PRACTICE EXAM 13: FE ELECTRICAL AND COMPUTER SIMULATION (110 QUESTIONS)

Time allotted: 5 hours 20 minutes

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

1. What is the derivative of $f(x) = 1/x$ (i.e., x^{-1})?

A. $\ln(x)$

B. $-1/x^2$

C. $1/x^2$

D. $-x^{-2} \cdot \ln(x)$

2. Evaluate $\int \sin(x)\, dx$.

A. $\cos(x) + C$

B. $\sin(x) + C$

C. $-\sin(x) + C$

D. $-\cos(x) + C$

3. The magnitude of the complex number $6 - j8$ is:

A. 10

B. 14

C. 2

D. 48

4. Solve for x: $5x - 3 = 2x + 9$.

A. 2

B. 6

C. 4

D. 12

5. The derivative of $f(x) = \ln(x)$ is:

A. x

B. $1/x$

C. $\ln(x)/x$

D. $-1/x^2$

6. Evaluate the limit $\lim(x \to 3) (x^2 - 9)/(x - 3)$.

A. 6

B. 0

C. 3

D. 9

7. The value of $\tan(45°)$ is:

A. 0

B. 0.5

C. $\sqrt{2}$

D. 1

8. Evaluate the definite integral $\int_0^{\pi} \sin(x)\, dx$.

A. 0

B. 1

C. 2

D. π

9. The sum of the first 5 positive integers (1 + 2 + 3 + 4 + 5) is:

A. 15

B. 10

C. 25

D. 20

10. The cross product of the unit vectors $i \times j$ equals:

A. k

B. $-k$

C. j

D. 0

11. If $f(x) = x^2 - 4x + 4$, the value of x at which $f(x) = 0$ is:

A. 4

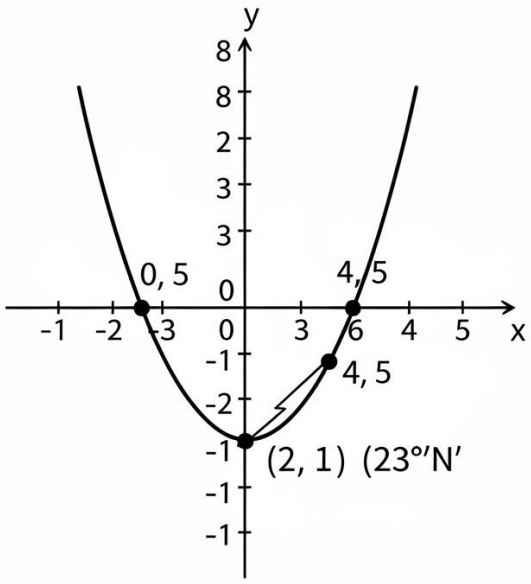
B. -2

C. 2

D. 0

12. The graph shown is the parabola $y = (x - 2)^2 + 1$. What are the coordinates of its vertex?

Figure PQ-1



A. (0, 5)

B. (−2, 1)

C. (1, 2)

D. (2, 1)

13. A standard die is rolled. What is the probability of rolling a 3 or a 5?

A. 1/6

B. 1/3

C. 1/2

D. 2/3

14. The range of the data set 4, 9, 15, 22 is:

A. 9

B. 18

C. 22

D. 12.5

15. If P(A) = 0.4 and P(B) = 0.5 and the events are mutually exclusive, then P(A or B) is:

A. 0.2

B. 0.45

C. 0.9

D. 0.1

16. The number of permutations of 3 items chosen from 5 distinct items (order matters) is:

A. 10

B. 15

C. 20

D. 60

17. In a normal distribution, the mean, median, and mode are:

A. All equal to one another

B. Always three different values

C. Unrelated to the distribution's shape

D. Located in the distribution's tails

18. Under the NSPE Code, when an engineer's name is used to promote a fraudulent business venture, the engineer should:

A. Allow it if they receive a share of the profits

B. Refuse to associate their name with the venture

C. Permit it only if the venture is in another state

D. Allow it after adding a small printed disclaimer

19. An engineer reviewing another engineer's work finds it technically sound but stylistically different from their own approach. The engineer should:

A. Reject the work for not matching their personal style

B. Demand the original engineer redo all the calculations

C. Evaluate the work fairly on its technical merits

D. Report the original engineer to the licensing board

20. Under the NSPE Code, an engineer who relies on the technical work of others in a design must:

A. Take sole personal credit for the combined work

B. Conceal the involvement of the other contributors

C. Avoid citing any external sources in the report

D. Give appropriate credit to those who did the work

21. The principle that engineers should "avoid all conduct or practice that deceives the public" most directly protects:

A. Public trust in the engineering profession

B. The engineer's individual profit margin

C. The confidentiality of client information

D. The engineer's right to refuse work

22. A deposit of $5,000 earns 4% simple interest annually. The total interest after 5 years is:

A. $200

B. $5,000

C. $1,000

D. $1,200

23. The equivalent annual cost (EAC) method is especially useful for comparing alternatives that have:

A. Identical first costs but different revenues

B. Different useful lives

C. The same salvage value in every case

D. No operating or maintenance costs

24. Money has a "future worth" greater than its present worth because of:

A. Inflation reducing future prices

B. Depreciation of physical assets

C. Increasing tax rates over time

D. The interest it can earn over time

25. The book value of an asset is its:

A. Original cost minus accumulated depreciation

B. Current resale price on the open market

C. Replacement cost at today's prices

D. Total revenue it has generated to date

26. If the nominal interest rate is 6% and the inflation rate is 2%, the approximate real interest rate is:

A. 8%

B. 4%

C. 3%

D. 12%

27. The resistance of a wire is directly proportional to its:

A. Cross-sectional area

B. Conductivity

C. Diameter squared

D. Length

28. Intrinsic (undoped) silicon at absolute zero temperature behaves as a(n):

A. Perfect conductor

B. Superconductor

C. Insulator

D. P-type semiconductor

29. The process of adding controlled impurities to a pure semiconductor is called:

A. Doping

B. Annealing

C. Etching

D. Sintering

30. The coercivity of a magnetic material is a measure of its:

A. Maximum saturation flux density

B. Electrical conductivity at saturation

C. Initial permeability at low field

D. Resistance to becoming demagnetized

31. A 12 V source drives a 4 Ω and an 8 Ω resistor in series. The power delivered by the source is:

A. 36 W

B. 12 W

C. 144 W

D. 4 W

32. Four 8 Ω resistors are connected in parallel. The equivalent resistance is:

A. 2 Ω

B. 32 Ω

C. 4 Ω

D. 8 Ω

33. The current through an ideal voltage source is determined by:

A. The external circuit connected to it

B. The internal resistance of the source

C. The frequency of the applied signal

D. The color code of the connecting wires

34. A 5 Ω resistor and a 5 Ω capacitive reactance are in series. The magnitude of the impedance is:

A. 10 Ω

B. 0 Ω

C. 5 Ω

D. 7.07 Ω

35. Kirchhoff's voltage law is fundamentally a statement of the conservation of:

A. Electric charge

B. Energy

C. Mass

D. Momentum

36. A 20 μF capacitor charged to 50 V holds a charge of:

A. 1 mC

B. 2.5 mC

C. 0.4 mC

D. 1000 mC

37. The angular frequency ω of a 50 Hz AC signal is approximately:

A. 50 rad/s

B. 100 rad/s

C. 314 rad/s

D. 25 rad/s

38. In a parallel circuit, the quantity that is the same across all branches is the:

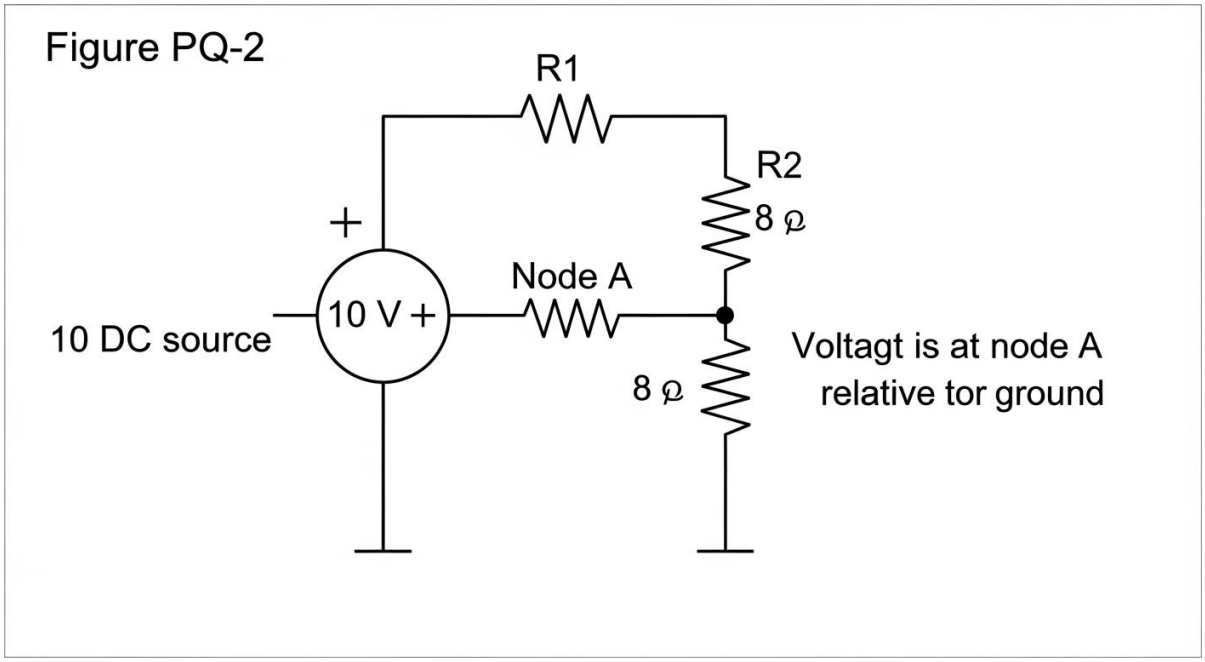
A. Current through each branch

B. Voltage across each branch

C. Power dissipated in each branch

D. Resistance of each branch

39. In the circuit shown, what is the voltage at node A with respect to ground?



A. 10 V

B. 2 V

C. 5 V

D. 8 V

40. The net reactance of a series circuit with an inductive reactance of 10 Ω and a capacitive reactance of 4 Ω is:

A. 6 Ω inductive

B. 14 Ω capacitive

C. 6 Ω capacitive

D. 40 Ω inductive

41. The instantaneous power in an AC circuit equals the product of:

A. RMS voltage and RMS current always

B. Peak voltage and peak current always

C. Instantaneous voltage and instantaneous current

D. Average voltage and average current

42. Two 100 Ω resistors carry the same current in series. The total power they dissipate compared with a single 100 Ω resistor at that current is:

A. One-half as much

B. The same

C. One-quarter as much

D. Twice as much

43. A 3 A current flows into a node, and two branches carry 1 A and 1.5 A out. The current in the third branch leaving the node is:

A. 0.5 A

B. 5.5 A

C. 2.5 A

D. 4.5 A

44. The Laplace transform of e^(2t)·u(t) is:

A. $1/(s + 2)$

B. $1/(s - 2)$

C. $2/(s^2 + 4)$

D. $s/(s^2 - 4)$

45. A system whose output depends on future values of the input is:

A. Stable

B. Linear

C. Non-causal

D. Time-invariant

46. The initial value theorem finds $f(0^+)$ from F(s) by evaluating:

A. $\lim(s\to 0)\ F(s)$

B. $\lim(s\to 0)\ s\cdot F(s)$

C. $\lim(s\to \infty)\ s\cdot F(s)$

D. $\lim(s\to \infty)\ F(s)/s$

47. A signal $x(t) = 3\cos(100\pi t)$ has a frequency of:

A. 100 Hz

B. 200 Hz

C. 314 Hz

D. 50 Hz

48. The transfer function H(s) = K (a constant) represents a system that provides:

A. A pure time delay

B. Pure gain (amplification) with no dynamics

C. Integration of the input

D. Differentiation of the input

49. To sample a 5 kHz signal without aliasing, the minimum sampling frequency is:

A. 2.5 kHz

B. 5 kHz

C. 10 kHz

D. 15 kHz

50. The bandwidth of an ideal low-pass filter with cutoff frequency f_c is:

A. 2f_c

B. f_c/2

C. Infinite

D. f_c

51. A linear system's response to a sum of two inputs equals the:

A. Sum of its responses to each input separately

B. Product of its responses to each input

C. Larger of the two individual responses

D. Difference of the two individual responses

52. In the z-domain, a unit delay of one sample is represented by:

A. z

B. z^{-1}

C. z^2

D. $1/(z - 1)$

53. The number of samples per second taken from a continuous signal is the:

A. Quantization level

B. Bit depth

C. Cutoff frequency

D. Sampling rate

54. The Fourier transform of a time-domain impulse $\delta(t)$ is:

A. Zero at all frequencies

B. An impulse in the frequency domain

C. A constant (flat) at all frequencies

D. A decaying exponential in frequency

55. Cascading two identical first-order low-pass filters produces an overall roll-off of:

A. −40 dB per decade

B. −20 dB per decade

C. −10 dB per decade

D. 0 dB per decade

56. The gain of an inverting op-amp amplifier with input resistor R_in and feedback resistor R_f is:

A. 1 + R_f/R_in

B. R_in/R_f

C. R_f + R_in

D. −R_f/R_in

57. The forward voltage drop across a typical conducting silicon diode is approximately:

A. 0.3 V

B. 0.7 V

C. 1.4 V

D. 5.0 V

58. A transistor in the cutoff region has:

A. Maximum collector current flowing

B. The base-emitter junction forward biased

C. Essentially no collector current flowing

D. Both junctions forward biased

59. The main advantage of negative feedback in an amplifier circuit is:

A. Improved gain stability and reduced distortion

B. A large increase in the overall gain

C. A narrower operating bandwidth

D. Higher output distortion at all frequencies

60. A photodiode operated in reverse bias produces a current that is proportional to the:

A. Applied reverse voltage magnitude

B. Intensity of the incident light

C. Temperature of the surrounding air

D. Frequency of the bias supply

61. The three regions of operation of a bipolar junction transistor are cutoff, saturation, and:

A. Breakdown

B. Depletion

C. Inversion

D. Active (forward-active)

62. A decoupling (bypass) capacitor placed near an integrated circuit's power pin serves to:

A. Increase the supply voltage to the chip

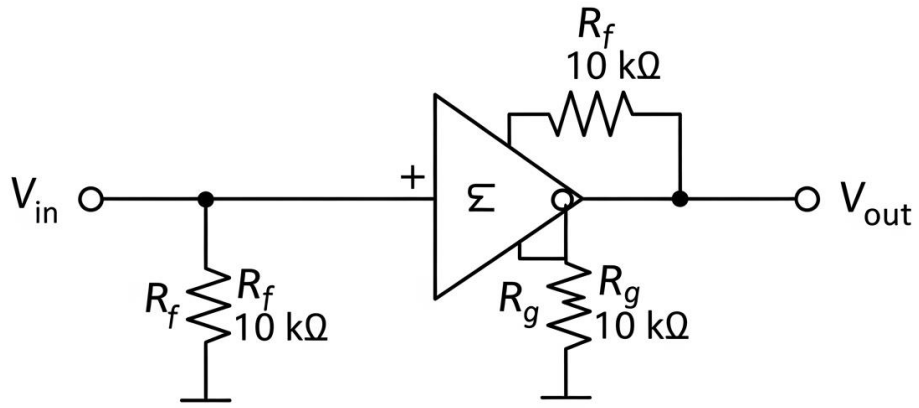
B. Provide a path for the DC bias current

C. Suppress high-frequency noise on the supply

D. Convert the DC supply into an AC signal

63. The op-amp circuit shown represents which standard configuration?

Figure PQ-3



A. Non-inverting amplifier

B. Inverting amplifier

C. Differentiator

D. Integrator

64. A 240 V single-phase supply delivers 3.6 kW to a resistive load. The load current is:

A. 5 A

B. 15 A

C. 30 A

D. 60 A

65. The neutral conductor in a balanced three-phase, four-wire wye system carries a current that is:

A. Equal to the line current

B. Greater than the phase current

C. Equal to √3 times the phase current

D. Approximately zero

66. A transformer transfers energy between its windings through:

A. A direct metallic connection

B. The flow of conduction electrons

C. A shared, time-varying magnetic flux

D. Electrostatic coupling between plates

67. The rotor of a synchronous motor rotates at:

A. A speed slightly below synchronous speed

B. Exactly synchronous speed in steady state

C. Twice the synchronous speed

D. A speed that varies with the load

68. A 10-pole, 60 Hz alternator produces output at a synchronous speed of:

A. 720 rpm

B. 600 rpm

C. 900 rpm

D. 1200 rpm

69. The efficiency of an electric motor is the ratio of:

A. Input current to output current

B. Input voltage to output voltage

C. Input power to output power

D. Output mechanical power to input electrical power

70. A load operating at a power factor of 1.0 means the:

A. Load is purely reactive

B. Reactive power is at its maximum

C. Real power equals the apparent power

D. Current leads the voltage by 90 degrees

71. A 50 kVA transformer supplies a load drawing 40 kW at a power factor of 0.8. The transformer is operating at:

A. 64% of its rated capacity

B. 100% of its rated capacity

C. 80% of its rated capacity

D. 125% of its rated capacity

72. Eddy-current losses in a transformer core are reduced by:

A. Laminating the core into thin insulated sheets

B. Increasing the supply voltage frequency

C. Using a solid one-piece iron core

D. Removing the core entirely (air core)

73. The unit of magnetic flux density (B) is the:

A. Weber

B. Henry

C. Ampere

D. Tesla

74. Lenz's law states that the direction of an induced current opposes the:

A. Resistance of the conducting loop

B. Direction of the applied voltage source

C. Change in magnetic flux that produced it

D. Flow of conventional current in the wire

75. The capacitance between two parallel plates is inversely proportional to the:

A. Separation distance between the plates

B. Permittivity of the dielectric used

C. Surface area of the conducting plates

D. Square of the applied voltage

76. The wavelength of a 100 MHz FM radio wave in free space is approximately:

A. 1 m

B. 3 m

C. 30 m

D. 0.3 m

77. A control system's "plant" refers to the:

A. Reference input signal applied

B. Feedback sensor element

C. Controller computing the action

D. Process or system being controlled

78. The time constant of a first-order system determines how quickly the output:

A. Responds to a change in the input

B. Reaches its maximum overshoot

C. Begins to oscillate at resonance

D. Saturates at the supply rail

79. A proportional (P) controller's output is:

A. The integral of the error over time

B. The derivative of the error signal

C. Proportional to the present error

D. A fixed constant regardless of error

80. Increasing the proportional gain in a control loop generally:

A. Slows the system's response significantly

B. Speeds the response but can reduce stability

C. Eliminates the steady-state error entirely

D. Has no effect on the transient behavior

81. A system on the verge of instability, producing sustained constant-amplitude oscillations, is described as:

A. Overdamped

B. Asymptotically stable

C. Critically damped

D. Marginally stable

82. The closed-loop poles of a control system are the roots of the:

A. Numerator of the open-loop transfer function

B. Forward-path transfer function alone

C. Characteristic equation, $1 + G(s)H(s) = 0$

D. Feedback-path transfer function alone

83. A Bode plot displays a system's frequency response as:

A. Magnitude (in dB) and phase versus frequency

B. Output versus input in the time domain

C. Pole and zero locations in the s-plane

D. Real versus imaginary parts of the gain

84. The bandwidth of a standard AM signal is _____ the highest frequency of the modulating message signal.

A. Equal to

B. Twice

C. Half

D. Four times

85. The main purpose of modulation in a communication system is to:

A. Reduce the total transmitted power needed

B. Convert digital data into analog noise

C. Shift the message to a suitable carrier frequency

D. Increase the noise level in the channel

86. In frequency modulation (FM), the instantaneous frequency of the carrier varies with the:

A. Phase of the previous symbol sent

B. Amplitude of the carrier wave itself

C. Square of the message signal

D. Amplitude of the message signal

87. The capacity of a noiseless channel, by Nyquist's formula, is proportional to the:

A. Channel bandwidth

B. Square of the noise power

C. Inverse of the carrier frequency

D. Transmitted signal phase

88. A digital signal with 16 possible amplitude levels per symbol carries how many bits per symbol?

A. 2

B. 4

C. 8

D. 16

89. The OSI layer that provides the physical transmission of raw bits over a medium is the:

A. Transport layer

B. Network layer

C. Data link layer

D. Physical layer

90. A protocol used to securely transfer web pages with encryption is:

A. HTTP

B. FTP

C. HTTPS

D. Telnet

91. The process of dividing a large network into smaller logical networks is called:

A. Subnetting

B. Multiplexing

C. Encapsulation

D. Broadcasting

92. In networking, latency refers to the:

A. Maximum data rate of the channel

B. Time delay for data to travel across the network

C. Number of devices connected to the network

D. Total bandwidth available to all users

93. Convert the decimal number 9 to binary.

A. 1010

B. 1000

C. 1100

D. 1001

94. The Boolean expression A · 0 evaluates to:

A. A

B. 1

C. 0

D. A'

95. An OR gate produces a LOW output only when:

A. All of its inputs are LOW

B. All of its inputs are HIGH

C. Exactly one input is HIGH

D. Its inputs differ from each other

96. The number of outputs of a 2-to-4 line decoder is:

A. 2

B. 1

C. 8

D. 4

97. A "byte" consists of how many bits?

A. 4

B. 8

C. 16

D. 32

98. Convert the binary number 1010 to decimal.

A. 8

B. 12

C. 10

D. 5

99. A counter that counts both up and down depending on a control input is called a(n):

A. Up-down counter

B. Ring counter

C. Johnson counter

D. Decade counter

100. In a positive-edge-triggered flip-flop, the output can change only on the:

A. Falling edge of the clock

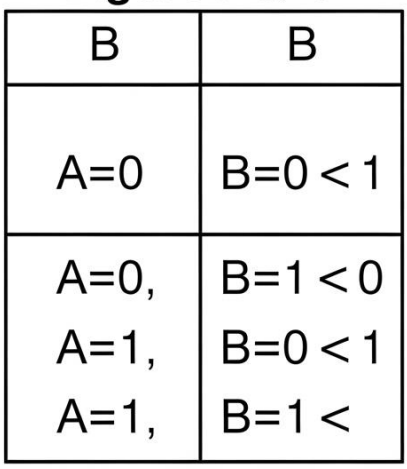
B. Rising edge of the clock

C. High level of the clock

D. Low level of the clock

101. The Karnaugh map shown is for a two-variable function F(A, B). What is the simplified expression for F?

Figure PQ-4



A. F = B

B. F = A

C. F = B'

D. F = A'

102. The part of a computer that temporarily holds data and instructions currently in use is the:

A. Hard disk drive

B. Optical drive

C. Power supply unit

D. Main memory (RAM)

103. An assembler is a program that translates:

A. Assembly language into machine code

B. High-level source code into assembly

C. Machine code back into source code

D. One high-level language into another

104. The clock signal in a synchronous computer system is used to:

A. Supply electrical power to the components

B. Synchronize the timing of operations

C. Store the results of computations

D. Convert analog inputs to digital form

105. In a cache memory system, the principle of temporal locality refers to the tendency to:

A. Access nearby memory addresses together

B. Access memory in a fixed sequential order

C. Distribute accesses evenly across memory

D. Reuse the same data within a short time

106. The data bus width of a processor determines the:

A. Maximum clock frequency achievable

B. Number of address locations available

C. Number of bits transferred at once

D. Physical size of the memory chips

107. In Big-O notation, an algorithm with two nested loops, each running n times, has time complexity:

A. $O(n^2)$

B. $O(n)$

C. $O(\log n)$

D. O(1)

108. A "function" (or subroutine) in programming is used primarily to:

A. Permanently store data on disk

B. Group reusable code into a named unit

C. Define the program's variable types

D. Establish a network connection

109. The data structure that organizes elements in a hierarchy of parent and child nodes is a:

A. Stack

B. Queue

C. Tree

D. Array

110. In software version control, "merging" refers to:

A. Deleting an outdated branch permanently

B. Compiling the source into an executable

C. Creating a brand-new empty repository

D. Combining changes from different branches

PRACTICE EXAM 13 — ANSWER KEY AND FULL ANSWER EXPLANATIONS

1. B — Using the power rule, $d/dx[x^{-1}] = -1 \cdot x^{-2} = -1/x^2$. The negative exponent decreases by one and the original exponent multiplies the term.

2. D — The integral of sin(x) is −cos(x) + C, since the derivative of −cos(x) is sin(x). The negative sign distinguishes it from the cosine integral.

3. A — The magnitude is $\sqrt{(6^2 + 8^2)} = \sqrt{100} = 10$. This is the familiar 6-8-10 scaling of the 3-4-5 right triangle.

4. C — Subtracting 2x and adding 3 gives 3x = 12, so x = 4. Collecting like terms isolates the variable.

5. B — The derivative of ln(x) is 1/x, a standard logarithmic derivative. It reflects the reciprocal slope of the natural log curve.

6. A — Factoring gives $(x^2 - 9)/(x - 3) = x + 3$, which approaches 6 as $x \to 3$. The removable factor cancels, leaving a finite limit.

7. D — tan(45°) = sin(45°)/cos(45°) = 1, since the two are equal at 45°. This is a standard reference-angle value.

8. C — $\int_0^{\pi} \sin(x)\,dx = [-\cos(x)]_0^{\pi} = -(-1) - (-1) = 2$. The sine's positive half-arch encloses an area of 2.

9. A — The sum 1 + 2 + 3 + 4 + 5 = 15, consistent with $n(n+1)/2 = 5 \cdot 6/2$. The arithmetic-series formula confirms the total.

10. A — By the right-hand rule, i × j = k. The cross product of the first two unit vectors yields the third.

11. C — Factoring $x^2 - 4x + 4 = (x - 2)^2 = 0$ gives the repeated root x = 2. The perfect square has a single solution.

12. D — In vertex form $y = (x - h)^2 + k$, the vertex is at (h, k) = (2, 1). The graph confirms the lowest point at (2, 1).

13. B — Two of six faces (3 and 5) satisfy the condition, giving 2/6 = 1/3. The outcomes are equally likely on a fair die.

14. B — Range is the largest value minus the smallest: 22 − 4 = 18. It measures the total spread of the data.

15. C — For mutually exclusive events, P(A or B) = P(A) + P(B) = 0.4 + 0.5 = 0.9. No overlap means no subtraction of a joint probability.

16. D — Permutations are $P(5,3) = 5 \times 4 \times 3 = 60$, since order matters. Each successive choice has one fewer option.

17. A — In a normal distribution, the mean, median, and mode coincide at the center. Its perfect symmetry places all three at the same point.

18. B — Lending one's name to a fraudulent venture violates the duty of honesty, so the engineer must refuse to be associated with it. A disclaimer or profit share does not excuse the deception.

19. C — A reviewing engineer must judge work on its technical merits, not on stylistic preference. Sound work should not be rejected merely for differing in approach.

20. D — Engineers must give appropriate credit to those whose work they rely upon. Acknowledging contributions upholds honesty and professional fairness.

21. A — Avoiding deceptive conduct preserves public trust in the engineering profession. That trust is the foundation of engineers' authority to protect the public.

22. C — Simple interest is $P \times r \times t = 5{,}000 \times 0.04 \times 5 = \$1{,}000$. It accrues only on the original principal each year.

23. B — The equivalent annual cost method puts alternatives with different useful lives on a common yearly basis for comparison. Converting to an annual figure removes the distortion of unequal time spans.

24. D — Future worth exceeds present worth because invested money earns interest over time. This earning potential is the essence of the time value of money.

25. A — Book value equals the asset's original cost minus the accumulated depreciation to date. It is an accounting figure, not necessarily the market price.

26. B — The approximate real rate is the nominal rate minus inflation: $6\% - 2\% = 4\%$. This corrects the stated return for loss of purchasing power.

27. D — Resistance follows $R = \rho L/A$, so it is directly proportional to length. A longer wire presents more opposition to current.

28. C — At absolute zero, intrinsic silicon has no thermally excited carriers, so it behaves as an insulator. Conduction requires energy to lift electrons across the band gap.

29. A — Doping is the deliberate addition of impurity atoms to alter a semiconductor's conductivity. It creates the n-type or p-type material used in devices.

30. D — Coercivity measures the reverse field needed to demagnetize a material, indicating its resistance to demagnetization. High-coercivity materials make good permanent magnets.

31. B — Series resistance is 12 Ω, so I = 12/12 = 1 A and P = VI = 12 × 1 = 12 W. The source supplies the total power dissipated.

32. A — Four equal resistors in parallel give R/4 = 8/4 = 2 Ω. Parallel paths reduce the equivalent resistance.

33. A — An ideal voltage source maintains its voltage regardless of load, so the external circuit sets the current it delivers. The source itself does not limit the current.

34. D — Impedance magnitude is $\sqrt{(R^2 + X_C^2)} = \sqrt{(25 + 25)} \approx 7.07$ Ω. Resistance and reactance combine as perpendicular components.

35. B — Kirchhoff's voltage law follows from energy conservation, since the net work per charge around a closed loop is zero. Voltage rises must balance the drops.

36. A — Charge is $Q = CV = 20 \times 10^{-6} \times 50 = 1 \times 10^{-3}$ C = 1 mC. The stored charge scales with both capacitance and voltage.

37. C — Angular frequency is $\omega = 2\pi f = 2\pi \times 50 \approx 314$ rad/s. It converts cyclic frequency to radians per second.

38. B — In a parallel circuit every branch shares the same voltage, since they connect across the same two nodes. The current instead divides among the branches.

39. D — By voltage division, V_A = 10 × 8/(2 + 8) = 8 V. The larger series resistor takes the larger share of the source voltage.

40. A — Net reactance is X_L − X_C = 10 − 4 = 6 Ω, and since inductive reactance dominates, the result is 6 Ω inductive. The circuit appears inductive overall.

41. C — Instantaneous power is the product of the instantaneous voltage and instantaneous current at each moment. Averaging this product over a cycle yields the real power.

42. D — Two equal resistors in series at the same current dissipate twice the power of one, since total power is I^2 times the doubled resistance. The added resistor doubles the energy dissipated.

43. A — By Kirchhoff's current law, 3 = 1 + 1.5 + x, so the third branch carries x = 0.5 A. Current in equals current out at the node.

44. B — The Laplace transform of e^(2t)·u(t) is 1/(s − 2). The positive exponent places the pole at s = +2.

45. C — A system whose output depends on future inputs is non-causal and cannot be implemented in real time. Physical real-time systems must be causal.

46. C — The initial value theorem gives $f(0^+) = \lim(s\to\infty)\ s\cdot F(s)$, provided the limit exists. It extracts the starting value without inverse transforming.

47. D — With $\omega = 100\pi$, the frequency is $f = \omega/(2\pi) = 100\pi/(2\pi) = 50$ Hz. Dividing the angular frequency by 2π yields the cyclic frequency.

48. B — A constant transfer function $H(s) = K$ scales the input by K with no frequency dependence, giving pure gain. It introduces no dynamics, delay, or phase shift.

49. C — The Nyquist rate is twice the highest frequency: 2×5 kHz = 10 kHz. Sampling at least this fast avoids aliasing.

50. D — An ideal low-pass filter passes frequencies from zero up to f_c, so its bandwidth equals f_c. The bandwidth extends from DC to the cutoff.

51. A — A linear system obeys superposition, so its response to a sum of inputs is the sum of the individual responses. This additivity defines linearity.

52. B — In the z-domain, a one-sample delay corresponds to multiplication by z^{-1}. This shift operator is fundamental to discrete-system analysis.

53. D — The sampling rate is the number of samples taken per second from a continuous signal. It determines the highest frequency that can be represented.

54. C — The Fourier transform of $\delta(t)$ is a constant across all frequencies, reflecting the impulse's flat, infinitely broad spectrum. The impulse contains every frequency equally.

55. A — Each first-order stage contributes −20 dB/decade, so two in cascade give −40 dB/decade. Stacking filters adds their roll-off slopes.

56. D — The inverting amplifier gain is $-R_f/R_{in}$, with the minus sign indicating phase inversion. The resistor ratio sets the magnitude.

57. B — A conducting silicon diode drops about 0.7 V across its forward-biased junction. This threshold is the diode's characteristic turn-on voltage.

58. C — In cutoff, the base-emitter junction is not forward biased, so essentially no collector current flows. The transistor behaves as an open switch.

59. A — Negative feedback trades some gain for improved gain stability and reduced distortion. It makes the amplifier's behavior depend mainly on the feedback components.

60. B — A reverse-biased photodiode produces a current proportional to the incident light intensity. More photons generate more charge carriers and thus more current.

61. D — The third operating region of a BJT, besides cutoff and saturation, is the active (forward-active) region. Linear amplification occurs in this region.

62. C — A decoupling capacitor near a chip's power pin shunts high-frequency noise to ground, stabilizing the supply voltage. It supplies fast transient current the supply lines cannot deliver quickly.

63. A — With the signal applied to the non-inverting input and feedback resistors setting the gain, this is a non-inverting amplifier. The input does not pass through the feedback resistor as it would in an inverting design.

64. B — For a resistive load, I = P/V = 3,600/240 = 15 A. Power factor is unity, so real and apparent power are equal.

65. D — In a balanced three-phase wye system the phase currents sum to zero, so the neutral carries approximately no current. The balanced phases cancel at the neutral point.

66. C — A transformer couples energy between windings through a shared, time-varying magnetic flux, not a direct connection. The changing flux induces voltage in the secondary.

67. B — A synchronous motor's rotor locks to and turns at exactly the synchronous speed in steady state. It does not slip like an induction motor.

68. A — Synchronous speed is $120f/P = 120 \times 60/10 = 720$ rpm. More poles yield a lower speed for a given frequency.

69. D — Motor efficiency is the ratio of output mechanical power to input electrical power. The difference accounts for copper, core, and friction losses.

70. C — A unity power factor means the real power equals the apparent power, since the load is effectively resistive. No net reactive power is exchanged.

71. B — The load's apparent power is $S = P/pf = 40/0.8 = 50$ kVA, exactly the transformer's rating, so it runs at 100% capacity. The kVA rating, not the kW, sets the loading.

72. A — Laminating the core into thin insulated sheets interrupts the induced eddy-current paths, reducing those losses. The thin layers limit circulating currents in the iron.

73. D — Magnetic flux density B is measured in tesla. One tesla equals one weber per square meter.

74. C — Lenz's law states that an induced current flows so as to oppose the change in magnetic flux that created it. This opposition is a consequence of energy conservation.

75. A — From $C = \varepsilon A/d$, capacitance is inversely proportional to the plate separation distance. Moving the plates apart reduces the capacitance.

76. B — Wavelength is $\lambda = c/f = (3 \times 10^8)/(100 \times 10^6) = 3$ m. Lower frequency corresponds to longer wavelength.

77. D — The plant is the process or physical system being controlled by the loop. The controller acts on the plant to achieve the desired output.

78. A — The time constant governs how quickly a first-order system responds to an input change. A smaller time constant yields a faster response.

79. C — A proportional controller's output is directly proportional to the present error. The proportional gain scales the corrective action.

80. B — Raising the proportional gain speeds the response but can reduce stability margins, increasing overshoot or oscillation. Excessive gain may drive the system unstable.

81. D — Sustained constant-amplitude oscillation indicates marginal stability, with poles on the imaginary axis. The response neither decays nor grows.

82. C — The closed-loop poles are the roots of the characteristic equation $1 + G(s)H(s) = 0$. Their locations determine the system's stability and dynamics.

83. A — A Bode plot presents the frequency response as separate curves of magnitude in decibels and phase versus frequency. It reveals gain and phase behavior across the spectrum.

84. B — Conventional AM occupies a bandwidth equal to twice the highest message frequency, due to the two sidebands. Each sideband mirrors the message spectrum.

85. C — Modulation shifts the message onto a carrier at a frequency suitable for transmission and antenna size. It enables efficient propagation and channel sharing.

86. D — In FM, the carrier's instantaneous frequency varies in proportion to the amplitude of the message signal. Larger message amplitudes produce larger frequency deviations.

87. A — Nyquist's formula makes a noiseless channel's capacity proportional to its bandwidth. Greater bandwidth allows more symbols per second.

88. B — With 16 levels per symbol, each symbol carries $\log_2(16) = 4$ bits. The bit count is the base-2 logarithm of the number of levels.

89. D — The physical layer transmits raw bits over the communication medium. It defines the electrical, mechanical, and signaling details.

90. C — HTTPS transfers web pages with encryption, securing the data in transit. It layers HTTP over a TLS/SSL connection.

91. A — Subnetting divides a large network into smaller logical subnetworks. It improves address management, security, and traffic control.

92. B — Latency is the time delay for data to travel across the network. It is distinct from bandwidth, which measures capacity.

93. D — Decimal 9 = 8 + 1 = 1001 in binary. Summing the corresponding powers of two confirms the conversion.

94. C — The Boolean product $A \cdot 0$ is always 0, since ANDing with logic 0 forces the output low. The 0 dominates the AND operation.

95. A — An OR gate outputs LOW only when all inputs are LOW; any HIGH input makes the output HIGH. It detects the presence of any true input.

96. D — A 2-to-4 decoder has $2^2 = 4$ outputs, one active for each input combination. Each output corresponds to a unique 2-bit code.

97. B — A byte consists of 8 bits, the standard unit for representing a character or small integer. Two nibbles make one byte.

98. C — Binary 1010 = 8 + 0 + 2 + 0 = 10 in decimal. The set bits in the 8s and 2s places give the value.

99. A — An up-down counter counts in either direction depending on a control input. It can increment or decrement its stored value.

100. B — A positive-edge-triggered flip-flop changes state only on the rising edge of the clock. Edge triggering synchronizes the output to that instant.

101. C — The output is 1 wherever B = 0 and 0 wherever B = 1, regardless of A, so F simplifies to B'. The variable A drops out because it does not affect the output.

102. D — Main memory (RAM) temporarily holds the data and instructions currently in use by the processor. It provides fast access compared with disk storage.

103. A — An assembler translates assembly language into the machine code the processor executes. It maps each mnemonic to its binary instruction.

104. B — The clock signal synchronizes the timing of operations in a synchronous system. Its edges trigger coordinated state changes across the circuit.

105. D — Temporal locality is the tendency to reuse the same data within a short time interval. Caches exploit this by retaining recently accessed items.

106. C — The data bus width sets how many bits the processor transfers in a single operation. A wider bus moves more data per cycle.

107. A — Two nested loops each running n times execute about $n \times n$ iterations, giving $O(n^2)$ complexity. The work grows with the square of the input size.

108. B — A function groups reusable code into a named unit that can be called from multiple places. This promotes modularity and avoids duplication.

109. C — A tree organizes elements in a hierarchy of parent and child nodes. It models relationships such as file systems and decision structures.

110. D — Merging combines changes from different branches into a single branch. It integrates parallel lines of development in version control.