

# PRACTICE EXAM 8: FE ELECTRICAL AND COMPUTER SIMULATION (110 QUESTIONS)

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**Time allotted: 5 hours 20 minutes**

**Materials: NCEES-approved calculator + NCEES FE Reference Handbook only**

1. What is the derivative of  $f(x) = \tan(x)$ ?

- A.  $\cot(x)$
- B.  $-\sec^2(x)$
- C.  $\sec^2(x)$
- D.  $\csc^2(x)$

2. Evaluate the indefinite integral  $\int e^x dx$ .

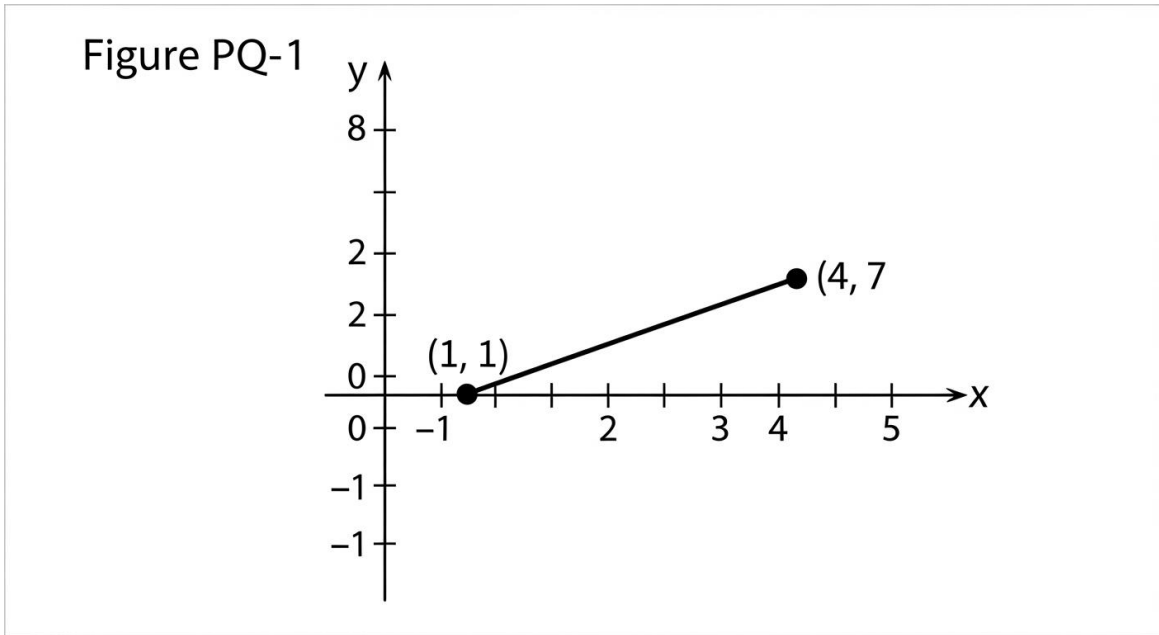
- A.  $e^x + C$
- B.  $x \cdot e^x + C$
- C.  $e^x/x + C$
- D.  $(1/x)e^x + C$

3. Simplify the complex expression  $j^2$ , where  $j = \sqrt{-1}$ .

- A.  $j$
- B.  $1$
- C.  $-j$

D. -1

4. From the graph shown, what is the slope of the line passing through the two marked points?



A. 3

B. 2

C. 0.5

D. 6

5. Find the value of  $x$  that satisfies the equation  $3^x = 81$ .

A. 3

B. 9

C. 4

D. 27

6. The cross product of two parallel vectors is:

- A. Equal to the product of their magnitudes
- B. A vector of unit length along the x-axis
- C. The zero vector
- D. Equal to the sum of the two vectors

7. Evaluate the definite integral  $\int_0^1 3x^2 dx$ .

- A. 3
- B. 1
- C. 0.5
- D. 2

8. What is the solution set of the inequality  $|x| < 3$ ?

- A.  $x > 3$  only
- B.  $x < -3$  only
- C.  $x > 3$  or  $x < -3$
- D.  $-3 < x < 3$

9. The angle whose sine equals 0.5 (in the first quadrant) is:

- A.  $30^\circ$
- B.  $45^\circ$
- C.  $60^\circ$
- D.  $90^\circ$

10. Find the second derivative of  $f(x) = x^3$ .

- A.  $6x$
- B.  $3x^2$
- C.  $6x^2$
- D.  $3x$

11. The determinant of a  $2 \times 2$  matrix is zero. This indicates that the matrix is:

- A. Orthogonal and invertible
- B. Singular and non-invertible
- C. Symmetric about its diagonal
- D. Equal to the identity matrix

12. Evaluate the limit  $\lim_{x \rightarrow 0} (1 - \cos x)/x$ .

- A. 1
- B.  $\infty$
- C. 0.5
- D. 0

13. A coin is flipped 3 times. What is the probability of getting exactly 3 heads?

- A.  $1/8$
- B.  $1/2$
- C.  $3/8$
- D.  $1/4$

14. The arithmetic mean of the numbers 2, 4, 6, 8, 10 is:

- A. 5
- B. 30
- C. 6
- D. 4

15. In a normal distribution, what percentage of data falls within two standard deviations of the mean?

- A. 68%
- B. 95%
- C. 99.7%
- D. 50%

16. A box has 5 white and 5 black balls. One ball is drawn at random. What is the probability it is white?

- A.  $1/5$
- B.  $1/2$
- C.  $1/10$
- D.  $2/5$

17. The standard deviation of a data set is the:

- A. Average of all the data values combined
- B. Difference between the largest and smallest values
- C. Square root of the variance of the data
- D. Most frequently occurring value in the set

18. Under the NSPE Code, when an engineer signs and seals a document, the seal signifies that the engineer:

- A. Took responsible charge of the work being certified
- B. Personally drafted every line of the document by hand
- C. Guarantees the project will never fail under any load
- D. Approves the client's budget for the entire project

19. An engineer becomes aware that a former employer's product has a defect that endangers the public. Under the NSPE Code, the engineer should:

- A. Keep silent because the employment relationship has ended
- B. Disclose the firm's confidential trade secrets to the press
- C. Wait until a member of the public is actually harmed first
- D. Notify the appropriate authority about the safety concern

20. Under the NSPE Code, an engineer may accept assignments from more than one client on the same project only when:

- A. The total combined fee exceeds the firm's minimum rate
- B. The clients are competitors in the same industry sector
- C. The work can be completed within the original deadline
- D. The circumstances are fully disclosed and all parties agree

21. The NSPE Code holds that engineers shall continue their professional development primarily to:

- A. Increase their hourly billing rate over their career
- B. Qualify for higher positions within their current firm
- C. Maintain and improve their competence and skills
- D. Satisfy the marketing requirements of their employer

22. If \$1,000 grows to \$1,100 in one year, what is the simple annual interest rate?

- A. 10%
- B. 11%
- C. 1%
- D. 100%

23. The "time value of money" principle states that a dollar received today is:

- A. Worth exactly the same as a dollar received later
- B. Worth more than a dollar received in the future
- C. Worth less than a dollar received in the future
- D. Worthless unless invested in physical assets only

24. A project requires \$100,000 now and returns \$115,000 in one year. If the MARR is 10%, the project is:

- A. Rejected because the return is below the initial cost
- B. Rejected because the MARR exceeds the project return
- C. Indifferent because the return exactly equals the MARR
- D. Accepted because the 15% return exceeds the 10% MARR

25. Depreciation in engineering economics represents the:

- A. Decline in an asset's value over its useful life
- B. Total interest paid on a loan for the asset
- C. Increase in market price due to inflation effects
- D. Annual operating and maintenance cost of the asset

26. The number of years required for an investment to double at a 6% annual rate, using the Rule of 72, is approximately:

- A. 6 years
- B. 36 years
- C. 12 years
- D. 72 years

27. The temperature coefficient of resistance for most pure metals is:

- A. Negative, so resistance falls as temperature rises
- B. Zero, so resistance is independent of temperature
- C. Imaginary at room temperature operating conditions
- D. Positive, so resistance rises as temperature rises

28. The relative permittivity (dielectric constant) of free space (vacuum) is defined as:

- A. Zero
- B. One
- C.  $8.85 \times 10^{-12}$
- D. Infinite

29. In a semiconductor, the "hole" acts as a charge carrier with an effective charge that is:

- A. Positive, equal in magnitude to the electron charge
- B. Negative, twice the magnitude of the electron charge
- C. Neutral, carrying no net electric charge at all
- D. Variable, depending on the doping concentration used

30. A material with magnetic permeability much greater than that of free space is classified as:

- A. Diamagnetic
- B. Paramagnetic
- C. Ferromagnetic
- D. Nonmagnetic

31. A 10 V source drives a 5  $\Omega$  resistor. What power is delivered to the resistor?

- A. 2 W
- B. 50 W
- C. 5 W
- D. 20 W

32. Two 10  $\Omega$  resistors are connected in series, and the pair is connected in parallel with a third 10  $\Omega$  resistor. What is the total resistance?

- A. 30  $\Omega$
- B. 6.67  $\Omega$
- C. 10  $\Omega$
- D. 3.33  $\Omega$

33. By Ohm's law, the current through a 25  $\Omega$  resistor with 5 V across it is:

- A. 0.2 A
- B. 5 A
- C. 125 A
- D. 0.04 A

34. A  $50 \mu\text{F}$  capacitor is charged to  $100 \text{ V}$ . What energy is stored in it?

- A.  $5 \text{ J}$
- B.  $2.5 \text{ J}$
- C.  $0.25 \text{ J}$
- D.  $0.5 \text{ J}$

35. Kirchhoff's voltage law states that the algebraic sum of voltages around any closed loop is:

- A. Equal to the largest source voltage in the loop
- B. Proportional to the total loop resistance present
- C. Equal to the total current in the loop times two
- D. Zero, expressing conservation of energy

36. The phase angle of the impedance  $Z = 3 + j3 \Omega$  is:

- A.  $30^\circ$
- B.  $45^\circ$
- C.  $60^\circ$
- D.  $90^\circ$

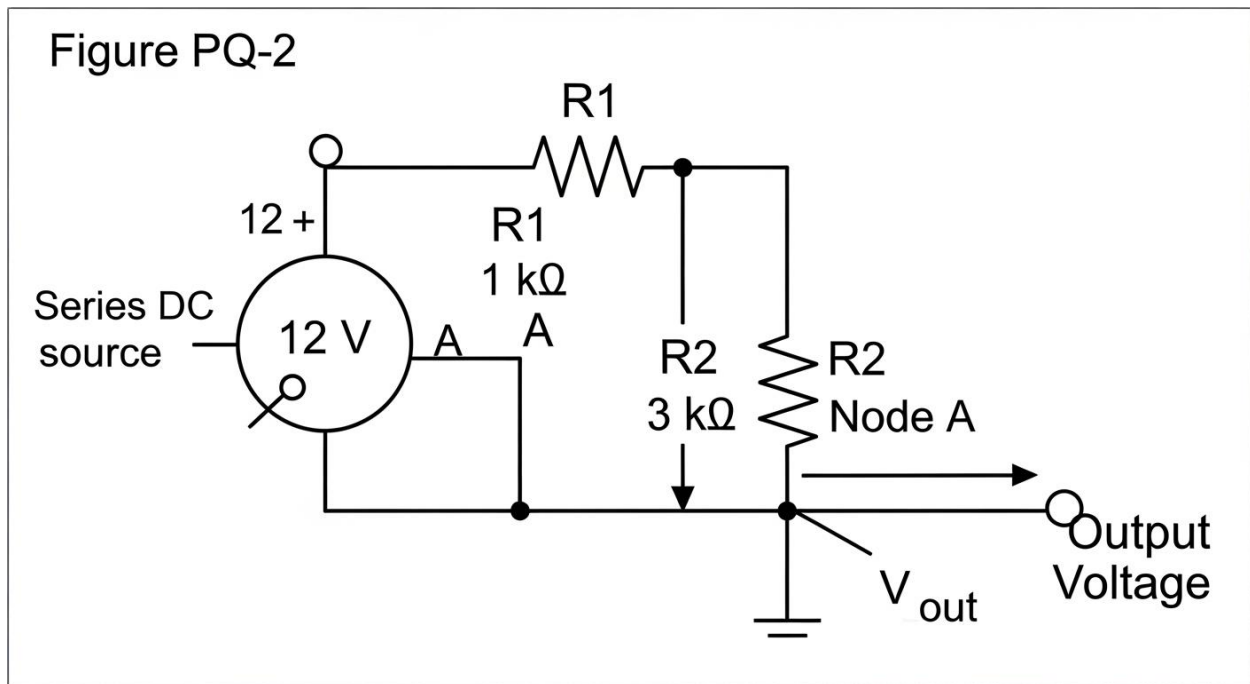
37. A  $2 \mu\text{F}$  and a  $3 \mu\text{F}$  capacitor are connected in parallel. The equivalent capacitance is:

- A.  $5 \mu\text{F}$
- B.  $1.2 \mu\text{F}$
- C.  $6 \mu\text{F}$
- D.  $0.83 \mu\text{F}$

38. The instantaneous power delivered to a resistor is always:

- A. Negative during half of each AC cycle
- B. Zero at the peak of the voltage waveform
- C. Equal to the reactive power in the circuit
- D. Non-negative, since it equals  $i^2R$

39. In the circuit shown, use the voltage-divider rule to find the voltage  $V_{out}$  across the 3 k $\Omega$  resistor.



- A. 12 V
- B. 4 V
- C. 9 V
- D. 3 V

40. The RMS value of a symmetric square wave that alternates between +5 V and -5 V is:

- A. 0 V

- B. 5 V
- C. 3.54 V
- D. 2.5 V

41. In a parallel RLC circuit at resonance, the total impedance seen by the source is:

- A. Maximum and purely resistive
- B. Minimum and purely reactive
- C. Zero at all driving frequencies
- D. Equal to the inductive reactance only

42. A dependent (controlled) source differs from an independent source in that its value:

- A. Is always exactly zero under all conditions
- B. Cannot be used in linear circuit analysis methods
- C. Depends on a voltage or current elsewhere in the circuit
- D. Is fixed and unaffected by the rest of the circuit

43. The conductance of a  $4\ \Omega$  resistor is:

- A. 4 S
- B. 0.25 S
- C. 16 S
- D. 2 S

44. The Laplace transform of a constant function  $f(t) = 5 \cdot u(t)$  is:

- A. 5

- B.  $5s$
- C.  $1/s$
- D.  $5/s$

45. Two LTI systems with transfer functions  $H_1(s)$  and  $H_2(s)$  are connected in cascade (series). The overall transfer function is:

- A. The product  $H_1(s) \cdot H_2(s)$
- B. The sum  $H_1(s) + H_2(s)$
- C. The difference  $H_1(s) - H_2(s)$
- D. The ratio  $H_1(s)/H_2(s)$

46. A signal that repeats itself at regular intervals  $T$  is described as:

- A. Aperiodic with finite energy
- B. Periodic with period  $T$
- C. Random and non-deterministic
- D. Causal and absolutely summable

47. The frequency response of a system is obtained from its transfer function  $H(s)$  by substituting:

- A.  $s = 0$
- B.  $s = 1$
- C.  $s = \sigma$  (real part only)
- D.  $s = j\omega$

48. A pole of a continuous-time transfer function located in the right half of the  $s$ -plane indicates the system is:

- A. Marginally stable with sustained oscillation
- B. Critically damped with a fast response
- C. Unstable with a growing output response
- D. A pure delay with no amplitude change

49. The Nyquist rate for a signal band-limited to 4 kHz is:

- A. 8 kHz
- B. 4 kHz
- C. 2 kHz
- D. 16 kHz

50. In an analog-to-digital converter, the number of distinct output levels for an n-bit converter is:

- A. n
- B. 2n
- C.  $2^n$
- D.  $n^2$

51. The impulse response of an ideal low-pass filter is a:

- A. Rectangular pulse of finite duration
- B. Sinc function extending infinitely in time
- C. Single decaying exponential function
- D. Constant value for all time instants

52. A system is linear if it satisfies the properties of:

- A. Causality and time-invariance together
- B. Stability and memorylessness together
- C. Periodicity and absolute summability
- D. Superposition (additivity and homogeneity)

53. An 8-bit ADC has a full-scale input range of 0 to 5.1 V. What is the approximate resolution (voltage per step)?

- A. 20 mV
- B. 200 mV
- C. 5 mV
- D. 640 mV

54. The transfer function of an ideal time delay of T seconds is:

- A.  $H(s) = sT$
- B.  $H(s) = 1/(sT)$
- C.  $H(s) = e^{(-sT)}$
- D.  $H(s) = T$

55. Quantization noise in an ADC can be reduced by:

- A. Decreasing the number of bits in the converter
- B. Increasing the number of bits in the converter
- C. Lowering the sampling rate below Nyquist
- D. Removing the anti-aliasing input filter

56. The input bias current of an ideal operational amplifier is assumed to be:

- A. Zero
- B. Equal to the output current
- C. Infinite
- D. Equal to the supply current

57. A summing amplifier built around an op-amp produces an output proportional to the:

- A. Product of all the input voltages applied
- B. Difference between two of the input voltages
- C. Highest single input voltage present
- D. Weighted sum of the input voltages

58. In a PNP bipolar junction transistor operating in the active region, the emitter-base junction is:

- A. Reverse biased and the collector-base forward biased
- B. Forward biased and the collector-base reverse biased
- C. Both junctions reverse biased simultaneously
- D. Both junctions forward biased simultaneously

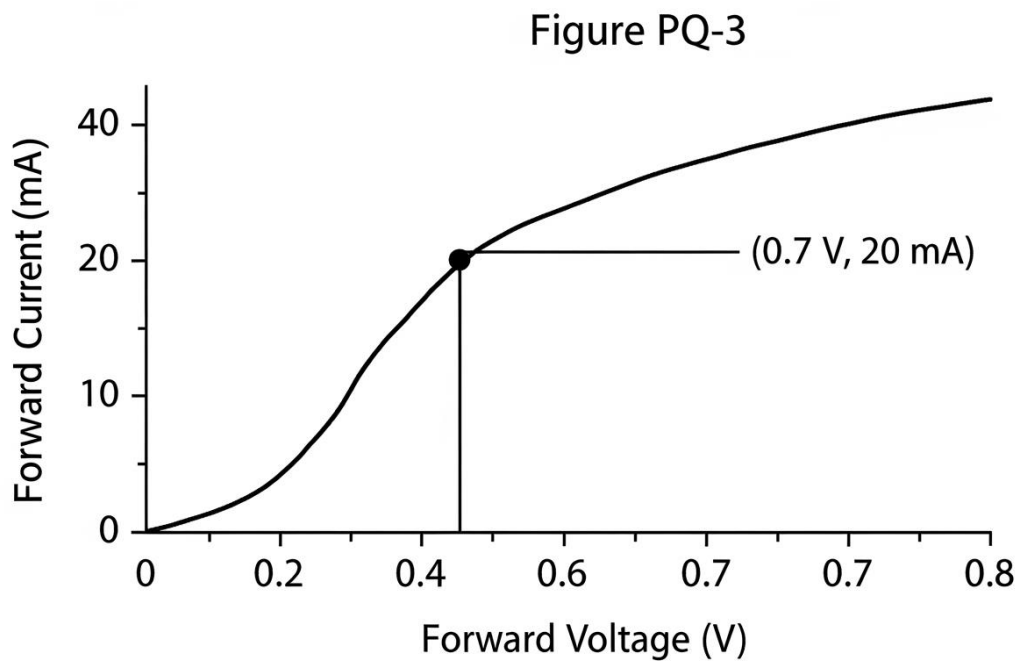
59. The threshold voltage of a MOSFET is the gate-source voltage at which:

- A. The device enters permanent breakdown conduction
- B. The drain current reaches its absolute maximum
- C. A conducting channel just begins to form
- D. The transistor switches fully into cutoff mode

60. A voltage regulator's primary function in a power supply is to:

- A. Convert AC line voltage into DC voltage
- B. Step the input voltage up to a higher level
- C. Filter out high-frequency switching noise only
- D. Maintain a constant output voltage despite load changes

61. The figure shows the forward I-V characteristic curve of a diode. At a forward voltage of 0.7 V, what is the approximate forward current read from the curve?



- A. 20 mA
- B. 0 mA
- C. 50 mA
- D. 0.7 mA

62. The purpose of a heat sink attached to a power transistor is to:

- A. Increase the electrical gain of the transistor
- B. Provide electrical insulation from the chassis

- C. Improve heat dissipation away from the device
- D. Filter ripple from the DC supply voltage

63. A class-A amplifier conducts for what portion of the input signal cycle?

- A. Exactly one-half ( $180^\circ$ ) of the cycle
- B. The entire cycle ( $360^\circ$ )
- C. Slightly more than half the cycle
- D. Less than half the cycle

64. A 120 V RMS source supplies a  $60\ \Omega$  resistive load. What is the average power dissipated?

- A. 2 W
- B. 7200 W
- C. 720 W
- D. 240 W

65. The power triangle relates real power  $P$ , reactive power  $Q$ , and apparent power  $S$  by:

- A.  $S = P + Q$  (direct algebraic sum)
- B.  $S = P - Q$  (algebraic difference)
- C.  $S = \sqrt{P^2 + Q^2}$  (vector magnitude)
- D.  $S = P \times Q$  (direct product)

66. A three-phase wye-connected source has a phase voltage of 120 V. What is the line-to-line voltage?

- A. 208 V
- B. 120 V

- C. 360 V
- D. 240 V

67. The torque produced by a DC motor is directly proportional to the:

- A. Square of the supply line frequency
- B. Armature current and the field flux
- C. Inverse of the rotational speed always
- D. Total resistance of the field winding

68. A transformer's voltage regulation is a measure of the:

- A. Efficiency at full rated load conditions
- B. Ratio of primary to secondary turns
- C. Total core and copper power losses
- D. Change in secondary voltage from no-load to full-load

69. In a balanced three-phase system, the total instantaneous power delivered to the load is:

- A. Constant, not pulsating with time
- B. Zero at the peak of each phase voltage
- C. Pulsating at twice the line frequency
- D. Negative during one-third of the cycle

70. The no-load speed of a separately excited DC motor, if the field flux is reduced, will:

- A. Decrease toward zero rotational speed
- B. Increase above the rated base speed

- C. Remain exactly at the rated base speed
- D. Reverse the direction of shaft rotation

71. A 480 V, three-phase motor draws a line current of 20 A at a power factor of 0.85. What is the real power consumed?

- A. 9.6 kW
- B. 16.6 kW
- C. 14.1 kW
- D. 8.2 kW

72. A capacitor bank is added in parallel with an inductive load to:

- A. Increase the total reactive power demand
- B. Decrease the supply line voltage level
- C. Convert the real power into reactive power
- D. Improve the power factor toward unity

73. Ampère's law (in its basic form) relates the magnetic field around a closed loop to the:

- A. Total electric current enclosed by the loop
- B. Total electric charge inside the loop region
- C. Rate of change of the electric field only
- D. Magnetic flux density at a single point

74. The magnitude of the electric field at distance  $r$  from a point charge  $q$  in free space is proportional to:

- A.  $r$  (linearly with distance)
- B.  $1/r^2$  (inverse square of distance)

- C.  $1/r$  (inverse of distance)
- D.  $r^2$  (square of distance)

75. The wavelength of a 3 GHz electromagnetic wave in free space is approximately:

- A. 3 m
- B. 1 m
- C. 0.3 m
- D. 0.1 m

76. A transmission line is "matched" to its load when the load impedance equals the:

- A. Source internal resistance value
- B. Reciprocal of the line's characteristic impedance
- C. Characteristic impedance of the line
- D. Square of the characteristic impedance

77. The primary advantage of a closed-loop (feedback) control system over an open-loop system is its:

- A. Ability to reduce sensitivity to disturbances and parameter changes
- B. Lower component count and simpler overall construction
- C. Complete elimination of the need for any sensors
- D. Guaranteed stability regardless of the loop gain used

78. The order of a control system is determined by the:

- A. Number of summing junctions in the diagram
- B. Number of input reference signals applied

- C. Highest power of  $s$  in the denominator of its transfer function
- D. Number of feedback paths around the forward loop

79. The settling time of a second-order system is most directly decreased by:

- A. Decreasing the natural frequency  $\omega_n$
- B. Increasing the product  $\zeta\omega_n$  (the real-pole magnitude)
- C. Reducing the damping ratio toward zero
- D. Adding a pure time delay to the loop

80. A system's gain margin is the factor by which the loop gain can be increased before the system reaches:

- A. Its maximum allowable steady-state error
- B. The desired bandwidth in radians per second
- C. The peak of its resonant frequency response
- D. The verge of instability (marginal stability)

81. In a root-locus plot, the branches of the locus always begin (at zero gain) at the:

- A. Open-loop poles of the system
- B. Open-loop zeros of the system
- C. Origin of the complex  $s$ -plane
- D. Points on the imaginary axis only

82. A proportional-only (P) controller applied to a Type 0 system will generally leave:

- A. Zero steady-state error to a step input
- B. A nonzero steady-state error to a step input

- C. An unstable, growing output response
- D. A pure sinusoidal oscillation at the output

83. The bandwidth of a closed-loop control system is an indicator of its:

- A. Steady-state accuracy to a ramp input
- B. Total power consumption during operation
- C. Speed of response to changing inputs
- D. Resistance to electrical noise interference

84. The bandwidth required to transmit a signal generally increases as the:

- A. Carrier amplitude is decreased gradually
- B. Transmission distance becomes shorter
- C. Signal-to-noise ratio is improved further
- D. Information (data) rate is increased

85. Frequency-division multiplexing (FDM) assigns each transmitted signal a distinct:

- A. Time slot in a repeating frame
- B. Frequency band within the channel
- C. Orthogonal spreading code sequence
- D. Polarization angle of the antenna

86. The modulation index of an AM signal is the ratio of the:

- A. Message amplitude to the carrier amplitude
- B. Carrier frequency to the message frequency

- C. Sideband power to the total signal power
- D. Receiver bandwidth to the channel bandwidth

87. In a digital communication system, increasing the number of bits per symbol (higher-order modulation) generally:

- A. Reduces the data rate for a fixed bandwidth
- B. Eliminates the need for error-correcting codes
- C. Decreases the required transmit power per symbol
- D. Increases data rate but demands a higher signal-to-noise ratio

88. The primary purpose of error-detecting codes such as a parity bit is to:

- A. Compress the transmitted data to save bandwidth
- B. Encrypt the message against eavesdropping
- C. Detect whether bit errors occurred in transmission
- D. Synchronize the transmitter and receiver clocks

89. In the OSI model, the layer responsible for routing packets between different networks is the:

- A. Network layer
- B. Transport layer
- C. Session layer
- D. Physical layer

90. The protocol used to transfer web pages between a browser and a web server is:

- A. FTP
- B. HTTP

- C. SMTP
- D. SNMP

91. A network topology in which all devices connect to a single central hub or switch is called a:

- A. Ring topology
- B. Bus topology
- C. Mesh topology
- D. Star topology

92. The maximum theoretical data rate of a channel with bandwidth B and a given signal-to-noise ratio is given by:

- A. Nyquist's sampling theorem formula
- B. Ohm's law for the channel resistance
- C. The Shannon-Hartley capacity theorem
- D. Kirchhoff's voltage law for the loop

93. Convert the binary number 1111 to decimal.

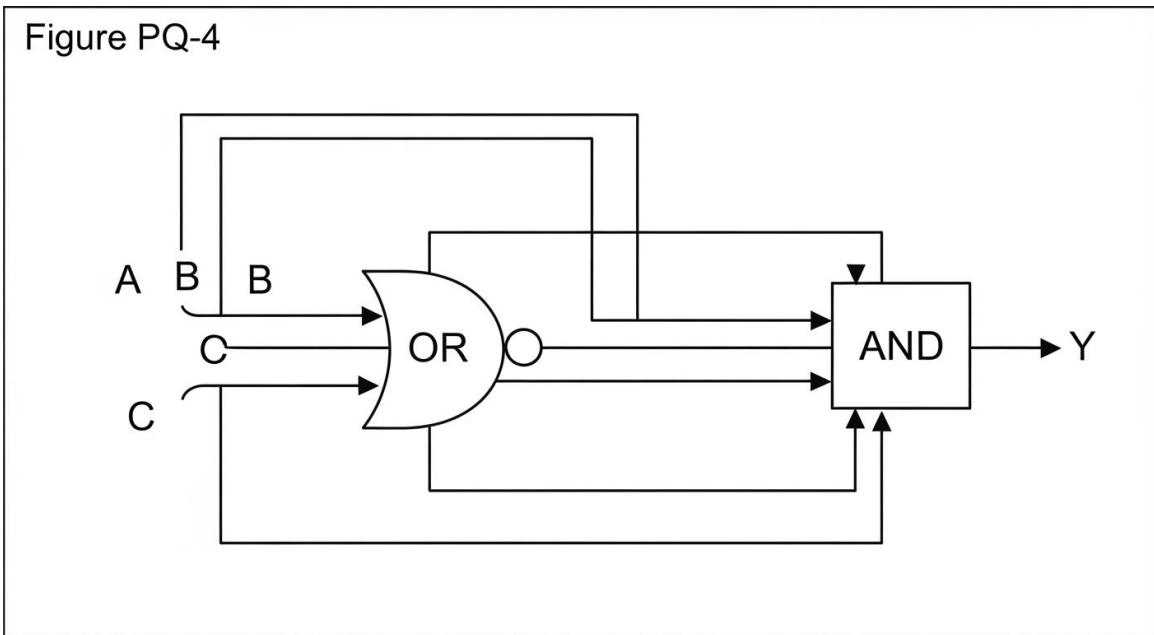
- A. 15
- B. 16
- C. 14
- D. 31

94. The Boolean identity  $A + 1$  evaluates to:

- A. A
- B. 1

- C. 0
- D. A'

95. For the logic network shown, determine the output Y when A = 1, B = 0, and C = 1.



- A. 0
- B. Undefined
- C. 1
- D. High impedance

96. A half-adder circuit produces which two outputs from its two inputs?

- A. Carry-in and borrow
- B. Quotient and remainder
- C. Enable and clock
- D. Sum and carry-out

97. How many select lines are needed for a 1-of-16 (4-to-16) decoder?

- A. 2
- B. 4
- C. 8
- D. 16

98. A JK flip-flop with both J and K inputs held HIGH will, on each clock edge:

- A. Toggle its output to the opposite state
- B. Hold its current output state unchanged
- C. Reset its output to logic zero always
- D. Set its output to logic one always

99. The number of unique states in a counter built from 5 flip-flops is at most:

- A. 5
- B. 10
- C. 25
- D. 32

100. Gray code differs from standard binary in that between successive values:

- A. All bits change at the same time
- B. The most significant bit never changes
- C. Only a single bit changes at a time
- D. The total number of ones stays constant

101. The two's complement of the 8-bit binary number 00000001 is:

- A. 00000001
- B. 11111111
- C. 10000001
- D. 00000010

102. The program counter (PC) in a CPU holds the:

- A. Address of the next instruction to be executed
- B. Result of the most recent arithmetic operation
- C. Data being written to main memory currently
- D. Status flags from the previous instruction

103. In a von Neumann architecture, instructions and data:

- A. Are stored in physically separate memories
- B. Use entirely different addressing schemes
- C. Cannot be modified once the program loads
- D. Share the same memory and data pathway

104. A cache "hit" occurs when the requested data is:

- A. Written back to the main memory successfully
- B. Loaded from the hard disk into the cache
- C. Found in the cache without accessing main memory
- D. Evicted from the cache to make room for new data

105. The clock speed of a processor measured in gigahertz indicates the:

- A. Number of clock cycles executed per second
- B. Total amount of memory the CPU can address
- C. Width of the internal data bus in bits
- D. Number of cores available on the chip

106. RISC (reduced instruction set computer) architectures are generally characterized by:

- A. A large number of complex, multi-cycle instructions
- B. A small set of simple, fixed-length instructions
- C. The absence of any pipelining in the design
- D. Direct execution of high-level language code

107. In Big-O notation, the time complexity of accessing an element by index in an array is:

- A.  $O(n)$
- B.  $O(\log n)$
- C.  $O(n^2)$
- D.  $O(1)$

108. A "syntax error" in a program is one that:

- A. Produces an incorrect result at runtime only
- B. Occurs only when the input data is invalid
- C. Violates the grammatical rules of the language
- D. Arises from a logical flaw in the algorithm

109. Which sorting algorithm has an average-case time complexity of  $O(n \log n)$ ?

- A. Bubble sort
- B. Merge sort
- C. Linear search
- D. Insertion sort

110. In version control systems such as Git, a "commit" represents:

- A. A permanent deletion of the entire repository
- B. A live connection to a remote server only
- C. A temporary copy stored only in memory
- D. A recorded snapshot of changes to the codebase

## PRACTICE EXAM 8— ANSWER KEY AND FULL ANSWER EXPLANATIONS

**1. C** — The derivative of  $\tan(x)$  is  $\sec^2(x)$ , a standard trigonometric derivative. It follows from the quotient rule applied to  $\sin(x)/\cos(x)$  and is always positive, reflecting that tangent is increasing on each branch.

**2. A** — The integral of  $e^x$  is  $e^x + C$ , since the exponential function is its own derivative and antiderivative. The constant of integration accounts for any vertical shift.

**3. D** — By definition  $j = \sqrt{-1}$ , so  $j^2 = -1$ . This identity is the basis of all complex-number arithmetic in AC circuit analysis.

**4. B** — Slope is rise over run:  $(7 - 1)/(4 - 1) = 6/3 = 2$ . The constant ratio of vertical to horizontal change defines the line's steepness.

**5. C** — Since  $3^4 = 81$ , the solution is  $x = 4$ . Expressing both sides with the same base lets the exponents be equated directly.

**6. C** — The cross product magnitude is  $|A||B|\sin \theta$ , and for parallel vectors  $\theta = 0$ , so  $\sin \theta = 0$  and the result is the zero vector. Parallel vectors span no area, which the cross product measures.

- 7. B** —  $\int_0^1 3x^2 dx = x^3$  evaluated from 0 to 1 = 1 - 0 = 1. The coefficient 3 cancels with the 1/3 from integrating  $x^2$ .
- 8. D** — The inequality  $|x| < 3$  holds when  $x$  lies strictly between  $-3$  and  $3$ . Absolute value less than a constant always yields a bounded interval.
- 9. A** — The angle whose sine is 0.5 in the first quadrant is  $30^\circ$ , a standard reference value. This corresponds to the 30-60-90 triangle ratios.
- 10. A** — The first derivative of  $x^3$  is  $3x^2$ , and differentiating again gives  $6x$ . Each differentiation reduces the power and multiplies by the previous exponent.
- 11. B** — A zero determinant means the matrix is singular and has no inverse, because its rows or columns are linearly dependent. Such a matrix collapses space onto a lower dimension.
- 12. D** — Since  $1 - \cos x$  behaves like  $x^2/2$  near zero,  $(1 - \cos x)/x$  approaches  $x/2$ , which tends to 0. The numerator vanishes faster than the denominator.
- 13. A** — The probability of three heads in three flips is  $(1/2)^3 = 1/8$ . Each independent flip multiplies the probability by one-half.
- 14. C** — The mean is the sum 30 divided by the count 5, giving 6. For an evenly spaced set, the mean equals the middle value.
- 15. B** — By the empirical rule, about 95% of a normal distribution lies within two standard deviations of the mean. This is the basis of common confidence intervals.
- 16. B** — With 5 white balls out of 10 total, the probability of drawing white is  $5/10 = 1/2$ . Equal counts give equal likelihood for each color.
- 17. C** — The standard deviation is the square root of the variance, returning the spread to the original units of the data. It measures dispersion about the mean.
- 18. A** — A professional seal certifies that the engineer was in responsible charge of the work, taking professional responsibility for it. It is not a personal authorship claim or a guarantee against all failure.
- 19. D** — The duty to protect the public persists beyond employment, so the engineer must notify the appropriate authority of a dangerous defect. Public safety outweighs loyalty to a former employer, but confidential information is not broadcast to the press.
- 20. D** — The NSPE Code permits serving multiple interests on one project only with full disclosure to and agreement from all affected parties. Transparency is what manages the conflict of interest.
- 21. C** — Engineers are obligated to maintain and improve their competence through continuing professional development. This keeps their skills current to protect the public they serve.

- 22. A** — Simple interest rate is the gain divided by the principal:  $100/1,000 = 10\%$ . With simple interest over one year, the rate equals the fractional growth.
- 23. B** — The time value of money holds that a present dollar is worth more than a future dollar because it can earn interest. This is why future cash flows are discounted in economic analysis.
- 24. D** — The project's 15% one-year return exceeds the 10% MARR, so it is economically acceptable. A return above the minimum attractive rate justifies the investment.
- 25. A** — Depreciation represents the systematic decline in an asset's value over its useful life. It allocates the asset's cost across the years it provides service.
- 26. C** — The Rule of 72 estimates doubling time as 72 divided by the rate:  $72/6 = 12$  years. It provides a quick approximation for compound growth.
- 27. D** — Pure metals have a positive temperature coefficient of resistance, so resistance increases as temperature rises. Increased lattice vibration scatters conduction electrons more at higher temperatures.
- 28. B** — The relative permittivity of vacuum is defined as exactly 1, serving as the reference for all other materials. The value  $8.85 \times 10^{-12}$  F/m is the absolute permittivity  $\epsilon_0$ , not the relative value.
- 29. A** — A hole behaves as a mobile positive charge carrier equal in magnitude to the electron charge. It represents the absence of an electron in the valence band.
- 30. C** — Ferromagnetic materials have permeability far greater than free space, allowing them to concentrate magnetic flux strongly. This property makes them ideal for cores in transformers and motors.
- 31. D** — Power dissipated is  $V^2/R = 10^2/5 = 20$  W. This form is convenient when voltage and resistance are known directly.
- 32. B** — The two series  $10 \Omega$  resistors give  $20 \Omega$ , and  $20 \Omega$  in parallel with  $10 \Omega$  yields  $(20 \times 10)/30 \approx 6.67 \Omega$ . Series elements add before combining the parallel branch.
- 33. A** — By Ohm's law,  $I = V/R = 5/25 = 0.2$  A. Current is the ratio of voltage to resistance.
- 34. C** — Stored energy is  $\frac{1}{2}CV^2 = 0.5 \times 50 \times 10^{-6} \times 100^2 = 0.25$  J. Capacitor energy grows with the square of the voltage.
- 35. D** — Kirchhoff's voltage law states the sum of voltages around a closed loop is zero, expressing conservation of energy. Voltage rises and drops must balance around any loop.
- 36. B** — The phase angle is  $\arctan(X/R) = \arctan(3/3) = 45^\circ$ . Equal resistance and reactance produce a  $45^\circ$  impedance angle.
- 37. A** — Capacitors in parallel add directly:  $2 + 3 = 5 \mu\text{F}$ . Parallel capacitance increases because the effective plate area combines.

- 38. D** — Instantaneous power in a resistor is  $i^2R$ , which is never negative regardless of current direction. A resistor only absorbs energy, never returns it.
- 39. C** — By voltage division,  $V_{\text{out}} = 12 \times 3/(1 + 3) = 9 \text{ V}$ . The larger series resistor takes the larger share of the source voltage.
- 40. B** — The RMS value of a symmetric square wave equals its peak amplitude, here 5 V, because the magnitude is constant. Unlike a sinusoid, no  $\sqrt{2}$  factor applies.
- 41. A** — At parallel (anti-) resonance the tank impedance is maximum and purely resistive, since the inductive and capacitive currents cancel. This produces minimum line current at resonance.
- 42. C** — A dependent source has a value determined by a voltage or current elsewhere in the circuit, unlike a fixed independent source. They model the controlled behavior of active devices.
- 43. B** — Conductance is the reciprocal of resistance:  $G = 1/4 = 0.25 \text{ S}$ . It measures how readily current flows.
- 44. D** — The Laplace transform of  $5 \cdot u(t)$  is  $5/s$ , scaling the unit-step transform  $1/s$  by the constant. The pole at the origin reflects the persistent constant value.
- 45. A** — Cascaded LTI systems multiply their transfer functions, since convolution in time becomes multiplication in the  $s$ -domain. The overall response is  $H_1(s) \cdot H_2(s)$ .
- 46. B** — A signal that repeats at fixed intervals  $T$  is periodic with period  $T$ . The repeating pattern defines its fundamental frequency  $1/T$ .
- 47. D** — Substituting  $s = j\omega$  into  $H(s)$  gives the frequency response, evaluating the system along the imaginary axis. This yields the steady-state gain and phase versus frequency.
- 48. C** — A right-half-plane pole produces a growing exponential in the time response, making the system unstable. Stability requires all poles to have negative real parts.
- 49. A** — The Nyquist rate is twice the highest frequency:  $2 \times 4 \text{ kHz} = 8 \text{ kHz}$ . Sampling at least this fast prevents aliasing.
- 50. C** — An  $n$ -bit converter resolves  $2^n$  distinct output levels. Each added bit doubles the number of quantization steps.
- 51. B** — The ideal low-pass filter's impulse response is a sinc function, which extends infinitely in both time directions. Its infinite, non-causal nature makes the ideal filter physically unrealizable.
- 52. D** — Linearity requires superposition, combining additivity and homogeneity (scaling). A system meeting both properties responds to a sum of inputs as the sum of responses.

- 53. A** — Resolution is the full-scale range divided by the number of steps:  $5.1 \text{ V}/(2^8 - 1) = 5.1/255 = 20 \text{ mV}$ . Each least-significant-bit change corresponds to this voltage increment.
- 54. C** — An ideal delay of  $T$  seconds has transfer function  $e^{(-sT)}$ , since a time shift corresponds to that exponential factor in the Laplace domain. Its magnitude is unity at all frequencies, affecting only phase.
- 55. B** — Adding bits to the converter shrinks each quantization step, lowering quantization noise. Finer resolution improves the signal-to-quantization-noise ratio.
- 56. A** — An ideal op-amp draws zero input bias current because its input impedance is infinite. No current flows into the input terminals in the ideal model.
- 57. D** — A summing amplifier outputs a weighted sum of its inputs, with each weight set by the ratio of feedback to input resistor. This makes it useful for analog signal mixing.
- 58. B** — In an active PNP transistor the emitter-base junction is forward biased and the collector-base junction is reverse biased. This biasing enables normal amplifying operation.
- 59. C** — The threshold voltage is the gate-source voltage at which a conducting channel first forms between source and drain. Below it the device is off; above it conduction begins.
- 60. D** — A voltage regulator maintains a constant output voltage despite variations in load current or input voltage. This stable supply protects sensitive downstream circuits.
- 61. A** — Reading the marked point on the curve at  $0.7 \text{ V}$  gives a forward current of  $20 \text{ mA}$ . The sharp rise past the knee voltage reflects the diode's exponential conduction.
- 62. C** — A heat sink increases surface area to dissipate heat away from the transistor, keeping junction temperature within safe limits. Effective cooling prevents thermal damage and runaway.
- 63. B** — A class-A amplifier conducts for the entire  $360^\circ$  of the input cycle, giving low distortion at the cost of low efficiency. The output device never cuts off during the cycle.
- 64. D** — Average power in a resistive load is  $V^2/R = 120^2/60 = 240 \text{ W}$ . With a purely resistive load, RMS voltage and resistance fully determine the power.
- 65. C** — The power triangle gives apparent power as  $S = \sqrt{(P^2 + Q^2)}$ , since real and reactive power are perpendicular components. This vector relationship defines the power factor as  $P/S$ .
- 66. A** — In a wye system, line voltage is  $\sqrt{3}$  times phase voltage:  $\sqrt{3} \times 120 \approx 208 \text{ V}$ . The  $\sqrt{3}$  factor arises from the phasor difference of two phase voltages.
- 67. B** — DC motor torque is proportional to the product of armature current and field flux. Controlling either quantity adjusts the developed torque.

- 68. D** — Voltage regulation quantifies how much the secondary voltage changes from no-load to full-load conditions. Lower regulation means a stiffer, more stable output voltage.
- 69. A** — In a balanced three-phase load the total instantaneous power is constant, not pulsating, because the phases sum smoothly. This steady power delivery is a key advantage of three-phase systems.
- 70. B** — Reducing the field flux of a separately excited DC motor raises its speed, since speed varies inversely with flux. This is the basis of field-weakening speed control above base speed.
- 71. C** — Three-phase real power is  $P = \sqrt{3} \cdot V_L \cdot I_L \cdot \text{pf} = \sqrt{3} \times 480 \times 20 \times 0.85 \approx 14.1 \text{ kW}$ . The  $\sqrt{3}$  factor applies to line voltage and line current in a balanced system.
- 72. D** — A parallel capacitor bank supplies leading reactive power that offsets the load's lagging demand, improving the power factor toward unity. This reduces line current and losses.
- 73. A** — Ampère's law relates the magnetic field circulating around a closed loop to the total current enclosed by that loop. It is the magnetic counterpart to charge-based field laws.
- 74. B** — The electric field of a point charge falls off as  $1/r^2$ , the inverse-square law. Field lines spread over a spherical area that grows with  $r^2$ .
- 75. D** — Wavelength is  $\lambda = c/f = (3 \times 10^8)/(3 \times 10^9) = 0.1 \text{ m}$ . Higher frequency yields shorter wavelength in free space.
- 76. C** — A line is matched when the load impedance equals the line's characteristic impedance, eliminating reflections. Matched conditions maximize power transfer and minimize standing waves.
- 77. A** — Feedback control reduces sensitivity to disturbances and parameter variations by continuously correcting the output. This robustness is the central benefit over open-loop control.
- 78. C** — The order of a system equals the highest power of  $s$  in its transfer function denominator. This count corresponds to the number of independent energy-storage elements.
- 79. B** — Settling time is approximately  $4/(\zeta\omega_n)$ , so increasing the real-pole magnitude  $\zeta\omega_n$  speeds the decay. A larger negative real part moves the response toward steady state faster.
- 80. D** — Gain margin is the factor by which loop gain may rise before the system reaches marginal stability. It quantifies how much extra gain the system can tolerate.
- 81. A** — Root-locus branches begin at the open-loop poles when the gain is zero. As gain increases they migrate toward the open-loop zeros or to infinity.
- 82. B** — A proportional-only controller on a Type 0 system leaves a finite nonzero steady-state error to a step, the familiar proportional offset. An integral term is needed to remove it.

- 83. C** — Closed-loop bandwidth indicates how quickly the system responds to changing inputs; wider bandwidth means a faster response. It reflects the range of frequencies the system can track.
- 84. D** — Required bandwidth grows with the information or data rate, since more rapid signal changes contain higher-frequency content. Faster transmission inherently demands more spectrum.
- 85. B** — FDM gives each signal its own distinct frequency band within the shared channel. The signals transmit simultaneously but occupy non-overlapping frequency slots.
- 86. A** — The AM modulation index is the ratio of message amplitude to carrier amplitude. Keeping it at or below one avoids overmodulation and distortion.
- 87. D** — Higher-order modulation packs more bits per symbol, raising the data rate, but the closer-spaced constellation points require a higher signal-to-noise ratio. This is the fundamental rate-versus-robustness trade-off.
- 88. C** — Error-detecting codes such as parity bits reveal whether bit errors occurred during transmission. They flag corruption so the data can be rejected or retransmitted.
- 89. A** — The network layer handles routing of packets between different networks using logical addresses. It determines the path data takes across interconnected networks.
- 90. B** — HTTP is the protocol used to transfer web pages between browsers and web servers. It defines how requests and responses are formatted and exchanged.
- 91. D** — In a star topology every device connects to a central hub or switch. A failure of one link affects only that device, but the central node is a single point of failure.
- 92. C** — The Shannon-Hartley theorem gives the maximum error-free data rate for a channel of given bandwidth and signal-to-noise ratio. It sets the theoretical ceiling on capacity.
- 93. A** — Binary 1111 equals  $8 + 4 + 2 + 1 = 15$ . Summing the weighted powers of two gives the decimal value.
- 94. B** — The Boolean identity  $A + 1$  always equals 1, since ORing anything with logic 1 yields 1. The 1 dominates the OR operation.
- 95. C** —  $\text{OR}(1, 0)$  gives 1, and  $\text{AND}(1, 1)$  with input  $C = 1$  gives  $Y = 1$ . The signal passes through both gates as logic high.
- 96. D** — A half-adder outputs a sum bit and a carry-out bit from its two input bits. It lacks a carry-in, which distinguishes it from a full adder.
- 97. B** — A 4-to-16 decoder needs 4 select lines because  $2^4 = 16$  outputs. Each added select line doubles the number of addressable outputs.

- 98. A** — With both J and K held high, a JK flip-flop toggles its output on each active clock edge. This toggle mode is the basis of binary counters.
- 99. D** — Five flip-flops provide  $2^5 = 32$  possible states. Each flip-flop stores one bit, doubling the state count.
- 100. C** — Gray code changes only a single bit between successive values, minimizing transition errors. This makes it valuable in position encoders and state machines.
- 101. B** — The two's complement of 00000001 is found by inverting to 11111110 and adding 1, giving 11111111, which represents  $-1$ . Negating a value yields its additive inverse in two's-complement arithmetic.
- 102. A** — The program counter holds the address of the next instruction to be executed. It increments automatically and is updated by branches and jumps.
- 103. D** — A von Neumann architecture stores instructions and data in the same memory accessed over a shared pathway. This unified design simplifies hardware but creates the von Neumann bottleneck.
- 104. C** — A cache hit occurs when requested data is found in the cache, avoiding a slower main-memory access. High hit rates are what make caching improve performance.
- 105. A** — Clock speed in gigahertz measures the number of clock cycles per second. It sets the basic timing rate at which the processor executes operations.
- 106. B** — RISC designs use a small set of simple, fixed-length instructions that typically execute in one cycle. This simplicity supports efficient pipelining and faster clock rates.
- 107. D** — Indexed access to an array element is  $O(1)$ , because the address is computed directly from the base and index. No traversal is required regardless of array size.
- 108. C** — A syntax error violates the grammatical rules of the programming language and is caught before execution. The compiler or interpreter cannot translate malformed code.
- 109. B** — Merge sort has an average- and worst-case time complexity of  $O(n \log n)$  through its divide-and-conquer approach. It consistently splits and merges sorted halves.
- 110. D** — A Git commit records a snapshot of changes to the codebase at a point in time. Each commit forms part of the project's version history for tracking and reverting.