubling of power adds 3 dB. From 1W to 100W is approximately 20 dB increase (power ratio of 100 = 20 dB). Starting from 90 dB: 90 + 20 = 110 dB SPL at 1 meter. This calculation enables amplifier and loudspeaker selection to achieve required SPL.

22. B — Coverage uniformity within ±3 dB across the listener area at the frequency of interest. ANSI/AVIXA A102.01 coverage uniformity specification targets ±3 dB variation across the listener area. This tight specification ensures consistent speech level for all audience positions. Wider variation (10 dB) creates distracting loud and soft spots.

23. C — Coverage geometry using the loudspeaker's dispersion pattern, ceiling height, and target listener plane. Ceiling loudspeaker count is an engineering calculation — each loudspeaker covers a calculable area based on its dispersion angle and mounting height. Overlapping coverage and target SPL uniformity determine the count. Preference, budget, or aesthetic don't drive this technical calculation.

24. A — Absorption coefficients of room materials vary with frequency. Reverberation time varies because different materials absorb different frequencies differently — thick carpet absorbs high frequencies but little low frequency; thin curtains absorb high frequencies only. Professional acoustic analysis accounts for frequency-dependent absorption.

25. D — 85%. NRC is expressed as a decimal (e.g., 0.85) representing the fraction of incident sound absorbed, so 0.85 equals 85% absorption. This rating averages absorption performance across speech-critical frequency bands.

26. D — The listener moves closer to the source or the room becomes less reverberant. Direct-to-reverberant ratio improves when the direct sound dominates — closer to the source increases direct

sound, and less reverberant rooms reduce reverberant sound. Both mechanisms improve intelligibility by reducing the masking effect of reverberation.

27. C — A single pair of parallel surfaces. Axial room modes form when sound waves reflect between one pair of parallel surfaces (length, width, or height dimensions). These are the strongest modes, producing the most pronounced acoustic buildup. Tangential (2 surface pairs) and oblique (3 surface pairs) modes are progressively weaker.

28. A — A calibrated sound level meter and RTA or similar measurement tools with appropriate calibration. Professional acoustic measurement uses calibrated instruments — Class 1 or Class 2 sound level meters, real-time analyzers, and related tools with regular calibration. Consumer apps, subjective impressions, or textbook charts don't provide the quantitative data acoustic design requires.

29. B — Manage reverberation and reflections for improved speech intelligibility. Acoustic treatment serves specific acoustic goals — reducing reverberation to appropriate levels, addressing problem reflections, controlling standing waves. It doesn't increase SPL, doesn't reduce equipment cost directly, and isn't a DSP substitute.

30. D — Scatters reflected sound energy across a wide area, reducing specific reflections without removing total energy. Diffusion redirects sound in many directions, eliminating strong specular reflections that cause coloration while preserving room energy. This differs from absorption, which removes energy. Diffusers address reflections without making rooms overly dead.

31. A — 343 m/s or 1,125 ft/s. Sound velocity at 20°C (standard reference temperature) is approximately 343 m/s (1,125 ft/s). Light travels at 186,000 m/s (the speed of light). The other values are not sound-physics quantities.

32. C — Standing waves from room modes. Low-frequency buildup at specific locations is characteristic of room modes — standing waves whose pressure maxima and minima occur at specific room locations. Microphones, DSP, or amplifier issues produce different symptom patterns not location-specific.

33. B — Polar plots showing coverage angle at various frequencies. Polar plots are the standard representation of loudspeaker dispersion — showing angular response typically at multiple frequencies, with the −6 dB points defining coverage angles. This format enables coverage design calculations.

34. D — Volume, surface materials, shape, HVAC noise, and intended use. Acoustic design is multi-dimensional — volume drives RT60, surface materials determine absorption, shape affects modal behavior, HVAC noise determines baseline, and use determines targets. Single-dimension considerations miss most of what matters acoustically.

35. A — It provides meaningful frequency resolution for human hearing and room acoustic analysis. 1/3 octave bands (approximately equivalent to human critical bands) provide resolution matched

to auditory perception and sufficient for room acoustic analysis. Wider bands miss detail; narrower bands over-sample.

36. C — Improves low-frequency absorption compared to mounting directly to the wall. An air gap between absorber and wall allows the absorber to operate at the velocity maximum of the standing wave (which occurs a quarter-wavelength from the rigid boundary), improving low-frequency effectiveness. This is the reason for suspended ceilings and spaced-panel installations.

37. B — Overlapping coverage circles with spacing calculated for target SPL uniformity. Ceiling loudspeaker grid spacing uses overlapping coverage patterns to achieve uniform SPL — typical spacing places adjacent loudspeakers at the −6 dB point of each other's coverage. This produces even coverage across the listener area.

38. D — Approximately 0.5 to 0.7 seconds, depending on room size and use. Speech-intelligibility optimum RT60 is approximately 0.5–0.7 seconds for conference rooms, with larger rooms tolerating slightly longer times. Too reverberant (multi-second) masks speech; too dead (zero) is unnatural and fatiguing. The optimum balances intelligibility with naturalness.

39. A — Approximately 3 dB increase. Adding a second identical coherent loudspeaker typically produces approximately 3 dB SPL increase (power summing). Uncorrelated or non-coherent sources add as 10log(2) = 3 dB. Coherent in-phase summing can yield up to 6 dB in specific regions.

40. C — The signal-to-noise ratio and reverberation characteristics of the listening environment. Speech intelligibility depends primarily on how much the speech signal exceeds room noise (S/N ratio) and how reverberation smears speech. Visual, color, and microphone-brand factors don't affect perceived intelligibility directly.

41. B — The half-power angle where output is 3 dB below the on-axis level. The −3 dB point marks half-power — the angle at which loudspeaker output has decreased by 3 dB relative to the on-axis maximum. The −6 dB points are typically used to define "coverage angle" (quarter-power points).

42. D — NC (Noise Criteria) or RC (Room Criteria) ratings of background sound. HVAC noise is quantified through NC or RC ratings that assess background sound level and spectral shape in occupied rooms. These ratings enable specification of acceptable HVAC noise for intended use and drive mechanical design coordination.

43. A — Array length and frequency. Line array directivity narrows as the array length increases relative to wavelength — longer arrays produce narrower beams, and the same array produces narrower beams at higher frequencies. This behavior follows from wave physics, not array color or weight.

44. C — The inverse square law in the direct field, with less variation in the reverberant field. Direct field SPL decreases 6 dB per distance doubling (inverse square law). In reverberant conditions, the

reverberant field contribution is nominally constant throughout the room, so SPL variation is less pronounced than free-field prediction.

45. B — STIpa measurements and/or C50 calculations in the occupied space. Speech intelligibility verification uses objective metrics — STIpa or C50 values measured in the occupied room. These quantify intelligibility through direct measurement or calculation. Visual appearance, amplifier output, or microphone brand don't measure intelligibility.

46. A — The total absorption (surface area × absorption coefficient) of surfaces. Sabine's equation shows RT60 inversely proportional to total absorption. Controlling RT60 requires modifying surface absorption — through added absorption, surface material changes, or both. Paint, decor changes, and more loudspeakers don't affect RT60.

47. D — The SPL produced at 1 meter with 1 watt of input power. Sensitivity rating (in dB SPL at 1W/1m) is the foundational loudspeaker efficiency metric enabling SPL prediction at any power level. Manufacturing date, position in product line, or color aren't rated performance specifications.

48. C — Balance slightly higher absorption to favor speech intelligibility while allowing acceptable music reproduction. Multi-purpose rooms require acoustic tradeoffs — speech favors shorter reverberation, music tolerates more reverberation. Balanced design leans toward speech requirements for conference-room primary use. Single-use designs or skipping design fail one or both requirements.

49. A — The way human hearing localizes sound to the first-arriving wavefront. Haas effect (precedence effect) describes how the auditory system localizes sound based on the first-arriving wavefront when subsequent arrivals come within approximately 30 ms. This is exploited in delay compensation for reinforcement systems.

50. D — Approximately 7 feet in diameter. With 60° total included angle (30° half-angle) at 6 feet from the listener's ear (10 feet mounting − 4 feet ear height): coverage radius = $6 \times \tan(30°) \approx 6 \times 0.577 \approx 3.46$ feet; diameter ≈ 7 feet. This geometric calculation drives spacing for 60° loudspeakers.

51. C — The low-frequency limit at which absorption becomes effective. Porous absorber effectiveness at low frequencies requires thickness approximately 1/4 of the wavelength of the lowest frequency targeted. Thicker absorbers work at progressively lower frequencies. Weight, color, and price aren't acoustic parameters.

52. D — Room acoustics and microphone-loudspeaker-listener geometry. PAG is constrained by the acoustic loop — microphone-to-loudspeaker distance, loudspeaker-to-listener distance, and room reverberation. PAG cannot be increased arbitrarily; it's a function of geometry and acoustics. Amplifier power or microphone quality don't directly determine PAG.

53. B — Broadband scattering of sound with mathematically determined dispersion characteristics. Schroeder diffusers use prime-number sequences to produce broadband scattering with

mathematically controlled dispersion. This provides specular reflection control across a wide frequency range, adding complexity to the sound field without excessive absorption.

54. A — The angle of incidence equals the angle of reflection from a smooth surface. Law of reflection for sound waves — angles measured from the normal — is identical to the optical equivalent. This is exploited in aimed surfaces, acoustic shells, and reflector design.

55. C — An absorber addresses mid-to-high frequencies; a bass trap targets low-frequency absorption, typically with greater depth or corner placement. Bass traps are specialized for low frequencies (where thick construction or corner placement is required); broadband absorbers address mid-to-high frequencies with thinner construction. Both are porous or membrane-based devices.

56. B — Coverage variations (peaks and nulls) at specific frequencies and locations. Multiple loudspeaker interference produces interference patterns — constructive at some locations/frequencies (peaks), destructive at others (nulls, "comb filtering"). This is why coverage design minimizes overlap in the listener area.

57. A — A grid of ceiling loudspeakers selected and placed for uniform coverage. A properly sized conference room (30x20 feet) typically uses a ceiling loudspeaker grid (typically 4-6 loudspeakers in overlapping coverage) designed for uniform speech coverage. Single front-wall loudspeakers produce uneven coverage; consumer speakers don't meet coverage uniformity specifications.

58. B — Mid-range frequencies approximately 500 Hz to 4 kHz. Speech intelligibility depends primarily on 500 Hz–4 kHz (consonant information), with some contribution from 100 Hz–8 kHz. Sub-bass and ultrasonic ranges don't contain speech information.

59. D — Specific ratios minimize pronounced room mode concentrations. Room dimension ratios (like 1:1.14:1.39) distribute modal frequencies across a wide range, minimizing concentrations at specific frequencies. Poor ratios (like 1:1:1, a cube) concentrate modes at the same frequency, producing strong acoustic problems.

60. A — The angle from horizontal or vertical reference, indicating where the loudspeaker's primary axis points. Loudspeaker aim specifies the direction of the primary acoustic axis — the centerline of the coverage pattern. This aim, plus dispersion angle, determines what area receives direct sound.

61. C — The near-field region where sound wavefronts have not yet formed into coherent spherical waves. The Fresnel (near-field) region is close to the source where wavefronts haven't yet converged to spherical shape — typical only within approximately one wavelength of the source. Beyond this, the Fraunhofer (far-field) region applies.

62. A — At least 6 dB, preferably more, below the feedback threshold. 6 dB headroom provides operational stability — room variations (temperature, occupancy, movement) can change acoustic loop gain by several dB. Less margin leads to feedback during normal operation; no margin or operating at threshold is guaranteed to feedback.

63. D — The required coverage pattern angle and therefore the loudspeaker type selection. Coverage geometry math translates ceiling height and required floor coverage area into the required loudspeaker dispersion pattern — wider pattern for taller ceilings or larger floor areas. This drives loudspeaker type selection. Brand, price, and carpet don't enter the engineering calculation.

64. B — Insufficient distance between microphones and loudspeakers, causing loop gain to exceed unity. Feedback in reinforcement systems is primarily a geometry/acoustic issue — mic-to-loudspeaker distance, pattern, and room reverberation determine when loop gain reaches unity. Amplifier internal feedback, microphone quality, or DSP speed aren't primary causes.

65. D — Room geometry, surface absorption, and loudspeaker polar data to predict coverage and RT60. Professional acoustic modeling software (like EASE, ODEON) simulates room acoustics using dimensional geometry, surface material absorption, and measured loudspeaker directivity data. This enables prediction of coverage, RT60, and STI before construction.

66. C — Approximately 20 Hz to 20 kHz with age-related reductions. Human hearing ranges from approximately 20 Hz (low limit of pitch perception) to 20 kHz (high limit, declining with age). This range is the target for audio system design across content types.

67. B — Add absorption in vertical or suspended configurations, typically for reverberation reduction. Baffles and banners are vertical-oriented absorbers suspended from the ceiling, providing broadband absorption in spaces where wall-mounted treatment is inadequate. They're practical solutions for large open spaces with high ceilings.

68. D — Locations where early reflections reach the listener from the loudspeaker-to-wall-to-listener path. First reflection points are the surface locations where sound bounces from the loudspeaker to the listener — first-order reflections occur at these points. Treating these locations with absorption or diffusion improves direct-sound clarity.

69. A — May attenuate high frequencies and must consider acoustic transparency of the material. Scrim or fabric placed in front of loudspeakers has acoustic properties — acoustic transparency varies by material and coverage. Professional installations select acoustically transparent materials or accept the attenuation the fabric adds.

70. C — A rapid repeating echo between parallel reflective surfaces that audibly degrades speech. Flutter echo is a specific pattern — rapid, distinct repetitions between parallel hard surfaces that imparts a characteristic "metallic" or ringing quality to speech. It's corrected by breaking the parallel surfaces with absorption or diffusion.

71. B — The system's noise floor and its maximum output SPL before distortion. Dynamic range is the usable window — from barely audible above system noise to maximum clean output. Larger dynamic range enables quiet passages to be heard and loud passages to be delivered without distortion.

72. D — Primary reflection surfaces and areas contributing to reverberation and standing waves. Effective acoustic panel placement targets specific acoustic problems — primary reflection points and reverberation-contributing surfaces. Decorative, corner-only, or random placement doesn't systematically address the acoustic goals.

73. A — Provides higher sensitivity and efficiency, typically used in horn-loaded high-frequency applications. Compression drivers coupled to horns provide much higher sensitivity than direct-radiator cone drivers, particularly for high-frequency reproduction in large-venue applications. This is why most professional high-frequency systems use compression-driver + horn architecture.

74. C — Its rejection of off-axis sound and susceptibility to feedback and ambient noise. Microphone polar pattern (cardioid, hypercardioid, omnidirectional) determines off-axis sensitivity — cardioids reject rear sound, useful for feedback control; omnidirectional patterns pick up all directions, useful for ambient capture. This affects system stability and capture characteristics.

75. B — Reverberation time (RT60) and intelligibility metrics like STIpa or C50. Speech-focused acoustic character is measured through reverberation time and intelligibility metrics together — RT60 characterizes overall room response, STIpa or C50 verify actual speech intelligibility at specific locations.

76. A — Low S/N ratio produces distortion; high S/N ratio enables quiet passages to be heard clearly without masking by system noise. S/N ratio determines the usable dynamic range — low ratios mask program content with noise; high ratios preserve clarity across the dynamic range. This is fundamental to professional audio quality.

77. D — Emphasized or peaked response at that frequency at specific locations in the room. Room resonances emphasize specific frequencies at specific locations — the pressure maxima of standing waves. This creates uneven frequency response that varies by room position, a hallmark of modal behavior that acoustic design addresses.

78. A — Is an important practice called loudspeaker alignment or aiming. Loudspeaker aiming is a fundamental design practice — directing the primary axis to the intended coverage area while angling away from reflective surfaces. Professional installations use aiming calculations and on-site verification.

79. A — Reduces the dynamic range, typically making program material more consistent in level. Dynamic compression reduces the level difference between loud and soft passages — making quiet parts louder and loud parts less loud. It's used to match material to the room's acceptable dynamic range and maintain consistent listening level.

80. B — Approximately half the acoustic power (a 3 dB decrease is a halving of power). Decibels are logarithmic — 3 dB represents a power ratio of 2 (or 1/2 for a decrease). A 6 dB change represents doubling/halving of pressure, while 3 dB corresponds to doubling/halving of power.

81. D — Effectively zero, for acoustic measurement purposes. An anechoic room is designed for minimal reflections through extensive absorptive treatment. Effective RT60 approaches zero, producing direct-field-only measurement conditions appropriate for loudspeaker and microphone testing.

82. A — Signal level, background noise, and reverberation characteristics together. Speech intelligibility is a function of multiple acoustic factors — signal level above noise, spectral content, and reverberation. Single-factor analysis misses the multivariate nature of actual intelligibility.

83. C — Control coverage pattern and delivery of direct sound to the listener area. Loudspeaker arrays are engineered to produce specific coverage characteristics — narrowed vertical pattern, extended throw, or distributed coverage. This engineering produces acoustic outcomes that single loudspeakers cannot achieve.

84. B — Is a logarithmic ratio of measured pressure to a reference pressure (typically 20 μPa). Decibel is a logarithmic ratio; dB SPL specifically uses 20 μPa (20 micropascals) as the reference pressure, corresponding to approximate human hearing threshold. This compressed scale enables representation of the wide dynamic range of human hearing.

85. D — Low frequencies build up in corners where three room surfaces intersect, making corner placement effective. Low-frequency pressure builds up at room boundaries — and peaks at corners where three surfaces meet. Corner-placed bass traps intercept this pressure buildup, making them particularly effective for low-frequency absorption.

86. C — Statistical (reverberant) behavior in rooms above a critical frequency defined by room volume and RT. Above the Schroeder frequency, mode density becomes high enough that statistical methods (Sabine) accurately describe room response. Below, individual modes dominate and require modal analysis. This defines the applicable acoustic model for different frequency ranges.

87. B — Addressed through absorption or diffusion at reflection points. Early reflections from walls can cause coloration, comb filtering, and reduced speech intelligibility. Professional acoustic design treats primary reflection points with absorption (to remove them) or diffusion (to scatter them), improving direct sound clarity.

88. D — Occupied state acoustic behavior (people, furnishings affect absorption). Occupied rooms have different acoustic behavior than empty rooms — people and furnishings add significant absorption. Acoustic design considers the occupied state because that's the actual use case. Furniture color, lighting, or table size don't acoustically dominate.

89. C — Comb filtering where specific frequencies constructively or destructively interfere. Coherent overlap of multiple loudspeakers produces interference patterns — at any given location, specific frequencies reinforce and others cancel, creating "comb" shaped response. This is why loudspeaker overlap regions are acoustically problematic.

90. A — 60 dB, from which RT60 is calculated. RT60 measures the time for sound to decay 60 dB — a full audibility range. In practice, measurement extrapolates from shorter decay portions (T20, T30) to the full 60 dB equivalent for practical measurement situations.

91. B — HVAC noise directly impacts signal-to-noise ratio and speech intelligibility. HVAC-generated noise raises the background sound level against which speech must compete. Higher background noise reduces signal-to-noise ratio, directly degrading speech intelligibility. This is why HVAC noise is part of conference room acoustic specification.

92. C — Array design with dispersion analysis to ensure coverage across the seating area with controlled direct-to-reverberant ratio. Large auditorium loudspeaker design requires engineering — array configurations for controlled coverage, analysis of direct-to-reverberant ratios across seating, and verification of intelligibility. Single loudspeakers or consumer equipment can't meet the design requirements.

93. A — Thicker or specialized materials, such as membrane or corner-placed bass traps. Low-frequency absorption requires materials that interact with long wavelengths — thick porous absorbers, tuned membrane absorbers, or corner-placed bass traps. Thin panels don't provide low-frequency absorption; reflective surfaces actively work against it.

94. D — Masking of speech frequencies, reducing the signal-to-noise ratio. Background noise in the speech frequency range directly masks speech — reducing the signal-to-noise ratio that determines intelligibility. This is why HVAC and ambient noise control is central to communication-focused acoustic design.

95. B — If two microphones are used, the distance between them should be at least 4 times the distance from microphone to source. The 4:1 rule minimizes phase cancellation when multiple microphones capture the same source — inter-microphone distance of 4× the source distance keeps delay differences from creating destructive interference. This is standard practice for multi-microphone setups.

96. A — Reverberation time exceeds approximately 1 second or signal-to-noise ratio is low. Excessive reverberation masks speech consonants; low S/N ratio masks speech with noise. Both effects independently reduce intelligibility, and both commonly combine in real rooms. Neither weather nor equipment brand directly affects intelligibility in this way.

97. C — The percentage of electrical input power converted to acoustic output power. Loudspeaker efficiency is the fraction of electrical input power converted to acoustic output — typical values are very low (a few percent for professional speakers, less than 1% for many consumer units). Marketing, color, and warranty aren't engineering metrics.

98. D — Multiple loudspeakers producing the same signal in phase. Coherent wave addition requires identical signals in phase — producing constructive interference with up to 6 dB SPL increase at

specific locations. Different signals, different phases, or single sources don't produce coherent addition.

99. B — Reduced speech intelligibility due to excessive reverberation and masking by reflections. Highly reflective surfaces produce long reverberation times and many reflections — both degrade speech intelligibility. This is why hard-surface spaces require acoustic treatment for speech-communication uses.

100. A — Create an acoustic environment supporting the intended use, balancing absorption, diffusion, and geometry. Acoustic design serves the intended room use — conference rooms need speech intelligibility, music rooms need balanced spectral behavior, etc. Design balances absorption, diffusion, and geometric factors to achieve use-specific targets. Cost-only, aesthetic-only, or eliminate-all-reflections aren't design goals.