PRACTICE EXAM 10 (110 QUESTIONS)

1. A complex impedance is given as 5 + j12 ohms. Its magnitude, needed for a current calculation, is:

A. 7 Ω

B. 12 Ω

C. 13 Ω

D. 17 Ω

2. A capacitor's current depends on the derivative of its voltage. For $v(t) = 3t^3$, that derivative dv/dt is:

A. $3t^2$

B. t^3

C. $9t^2$

D. $9t^3$

3. Two complex numbers must be divided. The most efficient form is:

A. Rectangular, subtracting real parts

B. Polar, dividing magnitudes and subtracting angles

C. Rectangular, adding imaginary parts

D. Exponential, adding the exponents

4. A second-order system has characteristic roots $-3 \pm j4$. Its response is:

A. Overdamped without oscillation

B. Critically damped and fastest

C. Unstable and growing

D. Underdamped with decaying oscillation

5. A dataset is heavily skewed by one large outlier. The measure that best represents its center is the:

A. Arithmetic mean

B. Median

C. Total range

D. Sum of values

6. The definite integral of $f(x) = 4x$ from $x = 1$ to $x = 3$ equals:

A. 8

B. 12

C. 16

D. 32

7. A cross product of two vectors is needed for a magnetic force direction. The result is:

A. A scalar equal to the projection

B. The sum of the magnitudes

C. A vector perpendicular to both

D. Zero for any two vectors

8. The sample standard deviation divides the sum of squared deviations by:

A. N, the total count

B. $N - 1$

C. $N + 1$

D. The square root of N

9. An investment yields \$2,000 with probability 0.4 and \$500 with probability 0.6. Its expected value is:

A. \$1,100

B. \$2,500

C. \$1,250

D. \$800

10. A machine costing \$20,000 with \$4,000 salvage over an 8-year life has annual straight-line depreciation of:

A. \$2,500

B. \$2,000

C. \$1,600

D. \$3,000

11. A nominal 8% annual rate is compounded quarterly. The effective annual rate is:

A. Exactly 8%

B. Below 8%

C. Impossible to determine

D. Above 8%

12. A benefit-cost ratio of 1.25 indicates the project's benefits:

A. Fall short of its costs

B. Exceed its costs and justify it

C. Equal its costs exactly

D. Cannot be evaluated

13. An engineer accepts undisclosed payment from two clients for the same deliverable. This violates the duty to:

A. Maximize personal income

B. Act as a faithful agent

C. Finish work quickly

D. Avoid all paid consulting

14. An invention's owner wants enforceable protection but must publicly disclose how it works, accepting a fixed term. The fitting IP type is a:

A. Trade secret

B. Trademark

C. Copyright

D. Patent

15. An engineer is asked to seal drawings prepared by an unsupervised outside party. The correct response is to:

A. Refuse, sealing only supervised work

B. Seal them to assist the client

C. Seal after a quick review

D. Delegate the sealing to staff

16. A semiconductor is doped to provide positive majority carriers. The resulting type and carrier are:

A. N-type with electrons

B. Intrinsic with no carriers

C. Insulating with bound charge

D. P-type with holes

17. A busbar's resistance increases as it heats during operation. This is expected because, in conductors, heating:

A. Frees additional carriers

B. Has no effect on resistance

C. Reduces resistance to zero

D. Increases atomic vibration

18. A capacitor's capacitance must be raised without changing its geometry. The dielectric property to increase is:

A. Magnetic permeability

B. Thermal conductivity

C. Electric permittivity

D. Mechanical hardness

19. A diode installed in reverse bias in a circuit will:

A. Block current, essentially open

B. Conduct heavily forward

C. Amplify the input signal

D. Oscillate at line frequency

20. A node has 5 A and 4 A entering and one branch leaving. By KCL, the leaving current is:

A. 9 A

B. 1 A

C. 20 A

D. 0 A

21. A complex two-terminal network is replaced by a single voltage source in series with a resistance. This is the:

A. Norton equivalent

B. Thevenin equivalent

C. Superposition sum

D. Resonant model

22. A 311 V peak sinusoid is applied to a resistor. For the power calculation, the voltage used is approximately:

A. 311 V

B. 440 V

C. 220 V

D. 156 V

23. The impedance of an ideal inductor at angular frequency ω is:

A. A purely real value R

B. jωL, positive imaginary

C. 1/(jωC), negative imaginary

D. Zero at all frequencies

24. At series resonance, an RLC circuit's current is at a maximum because the impedance is:

A. Maximum and reactive

B. Minimum and purely resistive

C. Infinite, blocking current

D. Negative and capacitive

25. The Laplace transform converts time-domain integration into:

A. Division by s

B. Multiplication by s

C. Addition of a constant

D. A 90-degree phase shift

26. A transfer function's denominator is zero at $s = -4$. This value is a:

A. Zero of the system

B. Pole of the system

C. Gain margin point

D. Steady-state error

27. A signal contains frequencies up to 12 kHz. The minimum Nyquist sampling rate is:

A. 12 kHz

B. 6 kHz

C. 3 kHz

D. 24 kHz

28. A 30 kHz interference must be removed while a 200 Hz signal passes. The required filter is a:

A. High-pass filter

B. Low-pass filter

C. All-pass filter

D. Pure differentiator

29. A resonant circuit must select a very narrow frequency band. This requires a:

A. Low quality factor

B. Broad bandwidth

C. High quality factor

D. Purely resistive load

30. A conducting silicon diode is modeled in hand calculations with a forward drop of:

A. 0.0 V

B. 0.7 V

C. 5.0 V

D. 12.0 V

31. An amplifier must isolate a high-impedance source from a low-impedance load without voltage gain. The choice is a:

A. Common-emitter stage

B. Tuned amplifier

C. Class-C switcher

D. Voltage follower

32. An op-amp circuit is analyzed by assuming no current enters its inputs. This follows from the op-amp's:

A. Zero output impedance

B. Negative supply rail

C. Infinite input impedance

D. Finite open-loop gain

33. A DC battery must power an AC load. The required power-electronic device is a(n):

A. Rectifier

B. Forward diode

C. Linear regulator

D. Inverter

34. A transistor used as a digital switch operates between which two regions?

A. Cutoff and saturation

B. Active and breakdown

C. Active region only

D. Forward and reverse bias

35. A weak sensor signal is amplified while noise common to both leads is rejected. The device is an:

A. Instrumentation amplifier

B. Half-wave rectifier

C. Simple common-base stage

D. Passive RC filter

36. A load draws real power 900 W and reactive power 1200 VAR. Its apparent power is:

A. 2100 VA

B. 300 VA

C. 1050 VA

D. 1500 VA

37. A balanced wye source has a phase voltage of 120 V. The line voltage is approximately:

A. 120 V

B. 69 V

C. 208 V

D. 360 V

38. Power is transmitted at high voltage to reduce, for fixed power, the:

A. Supply frequency

B. Voltage at the load

C. Current and I^2R losses

D. Transformer count

39. A transformer with 300 primary and 100 secondary turns is fed 360 V. The secondary voltage is:

A. 1080 V

B. 360 V

C. 240 V

D. 120 V

40. A motor runs at constant speed regardless of load. It is most likely a(n):

A. Synchronous motor

B. Induction motor

C. DC series motor

D. Universal motor

41. A coil produces voltage only when its magnetic flux changes. This is described by:

A. Faraday's law

B. Coulomb's law

C. Ohm's law

D. Gauss's law for electricity

42. Two charges are moved twice as far apart, and the force becomes one-quarter. This confirms the:

A. Linear distance law

B. Cube-law dependence

C. Distance independence

D. Inverse-square law

43. A high-frequency signal on a cable comparable in length to its wavelength must be modeled as a:

A. Lumped resistor

B. Pure capacitor

C. Transmission line

D. DC short circuit

44. A transmission line has no reflections when the load impedance equals the:

A. Characteristic impedance

B. Source voltage

C. Total line length

D. Operating frequency

45. A system measures its output and adjusts automatically to reduce error. This is a:

A. Pure feedforward path

B. Manual override

C. Closed-loop feedback design

D. Single open-loop chain

46. A negative-feedback system with G = 24 and H = 1 has a closed-loop gain of approximately:

A. 24

B. 25

C. 0.96

D. 1.0

47. A system is unstable if any closed-loop pole lies in the:

A. Left half-plane

B. Negative real axis only

C. Origin exclusively

D. Right half-plane

48. Gain and phase versus frequency are read to assess stability margins from a:

A. Smith chart

B. Karnaugh map

C. Bode plot

D. Cash-flow diagram

49. A 2 kHz audio signal is shifted onto a 900 MHz carrier for transmission. This process is:

A. Modulation

B. Quantization

C. Multiplexing

D. Rectification

50. FM is preferred over AM for a noisy link, accepting wider bandwidth, because FM is:

A. Lower in cost

B. Free of any carrier

C. Narrower in bandwidth

D. More resistant to noise

51. A periodic square wave is decomposed into a fundamental and harmonics using a:

A. Z-transform

B. Karnaugh map

C. Power triangle

D. Fourier series

52. Several signals share a cable, each in a distinct time slot in a repeating sequence. This is:

A. Frequency division multiplexing

B. Time division multiplexing

C. Code division multiplexing

D. Wavelength division only

53. On a fixed-bandwidth channel, raising data rate requires, per Shannon-Hartley, improving the:

A. Cable length

B. Signal-to-noise ratio

C. Carrier frequency

D. Number of users

54. Convert binary 11010 to decimal:

A. 26

B. 24

C. 22

D. 52

55. A designer simplifies NOT(A AND B) for an OR-gate implementation. By De Morgan's theorem this is:

A. (NOT A) OR (NOT B)

B. (NOT A) AND (NOT B)

C. A OR B

D. A AND B unchanged

56. A complex function is built using only NAND gates because NAND is:

A. The fastest gate

B. The cheapest gate

C. Functionally complete

D. Free of delay

57. A memory element holds one bit and updates only on a clock edge. The device is a:

A. Resistor

B. Logic AND gate

C. Multiplexer

D. Flip-flop

58. A circuit glitches intermittently because two signals meant to arrive together have unequal delays. This is a:

A. Steady-state error

B. Quantization error

C. Race condition

D. Power-factor problem

59. Reconfigurable hardware programmable after manufacture is a(n):

A. FPGA

B. Fixed-function chip

C. Discrete transistor

D. Read-only memory

60. In a star network, a failed central hub will:

A. Disable the entire network

B. Affect only one device

C. Reroute traffic automatically

D. Improve performance

61. The OSI layer that routes packets between different networks is the:

A. Physical layer

B. Session layer

C. Presentation layer

D. Network layer

62. A security tool that detects and actively blocks malicious traffic is a(n):

A. Intrusion prevention system

B. Passive logging monitor

C. Standard network switch

D. Simple firewall log

63. Ensuring transmitted data is not altered in transit protects which CIA pillar?

A. Confidentiality

B. Availability

C. Integrity

D. Redundancy

64. A processor repeatedly retrieves, interprets, and carries out instructions in the:

A. Fetch-decode-execute cycle

B. Memory refresh cycle

C. Interrupt routine

D. Direct memory access

65. Frequently used data is held near the CPU in fast memory called:

A. Secondary disk storage

B. Cache memory

C. Optical media

D. Magnetic tape

66. A large data block moves to memory with minimal CPU involvement using:

A. Programmed polling

B. Direct memory access

C. Per-byte interrupts

D. Manual register copying

67. Comparing O(log n) to O(n) for large inputs, the logarithmic algorithm grows:

A. Faster than linear

B. At the same rate

C. As the square of n

D. Much more slowly

68. Print jobs must be processed strictly in arrival order. The data structure is a:

A. Queue

B. Stack

C. Binary tree

D. Hash table

69. A recursive routine avoids infinite calls by including a:

A. Base case

B. Global counter

C. Outer loop limit

D. Hardware timer

70. Fast access to any element by index in a fixed collection is provided by a(n):

A. Linked list

B. Array

C. FIFO queue

D. LIFO stack

71. Two's complement of 4-bit 0011 (decimal 3), representing −3, is:

A. 0011

B. 0100

C. 1011

D. 1101

72. A loop, a conditional, and a sequence are the three structures of:

A. Object inheritance

B. Structured programming

C. Network layering

D. Memory addressing

73. Convert hexadecimal 0x1E to decimal:

A. 28

B. 30

C. 36

D. 60

74. Non-volatile memory that retains boot firmware without power is:

A. ROM

B. Static RAM

C. Dynamic RAM

D. CPU registers

75. A gate outputs 1 only when its inputs differ. For a parity checker, the technician uses the:

A. AND gate

B. NOR gate

C. NOT gate

D. XOR gate

76. A binary search on 4096 sorted elements requires at most about how many comparisons?

A. 12

B. 4096

C. 2048

D. 64

77. A delta source has a phase current of 20 A. The line current is approximately:

A. 20 A

B. 34.6 A

C. 11.5 A

D. 60 A

78. A 14-bit address bus can address how many memory locations?

A. 14

B. 256

C. 1,024

D. 16,384

79. An algorithm's runtime grows with the square of its input. Its complexity is:

A. O(1)

B. $O(n^2)$

C. O(log n)

D. O(n)

80. An ideal transformer delivers 400 W to its load. The primary power drawn is approximately:

A. 400 W

B. 200 W

C. 100 W

D. 800 W

81. A very brief pulse in time occupies a frequency spectrum that is:

A. A single frequency only

B. At zero frequency

C. Equally narrow

D. Wide in bandwidth

82. An induction motor at 4% slip with 1500 rpm synchronous speed turns at about:

A. 1500 rpm

B. 60 rpm

C. 1560 rpm

D. 1440 rpm

83. A general-purpose amplifier stage offering high voltage and current gain is the:

A. Common collector

B. Emitter follower

C. Common emitter

D. Common base

84. A magnetic field circles a current-carrying wire; its direction is found by the:

A. Coulomb inverse-square law

B. Ohmic voltage rule

C. Superposition principle

D. Right-hand rule

85. Parallel impedances in an AC circuit are combined using:

A. Direct addition of values

B. Subtraction of magnitudes

C. Multiplication of angles

D. Reciprocals, like parallel resistors

86. A 7-bit register holds a maximum unsigned decimal value of:

A. 128

B. 127

C. 64

D. 256

87. A penetration test, unlike intrusion detection, is a(n):

A. Continuous passive monitor

B. Hardware firewall appliance

C. Automatic backup process

D. Proactive simulated attack

88. A linear system's response right after a sudden input is dominated by the:

A. Steady-state forced response

B. Final settled value

C. DC offset only

D. Transient natural response

89. Step-up transformers at a generating station serve to:

A. Raise voltage for efficient transmission

B. Convert AC into DC

C. Increase the supply frequency

D. Lower voltage for safety

90. A gate outputs 0 only when both inputs are 1; otherwise 1. This is a:

A. AND gate

B. NAND gate

C. OR gate

D. XOR gate

91. A household outlet reads 120 V RMS. The peak voltage is approximately:

A. 170 V

B. 85 V

C. 240 V

D. 60 V

92. A transformer's secondary impedance appears at the primary scaled by the:

A. Turns ratio directly

B. Inverse turns ratio

C. Unity factor

D. Square of the turns ratio

93. A control system is stable but settles slowly with large steady-state error. This shows stability:

A. Guarantees fast response

B. Does not by itself ensure good performance

C. Requires right half-plane poles

D. Eliminates all error

94. The standard deviation is found by taking the square root of the:

A. Mean

B. Variance

C. Median

D. Range

95. A material with a moderate band gap tunable by doping is a:

A. Conductor

B. Insulator

C. Semiconductor

D. Superconductor

96. A diode conducts when its anode is positive relative to its cathode. This is:

A. Forward bias

B. Reverse breakdown

C. Cutoff

D. Saturation blocking

97. Expected value is computed by weighting outcomes by probability: \$1,000 at 0.3 and \$0 at 0.7. The result is:

A. \$1,000

B. \$700

C. \$300

D. \$500

98. An RC circuit with R = 4 kΩ and C = 5 μF has a time constant of:

A. 0.8 ms

B. 20 ms

C. 9 ms

D. 200 ms

99. A sorting algorithm for very large random data should target the complexity class:

A. $O(n^2)$ quadratic

B. $O(2^n)$ exponential

C. O(n log n) linearithmic

D. $O(n^3)$ cubic

100. A capacitor's reactance at very high frequency approaches:

A. Infinity, blocking the signal

B. The resistance value

C. Zero, passing the signal

D. A fixed negative constant

101. A node has 9 A entering and 6 A leaving on one branch. By KCL, the other branch carries:

A. 3 A

B. 15 A

C. 54 A

D. 0 A

102. A signal sampled below its Nyquist rate shows a false low-frequency component. This is:

A. Resonance

B. Aliasing

C. Quantization gain

D. Phase margin

103. A processor suspends its task to run a routine triggered by an external event. The trigger is a(n):

A. Cache miss

B. Clock divide

C. Interrupt

D. DMA burst

104. A capacitor of 5 μF at ω = 4000 rad/s has a reactance magnitude of:

A. 5 Ω

B. 200 Ω

C. 50 Ω

D. 1000 Ω

105. An engineer compares two machines with different service lives. The cleanest method is:

A. Present worth without horizon match

B. Equivalent annual cost analysis

C. Simple payback ignoring interest

D. Counting replaced parts

106. A technician declines an assignment outside their specialty, citing the duty to:

A. Maximize billable hours

B. Conceal the limitation

C. Practice within one's competence

D. Accept every task

107. A signal sampled at 50 kHz can faithfully represent frequencies up to:

A. 50 kHz

B. 100 kHz

C. 25 kHz

D. 12.5 kHz

108. The current through a capacitor is proportional to the rate of change of:

A. The voltage across it

B. The magnetic flux

C. The current itself

D. The resistance

109. A three-phase wye load draws 7 A line current at 208 V line voltage with unity power factor. The total real power is approximately:

A. 1,456 W

B. 840 W

C. 2,520 W

D. 4,200 W

110. A NAND-only implementation of arbitrary logic is possible because the NAND gate is:

A. The fastest available gate

B. Built from one transistor

C. Functionally complete

D. Free of propagation delay

Answer Key & Full Explanations

1. C — The magnitude of $5 + j12$ is $\sqrt{(5^2 + 12^2)} = \sqrt{169} = 13\ \Omega$. Impedance magnitude is the root of the sum of squared components. This is the classic 5-12-13 triangle.

2. C — By the power rule, the derivative of $3t^3$ is $9t^2$. Since capacitor current is $i = C\ dv/dt$, this gives the current's time dependence. The exponent multiplies the coefficient and decreases by one.

3. B — Division of complex numbers is most efficient in polar form: divide the magnitudes and subtract the angles. Rectangular form favors addition instead. Choosing the right form avoids extra steps.

4. D — Complex conjugate roots ($-3 \pm j4$) produce an underdamped response that oscillates while decaying toward steady state. The negative real part ensures decay. Root type fully determines transient behavior.

5. B — For heavily skewed data with one large outlier, the median best represents the center because it resists outlier distortion. The mean shifts toward the outlier. This robustness distinguishes the median.

6. C — The integral of $4x$ is $2x^2$, evaluated from 1 to 3: $2(9) - 2(1) = 18 - 2 = 16$. A definite integral gives the net accumulated value over the limits. This underlies area, charge, and energy calculations.

7. C — The cross product yields a vector perpendicular to both originals, with direction from the right-hand rule. The dot product yields a scalar instead. The cross product underlies magnetic force direction.

8. B — The sample standard deviation divides the sum of squared deviations by $N - 1$, correcting for sample bias. The population version divides by N. Misreading which applies changes the answer.

9. A — Expected value is the probability-weighted average: (0.4)(\$2,000) + (0.6)(\$500) = \$800 + \$300 = \$1,100. Each outcome is weighted by its probability. This underlies economic risk analysis.

10. B — Straight-line depreciation is (cost − salvage)/life = (20,000 − 4,000)/8 = 16,000/8 = \$2,000 per year. The depreciable base is spread evenly. This gives a constant annual charge.

11. D — When a nominal rate compounds more often than annually, the effective annual rate exceeds the nominal, since interest earns interest within the year. An 8% nominal compounded quarterly is therefore above 8%. Failing to convert understates it.

12. B — A benefit-cost ratio above 1.0 (here 1.25) means benefits exceed costs, justifying the project. A ratio below 1.0 would not. The threshold is the decision rule.

13. B — Accepting undisclosed pay from two clients for the same deliverable violates the duty to act as a faithful agent. Disclosure and consent are required. This protects client trust.

14. D — Enforceable protection requiring public disclosure for a fixed term describes a patent. A trade secret avoids disclosure but offers no protection against independent discovery. The trade-off between the two is a frequent exam topic.

15. A — An engineer may seal only work prepared by them or under their direct supervision, so they must refuse to seal unsupervised outside work. Sealing it would be a serious violation. This rule preserves accountability.

16. D — Doping for positive majority carriers (holes) produces P-type material. N-type doping adds free electrons instead. Carrier type governs junction behavior.

17. D — A busbar's resistance rises with heating because increased atomic vibration impedes electron flow in conductors. Semiconductors behave oppositely. This contrast is a common exam point.

18. C — Raising capacitance without changing geometry means increasing the dielectric's electric permittivity, on which capacitance directly depends. Permeability governs magnetic behavior instead. Dielectric choice is key in capacitor design.

19. A — A reverse-biased diode blocks current, behaving essentially as an open circuit. The widened depletion region prevents conduction. Forward bias is required for the diode to pass current.

20. A — By KCL, current in equals current out: (5 + 4) entering means 9 A must leave. Charge cannot accumulate at a node. The single leaving branch carries 9 A.

21. B — Replacing a network with a single voltage source in series with a resistance is the Thevenin equivalent. The Norton form uses a current source in parallel. Both simplify load analysis.

22. C — Power calculations use the RMS value: $311/\sqrt{2} \approx 220$ V. Using the peak would overstate the power. RMS is the equivalent DC value delivering the same power.

23. B — An inductor's impedance is $j\omega L$, a positive imaginary quantity that increases with frequency. A capacitor's is negative imaginary and a resistor's is real. This frequency dependence underlies filtering.

24. B — A series RLC circuit's current is maximum at resonance, where reactances cancel and the impedance is minimum and purely resistive. A parallel resonant circuit behaves oppositely. The resonant frequency depends only on L and C.

25. A — The Laplace transform converts time-domain integration into division by s, while differentiation becomes multiplication by s. This turns calculus into algebra. It enables solving differential equations algebraically.

26. B — A denominator root at $s = -4$ is a pole of the system, where the response tends toward infinity. Zeros are numerator roots. Pole location determines stability and frequency behavior.

27. D — The Nyquist rate is twice the highest frequency: 2×12 kHz = 24 kHz. Sampling at least this fast prevents aliasing. The factor of two is the key threshold.

28. B — Removing 30 kHz interference while passing a 200 Hz signal requires a low-pass filter, which passes low frequencies and blocks high ones. A high-pass filter would do the reverse. The cutoff is set between the two.

29. C — Selecting a very narrow band requires a high quality factor Q, giving a sharp resonant peak. Low Q gives a broad response. Q is inversely related to bandwidth.

30. B — A conducting silicon diode is modeled with a constant 0.7 V forward drop in hand calculations. This is accurate enough and far faster than the exponential equation. The ideal model assumes zero drop.

31. D — Isolating a high-impedance source from a low-impedance load without voltage gain is the job of a voltage follower. Its high input and low output impedance prevent loading. The common-emitter stage gives high voltage gain instead.

32. C — The rule that no current enters an op-amp's inputs follows from its infinite input impedance. This is one of the two golden rules. It enables clean KCL analysis at the inputs.

33. D — Powering an AC load from a DC battery requires an inverter to convert DC into AC. A rectifier does the opposite. Matching the device to its conversion direction gives the answer.

34. A — A transistor used as a digital switch operates between cutoff (off) and saturation (fully on). The active region is for analog amplification. The operating regions distinguish switching from amplifying.

35. A — Amplifying a weak sensor signal while rejecting noise common to both leads is the role of an instrumentation amplifier, valued for high common-mode rejection. A simple stage or rectifier would not reject the noise. This makes it ideal for sensor signals.

36. D — Apparent power is the hypotenuse: $S = \sqrt{(P^2 + Q^2)} = \sqrt{(900^2 + 1200^2)} = \sqrt{2{,}250{,}000} = 1500$ VA. It combines real and reactive power vectorially. The units VA distinguish it from watts.

37. C — In a wye connection, line voltage is $\sqrt{3}$ times phase voltage: $120 \times 1.732 \approx 208$ V. This is the familiar 120/208 V system. The $\sqrt{3}$ applies to voltage in wye.

38. C — High transmission voltage reduces current for fixed power, and since losses are I^2R, lower current sharply cuts losses. This is the rationale for high-voltage transmission. Transformers enable the voltage changes.

39. D — Secondary voltage scales with the turns ratio: $V_s = 360 \times (100/300) = 360 \times 0.333 = 120$ V. Fewer secondary turns step the voltage down. The current correspondingly steps up.

40. A — A motor running at constant speed regardless of load is a synchronous motor, locked to the supply frequency. An induction motor's speed drops slightly with load. Constant-speed behavior identifies the synchronous machine.

41. A — A coil producing voltage only when magnetic flux changes is described by Faraday's law. A static field induces nothing. This principle underlies transformers, generators, and inductors.

42. D — Force becoming one-quarter when distance doubles confirms the inverse-square law: doubling distance divides force by four. This is Coulomb's law for charges. The inverse-square dependence defines the electric field.

43. C — A cable comparable in length to the signal wavelength must be modeled as a transmission line. At low frequencies a short cable needs no such treatment. Recognizing this regime is the key judgment.

44. A — A line has no reflections when the load impedance equals the characteristic impedance. Characteristic impedance depends on geometry, not length. Matching is the central goal of high-frequency design.

45. C — Automatically reducing error by measuring the output requires a closed-loop feedback design. An open-loop system cannot self-correct. Feedback gives control systems their accuracy.

46. C — Closed-loop gain is $G/(1 + GH) = 24/(1 + 24\times1) = 24/25 = 0.96$. Negative feedback reduces gain while improving stability. This formula answers many control questions.

47. D — A system is unstable if any closed-loop pole lies in the right half-plane (positive real part), causing unbounded growth. Stability requires all poles in the left half-plane. A single right-half-plane pole suffices for instability.

48. C — Gain and phase versus frequency, used to assess stability margins, are read from a Bode plot. It is a standard control-analysis tool. Margins are read directly from it.

49. A — Shifting an audio signal onto a high-frequency carrier is modulation, which enables practical transmission. Quantization and multiplexing are different processes. Modulation underlies all radio communication.

50. D — FM is preferred for noisy links because it is more resistant to noise, since information rides on frequency rather than amplitude. The trade-off is wider bandwidth. This noise immunity is FM's key advantage.

51. D — A periodic square wave is decomposed into a fundamental and harmonics using a Fourier series, which applies to periodic signals. The Fourier transform handles non-periodic signals. Both reveal frequency content.

52. B — Signals sharing a cable in distinct repeating time slots use Time Division Multiplexing. FDM divides frequency and CDM uses codes. The shared dimension identifies the technique.

53. B — On a fixed-bandwidth channel, the Shannon-Hartley theorem says higher data rate requires improving the signal-to-noise ratio. Capacity grows with both bandwidth and SNR. This sets the ceiling on transmission.

54. A — Binary 11010 equals 16 + 8 + 0 + 2 + 0 = 26 in decimal. Summing the set bits' place values gives the value. Base conversion is a routine skill.

55. A — De Morgan's theorem gives NOT(A AND B) = (NOT A) OR (NOT B), enabling an OR-gate implementation. It converts an AND complement into an OR of complements. This identity is central to logic simplification.

56. C — Building a complex function from NAND gates alone is possible because NAND is functionally complete. NOR shares this property. This universality makes NAND fundamental in integrated circuits.

57. D — A memory element that holds one bit and updates only on a clock edge is a flip-flop. Gates and multiplexers are combinational and have no memory. Flip-flops give sequential circuits their state.

58. C — A glitch from unequal delays for signals meant to arrive together is a race condition, arising from timing rather than logic errors. Synchronous design is the standard defense. These faults are intermittent.

59. A — Reconfigurable hardware programmable after manufacture is an FPGA. Fixed-function chips and ROM cannot be rearranged this way. Reconfigurability is the FPGA's defining advantage.

60. A — In a star network, the central hub is a single point of failure; its failure disables the whole network. The star is easy to manage but carries this vulnerability. Each topology has a defining trade-off.

61. D — The Network layer of the OSI model routes packets between different networks. The Physical layer moves bits and higher layers manage sessions and applications. Routing is the Network layer's defining role.

62. A — A tool that detects and actively blocks malicious traffic is an intrusion prevention system. A detection system only monitors and alerts. The distinction is action versus observation.

63. C — Ensuring data is not altered in transit protects Integrity in the CIA triad. Confidentiality concerns secrecy and Availability concerns access. Each goal maps to one pillar.

64. A — The repeating cycle of retrieving, interpreting, and carrying out instructions is the fetch-decode-execute cycle. Paced by the clock, it is the processor's fundamental operation. It is the rhythm of computation.

65. B — Frequently used data held near the CPU in fast memory resides in cache. Cache is smaller and faster than main memory. This exploits the principle of locality.

66. B — Moving a large data block with minimal CPU involvement is best done with Direct Memory Access. Polling and per-byte interrupts tie up the processor. DMA is the most efficient for bulk transfers.

67. D — O(log n) grows much more slowly than O(n) for large inputs, so the logarithmic algorithm scales far better. Doubling the input adds only a constant to a logarithmic count. Lower-order complexity is better at scale.

68. A — Processing print jobs strictly in arrival order requires a queue, which follows First-In-First-Out order. A stack is LIFO instead. Queues model arrival-order processing.

69. A — A recursive routine must include a base case to stop recursion and avoid infinite calls. The base case must be reachable. Identifying it first is essential when writing recursion.

70. B — Fast access to any element by index in a fixed collection is provided by an array, whose contiguous storage allows direct indexed access. A linked list requires sequential traversal. Arrays trade this for slower middle insertion.

71. D — Two's complement of 0011 (3): invert to 1100, add 1 to get 1101, representing −3. This method lets subtraction use addition hardware. The leading 1 marks it negative.

72. B — A loop, a conditional, and a sequence are the three control structures of structured programming: iteration, selection, and sequence. Together they express any computation. Recognizing them is key to tracing logic.

73. B — Hex 0x1E equals 1×16 + 14 = 30 in decimal, where E is 14. Each hex digit is weighted by a power of 16. Hex-to-decimal conversion is a routine skill.

74. A — Non-volatile memory that retains boot firmware without power is ROM. SRAM, DRAM, and registers are all volatile. ROM stores permanent data.

75. D — An XOR gate outputs 1 only when its inputs differ, making it the building block of parity checkers. It sums bits modulo two. This difference-detecting behavior is its defining use.

76. A — Binary search halves the range each step, so 4096 elements require at most $\log_2(4096) = 12$ comparisons. This O(log n) efficiency requires sorted data. Repeated halving makes the search fast.

77. B — In a delta connection, line current is √3 times phase current: $20 \times 1.732 \approx 34.6$ A. The √3 factor applies to current in delta connections. Anchoring it to the connection type prevents errors.

78. D — A 14-bit address bus addresses $2^{14} = 16{,}384$ distinct locations. The address bus width sets the maximum addressable memory. Each added line doubles the reach.

79. B — An algorithm whose runtime grows with the square of its input has $O(n^2)$ complexity. Such quadratic growth becomes steep for large inputs. Lower-order complexity is far better at scale.

80. A — An ideal transformer conserves power, so primary power approximately equals secondary power: about 400 W. What is gained in voltage is lost in current. The ideal model assumes equality.

81. D — By the inverse time-frequency relationship, a very brief pulse occupies a wide bandwidth. Short pulses demand more spectrum. This trade-off ultimately limits data rates.

82. D — Actual speed is synchronous reduced by slip: $1500 \times (1 - 0.04) = 1500 \times 0.96 = 1440$ rpm. Slip is the fractional speed difference. It is essential for induction-motor torque.

83. C — The common-emitter amplifier offers high voltage and current gain, making it the general-purpose workhorse. The emitter follower buffers with near-unity voltage gain instead. Configurations are identified by their gain signatures.

84. D — The direction of the magnetic field circling a current-carrying wire is found with the right-hand rule. Coulomb's and Ohm's laws do not apply here. This rule resolves magnetostatics direction questions.

85. D — Parallel impedances combine using reciprocals, just as parallel resistors do, but with complex arithmetic. Series impedances add directly instead. Once components are impedances, DC rules apply with complex numbers.

86. B — A 7-bit register holds $2^7 = 128$ distinct values, so the maximum unsigned decimal value is 127 (since 0 is included). The range runs from 0 to $2^n - 1$. This bounds the register's numbers.

87. D — A penetration test is a proactive, simulated attack to find vulnerabilities, unlike passive intrusion detection. The test actively probes for weaknesses. Both serve security in different ways.

88. D — Immediately after a sudden input, a linear system's response is dominated by the transient (natural) response, which decays over time. The steady-state response dominates later. This maps to homogeneous and particular ODE solutions.

89. A — Step-up transformers at a generating station raise voltage for efficient transmission, reducing current and I^2R losses. Step-down transformers near consumers lower it. Transformers enable the whole transmission scheme.

90. B — A gate whose output is 0 only when both inputs are 1, and 1 otherwise, is a NAND gate (the complement of AND). NAND is functionally complete. It is common in integrated circuits.

91. A — Peak voltage equals RMS times √2: 120 × 1.414 ≈ 170 V. The RMS value is peak divided by √2, so the inverse multiplies by √2. This converts quoted RMS to the waveform peak.

92. D — A transformer's secondary impedance appears at the primary scaled by the square of the turns ratio. This lets transformers perform impedance matching. The squared relationship is a tested exam point.

93. B — A stable system that settles slowly with large steady-state error shows that stability does not by itself ensure good performance. Stability is a yes/no pole condition; performance is a matter of degree. The exam tests both separately.

94. B — The standard deviation is the square root of the variance, returning the measure to the original units. Variance is in squared units. Standard deviation is the most informative spread measure.

95. C — A material with a moderate band gap tunable by doping is a semiconductor. Conductors have negligible gaps and insulators large ones. This controllability is the basis of solid-state electronics.

96. A — A diode conducts when its anode is positive relative to its cathode, the condition called forward bias. Reverse bias blocks current. This one-way behavior is the basis of rectification.

97. C — Expected value is the probability-weighted average: (0.3)(\$1,000) + (0.7)(\$0) = \$300. Each outcome is weighted by its probability. This underlies economic risk analysis.

98. B — The time constant is $\tau = RC = 4000 \times 5\times10^{-6} = 0.02$ s = 20 ms. After one time constant the response completes about 63% of its change. This governs RC transients.

99. C — The fastest practical average performance for large random data is O(n log n), achieved by efficient sorts. Quadratic and worse classes are too slow at scale. Linearithmic time is the target.

100. C — A capacitor's reactance is $1/(\omega C)$, which approaches zero at very high frequency, so it passes high-frequency signals. At low frequency the reactance is large. This frequency dependence underlies filtering.

101. A — By KCL, 9 A enters and 6 A leaves on one branch, so the other branch carries $9 - 6 = 3$ A. Charge cannot accumulate at a node. The currents must balance.

102. B — A false low-frequency component from under-sampling is aliasing. It cannot be removed afterward. Adequate sampling rate or anti-aliasing filtering prevents it.

103. C — A signal that suspends the processor's task to run a routine is an interrupt. It lets the processor respond promptly without continuous polling. The processor resumes its task afterward.

104. C — Capacitive reactance is $1/(\omega C) = 1/(4000 \times 5\times10^{-6}) = 1/0.02 = 50\ \Omega$. Reactance decreases as frequency or capacitance rises. This sets the capacitor's opposition.

105. B — Comparing machines with different service lives is cleanest with equivalent annual cost analysis, which places everything on a per-year basis. Present worth would require equalizing horizons. Annual cost handles unequal lives directly.

106. C — Declining an assignment outside one's specialty reflects the duty to practice only within one's area of competence. Accepting it to maximize billable hours would violate that duty. Competence protects public safety.

107. C — A 50 kHz sampling rate can faithfully represent frequencies up to half that, the Nyquist limit: 25 kHz. Components above this would alias. Half the sampling rate is the maximum recoverable frequency.

108. A — The current through a capacitor is proportional to the rate of change of the voltage across it ($i = C\,dv/dt$). A constant voltage produces no current. This relationship defines capacitor behavior.

109. C — Three-phase real power is $P = \sqrt{3} \times V_{line} \times I_{line} \times \cos\theta = 1.732 \times 208 \times 7 \times 1.0 \approx 2{,}520$ W. The $\sqrt{3}$ factor is the signature of three-phase calculations. Unity power factor means all apparent power is real.

110. C — A NAND-only implementation of arbitrary logic is possible because the NAND gate is functionally complete. NOR shares this property. This universality makes NAND fundamental in integrated circuits.