PRACTICE EXAM 15: 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 $f(x) = 3x^2 + 2x + 1$?

A. $6x + 2$

B. $3x + 2$

C. $6x + 1$

D. $6x^2 + 2$

2. Evaluate $\int 6x\,dx$.

A. $6 + C$

B. $6x^2 + C$

C. $3x^2 + C$

D. $x^2 + C$

3. The reciprocal of the complex number j is:

A. j

B. −j

C. 1

D. −1

4. Solve the equation 2^x = 1/8.

A. 3

B. 8

C. 1/3

D. −3

5. Evaluate sin(90°).

A. 0

B. 0.5

C. 1

D. −1

6. The derivative of f(x) = √x (i.e., x^(1/2)) is:

A. 1/(2√x)

B. 2√x

C. √x/2

D. 1/√x

7. Evaluate the limit lim(x→0) (e^x − 1)/x.

A. 0

B. 1

C. e

D. ∞

8. A 3×3 identity matrix multiplied by any 3×3 matrix A yields:

A. The zero matrix

B. The transpose of A

C. The inverse of A

D. The matrix A unchanged

9. Convert the angle 45° to radians.

A. $\pi/4$

B. $\pi/2$

C. $\pi/3$

D. $\pi/6$

10. The area under the curve $y = 2$ from $x = 0$ to $x = 3$ is:

A. 2

B. 3

C. 6

D. 9

11. The second derivative of $f(x) = \sin(x)$ is:

A. $\cos(x)$

B. $-\sin(x)$

C. sin(x)

D. −cos(x)

12. The magnitude of the vector sum of (3, 0) and (0, 4) is:

A. 7

B. 1

C. 12

D. 5

13. A card is drawn from a standard 52-card deck. What is the probability it is an ace?

A. 1/13

B. 1/4

C. 1/52

D. 4/13

14. The mean of the values 10, 20, 30, 40 is:

A. 30

B. 20

C. 25

D. 100

15. If events A and B are independent with P(A) = 0.5 and P(B) = 0.4, then P(A and B) is:

A. 0.9

B. 0.1

C. 0.45

D. 0.2

16. The complement of an event with probability 0.85 has probability:

A. 0.85

B. 0.15

C. 1.85

D. 0.5

17. A standard normal distribution has a mean and standard deviation of:

A. Mean 1, standard deviation 0

B. Mean 100, standard deviation 15

C. Mean 0, standard deviation 1

D. Mean 0, standard deviation 0

18. Under the NSPE Code, an engineer who lacks expertise in a specialized area of a project should:

A. Engage or consult qualified specialists for that portion

B. Complete the work alone to keep the full fee

C. Submit the work without noting the limitation

D. Refuse the entire project to avoid any liability

19. An engineer is offered a lucrative contract that requires falsifying environmental test results. The engineer should:

A. Accept it and adjust the results slightly

B. Accept it but keep honest records privately

C. Negotiate a higher fee before deciding

D. Decline the contract and report the request if required

20. Under the NSPE Code, an engineer's primary professional obligation in any conflict between duties is to:

A. The engineer's own financial interest

B. The safety, health, and welfare of the public

C. The employer's competitive market position

D. The fastest possible project schedule

21. An engineer asked to express a public opinion on a technical matter should base that opinion on:

A. The position most favorable to their employer

B. The opinion that generates the most publicity

C. Competent knowledge and honest conviction

D. Whatever the paying client prefers to hear

22. The future value of $2,000 invested for 1 year at 10% compounded annually is:

A. $2,200

B. $2,000

C. $2,100

D. $2,020

23. A cost that has already been incurred and cannot be recovered is called a:

A. Sunk cost

B. Marginal cost

C. Fixed cost

D. Opportunity cost

24. The capital recovery factor (A/P) is used to convert a present amount into a series of:

A. Single future lump-sum payments

B. Equal annual payments

C. Increasing gradient payments

D. One-time present payments

25. The opportunity cost of an investment decision is best described as the:

A. Total cash outflow over the project life

B. Interest paid on borrowed project funds

C. Value of the best alternative forgone

D. Salvage value at the end of the life

26. At an interest rate of 0%, the present worth of a future cash flow is:

A. Equal to the future amount itself

B. Always exactly zero

C. Infinite regardless of the amount

D. One-half of the future amount

27. The unit of electrical conductivity is the:

A. Ohm-meter

B. Siemens per meter

C. Farad per meter

D. Henry per meter

28. The forbidden energy gap is largest in which class of material?

A. Conductors

B. Semiconductors

C. Superconductors

D. Insulators

29. The mobility of charge carriers in a semiconductor describes how:

A. Many carriers are present per unit volume

B. Strongly the material opposes magnetic fields

C. Easily carriers move under an applied electric field

D. Much charge the material can store electrically

30. A soft magnetic material is well suited for transformer cores because it has:

A. High coercivity and large hysteresis loss

B. Permanent magnetization once magnetized

C. Very low magnetic permeability throughout

D. Low coercivity and small hysteresis loss

31. An 18 V source drives a 6 Ω resistor. The power dissipated is:

A. 3 W

B. 108 W

C. 6 W

D. 54 W

32. Two capacitors of 4 µF each are connected in series. The equivalent capacitance is:

A. 8 µF

B. 2 µF

C. 4 µF

D. 16 µF

33. The current through a 10 Ω resistor with 20 V across it is:

A. 200 A

B. 0.5 A

C. 2 A

D. 30 A

34. The total resistance of three 2 Ω resistors connected in series is:

A. 6 Ω

B. 0.67 Ω

C. 2 Ω

D. 8 Ω

35. The reactance of a capacitor _____ as the frequency increases.

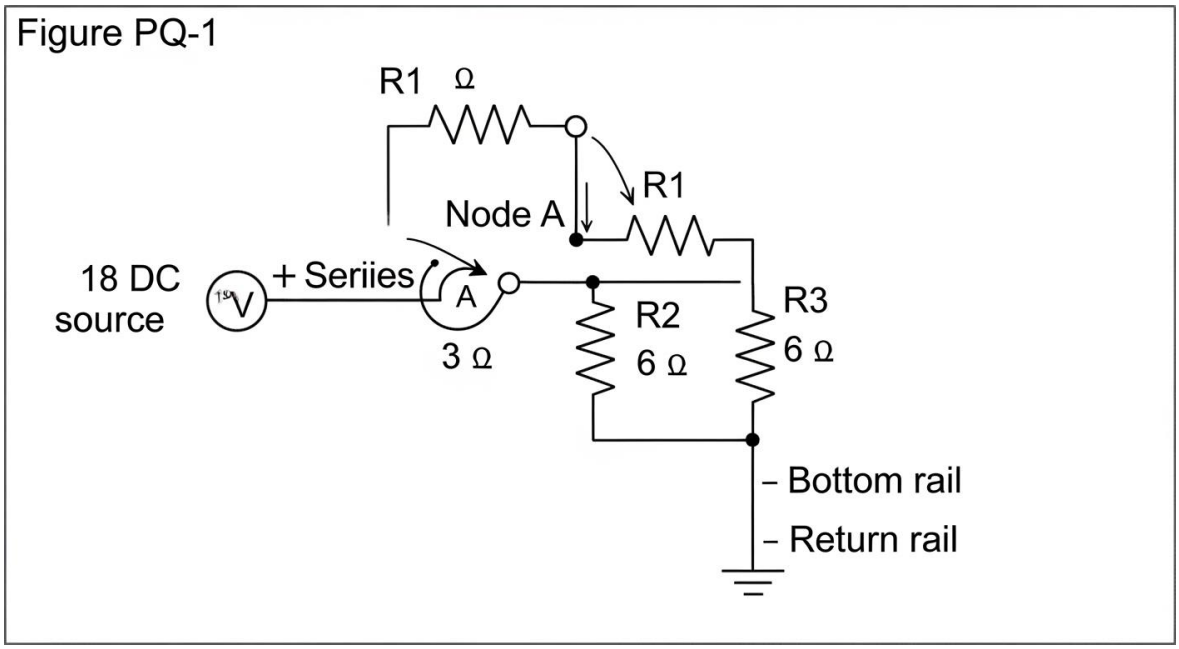
A. Increases

B. Decreases

C. Remains constant

D. Becomes infinite

36. In the circuit shown, what is the total current drawn from the 18 V source?



A. 1 A

B. 6 A

C. 2 A

D. 3 A

37. When using superposition, an ideal voltage source is temporarily replaced by a:

A. Short circuit

B. Open circuit

C. Current source

D. Resistor of equal value

38. The impedance of an ideal resistor is:

A. Purely imaginary

B. Frequency dependent

C. Purely real

D. Equal to zero

39. The RMS value of a steady DC voltage of 12 V is:

A. 8.49 V

B. 12 V

C. 6 V

D. 17 V

40. Two 100 Ω resistors in parallel give an equivalent resistance of:

A. 200 Ω

B. 50 Ω

C. 100 Ω

D. 25 Ω

41. The power factor of a circuit with a phase angle of 0° between voltage and current is:

A. 1.0

B. 0.0

C. 0.5

D. 0.707

42. The energy stored in a capacitor is given by:

A. ½LI^2

B. I^2R

C. ½CV^2

D. V^2/R

43. In a series RC circuit, immediately after a step voltage is applied ($t = 0^+$), an initially uncharged capacitor behaves as a:

A. Open circuit

B. Pure resistor

C. Constant voltage source

D. Short circuit

44. The Laplace transform of a unit ramp function $t \cdot u(t)$ is:

A. $1/s$

B. s

C. 1

D. $1/s^2$

45. A system described by $y(t) = 3 \cdot x(t)$ is:

A. Linear and memoryless

B. Nonlinear with memory

C. Time-varying and unstable

D. Causal but nonlinear

46. The poles of a transfer function are the values of s that make the:

A. Numerator equal to zero

B. Output equal to the input

C. Denominator equal to zero

D. Gain equal to unity

47. A signal x(t) = 5 (a constant for all time) has a Fourier transform consisting of:

A. A flat spectrum at all frequencies

B. An impulse at zero frequency (DC)

C. Two impulses at $\pm f_0$

D. A decaying exponential

48. The discrete-time signal $x[n] = \delta[n] - \delta[n-1]$ represents a:

A. Low-pass averaging filter

B. Pure time delay

C. Constant offset

D. First-difference (high-pass) operation

49. The Nyquist frequency is defined as:

A. One-half of the sampling frequency

B. Twice the sampling frequency

C. Equal to the sampling frequency

D. Equal to the signal bandwidth

50. A transfer function with a pole at s = 0 corresponds to a system that performs:

A. Differentiation

B. Pure gain

C. Integration

D. Time delay

51. The phase shift introduced by an ideal differentiator at all frequencies is:

A. 0 degrees

B. +90 degrees

C. −90 degrees

D. 180 degrees

52. Aliasing distortion in a sampled signal can be prevented by:

A. Filtering out frequencies above the Nyquist limit before sampling

B. Increasing the bit depth of the quantizer

C. Reducing the amplitude of the input signal

D. Adding random noise to the input signal

53. A finite impulse response (FIR) filter is always:

A. Potentially unstable for high orders

B. Dependent on feedback of past outputs

C. Equivalent to an analog RC filter

D. Inherently stable

54. Convolution in the discrete-time domain corresponds to _____ of the z-transforms.

A. Addition

B. Subtraction

C. Multiplication

D. Division

55. The bandwidth of a system is inversely related to its:

A. Steady-state gain value

B. Rise time of the step response

C. Number of poles in the left-half plane

D. Phase margin in degrees

56. An ideal op-amp has a differential voltage gain that is:

A. Infinite

B. Exactly unity

C. Zero

D. Equal to the supply voltage

57. The reverse saturation current of a diode is strongly dependent on:

A. The forward voltage applied

B. The series resistance of the circuit

C. The junction temperature

D. The frequency of the signal

58. A transistor used as an amplifier should be biased in its:

A. Cutoff region

B. Saturation region

C. Breakdown region

D. Active (linear) region

59. The voltage gain of a unity-gain buffer (voltage follower) is:

A. Very large (open-loop gain)

B. Approximately 1

C. Approximately −1

D. Zero

60. The function of a rectifier circuit is to convert:

A. AC voltage into DC voltage

B. DC voltage into AC voltage

C. Low voltage into high voltage

D. A digital signal into analog

61. In a MOSFET, the terminal that controls the channel conductivity without drawing DC current is the:

A. Source

B. Drain

C. Gate

D. Body

62. The primary purpose of a current-limiting resistor in series with an LED is to:

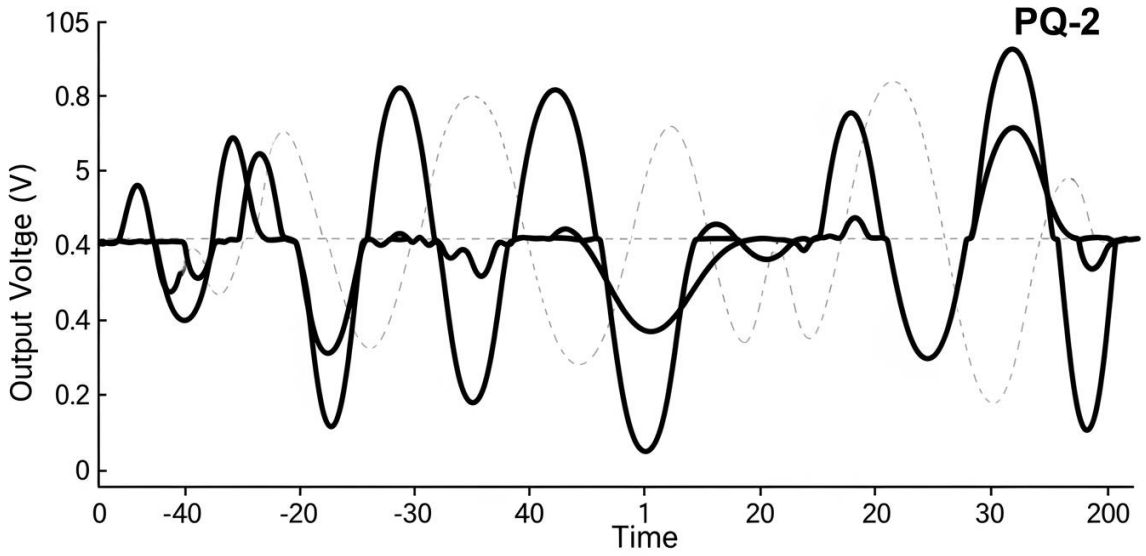
A. Increase the brightness of the LED

B. Change the color of the emitted light

C. Convert the LED's output to AC

D. Prevent excessive current that could damage it

63. The figure shows the output waveform of a rectifier driven by an AC input. Which type of rectifier produces this output?



A. Half-wave rectifier

B. Full-wave rectifier

C. No rectification (pass-through)

D. Voltage doubler

64. A 480 V supply delivers 24 A to a resistive load. The power consumed is:

A. 11,520 W

B. 504 W

C. 20 W

D. 23,040 W

65. The turns ratio of a transformer that steps 120 V down to 24 V is:

A. 1:5

B. 2:1

C. 24:1

D. 5:1

66. In a three-phase wye connection, the line current is _____ the phase current.

A. √3 times

B. one-third of

C. equal to

D. twice

67. The slip of an induction motor running at exactly synchronous speed would be:

A. Zero

B. One (100%)

C. Negative

D. Infinite

68. The primary function of a transformer in a power distribution system is to:

A. Convert AC into DC for the loads

B. Change voltage levels between circuits

C. Store electrical energy for later use

D. Improve the system's power factor

69. A 4-pole induction motor operating at 60 Hz with a slip of 5% runs at approximately:

A. 1800 rpm

B. 1890 rpm

C. 1710 rpm

D. 1500 rpm

70. The losses in a transformer that remain essentially constant regardless of load are the:

A. Copper (winding) losses

B. Resistive I^2R losses

C. Losses in the connected load

D. Core (iron) losses

71. To deliver 10 kW to a load at unity power factor from a 250 V single-phase supply, the current required is:

A. 40 A

B. 25 A

C. 4 A

D. 100 A

72. Power factor correction in an industrial facility primarily reduces the:

A. Real power consumed by the loads

B. Current drawn from the supply

C. Operating frequency of the system

D. Voltage delivered to the loads

73. The direction of the magnetic field around a straight current-carrying wire is given by the:

A. Left-hand rule for electron flow

B. Parallelogram law of vectors

C. Right-hand rule for conventional current

D. Inverse-square law of fields

74. The electric field inside an ideal hollow conductor in electrostatic equilibrium is:

A. Equal to the surface field

B. Directed radially inward

C. Proportional to the enclosed charge

D. Zero

75. The energy density stored in an electric field is proportional to the:

A. Square of the electric field strength

B. Inverse of the field strength

C. Square root of the field strength

D. Logarithm of the field strength

76. A half-wavelength dipole antenna designed for 150 MHz has an approximate total length of:

A. 2 m

B. 0.5 m

C. 1 m

D. 4 m

77. The transfer function of a system is the Laplace transform of its:

A. Step response

B. Impulse response (with zero initial conditions)

C. Steady-state output

D. Frequency response magnitude

78. In a control loop, a sensor that measures the output and returns a signal for comparison is part of the:

A. Forward path only

B. Reference input

C. Disturbance channel

D. Feedback path

79. A system with a larger phase margin generally exhibits:

A. Greater tendency to oscillate

B. Lower steady-state accuracy

C. A more stable, well-damped response

D. A faster but unstable response

80. A pure gain block K in a control system affects the:

A. Overall amplitude of the response

B. Number of poles in the system

C. Order of the differential equation

D. Time delay of the response

81. The steady-state value of a stable system's step response can be found using the:

A. Initial value theorem

B. Final value theorem

C. Convolution integral

D. Routh-Hurwitz criterion

82. An overdamped second-order system ($\zeta > 1$) responds to a step input with:

A. Sustained oscillation at the natural frequency

B. A single overshoot before settling

C. Growing oscillations that diverge

D. A slow, non-oscillatory approach to the final value

83. The gain margin and phase margin of a feedback system are both measures of its:

A. Relative stability

B. Steady-state accuracy

C. Bandwidth in hertz

D. Power consumption

84. In a digital communication system, "bandwidth efficiency" measures the data rate achieved per unit of:

A. Transmitted power

B. Antenna gain

C. Bandwidth

D. Time delay

85. The advantage of phase and frequency modulation over amplitude modulation is their:

A. Lower required bandwidth

B. Greater immunity to amplitude noise

C. Simpler receiver design

D. Higher carrier power efficiency loss

86. The Shannon channel capacity increases when the:

A. Noise power is increased

B. Bandwidth is decreased

C. Signal power is decreased

D. Signal-to-noise ratio is increased

87. In digital communications, a "symbol" can represent multiple bits when using:

A. On-off keying with two levels

B. Binary phase-shift keying only

C. Multi-level (M-ary) modulation

D. A single-frequency carrier tone

88. The primary purpose of a carrier signal in modulation is to:

A. Carry the message at a transmittable frequency

B. Add noise to improve security

C. Reduce the transmitted data rate

D. Replace the need for an antenna

89. The OSI layer responsible for establishing, managing, and terminating sessions between applications is the:

A. Transport layer

B. Session layer

C. Network layer

D. Physical layer

90. A protocol that translates a domain name into an IP address is:

A. HTTP

B. FTP

C. SMTP

D. DNS

91. The data unit at the transport layer of the TCP/IP model is commonly called a:

A. Frame

B. Packet

C. Segment

D. Bit

92. Bandwidth in a computer network is most precisely a measure of the:

A. Maximum data transfer rate of a channel

B. Physical length of the cabling used

C. Number of routers between two hosts

D. Time delay of a single packet

93. Convert the decimal number 5 to binary.

A. 110

B. 100

C. 111

D. 101

94. The Boolean expression A + A (A OR A) simplifies to:

A. 1

B. A

C. 0

D. A'

95. An AND gate outputs HIGH only when:

A. At least one input is HIGH

B. All inputs are LOW

C. All inputs are HIGH

D. The inputs differ from each other

96. The number of select lines required for an 8-to-1 multiplexer is:

A. 3

B. 8

C. 1

D. 4

97. The hexadecimal digit that represents the decimal value 12 is:

A. A

B. B

C. E

D. C

98. A combinational circuit that produces the binary sum and carry of two single bits is a:

A. Flip-flop

B. Half adder

C. Multiplexer

D. Decoder

99. The maximum value of a 4-bit unsigned binary number is:

A. 15

B. 16

C. 8

D. 31

100. In a synchronous counter, all flip-flops are triggered:

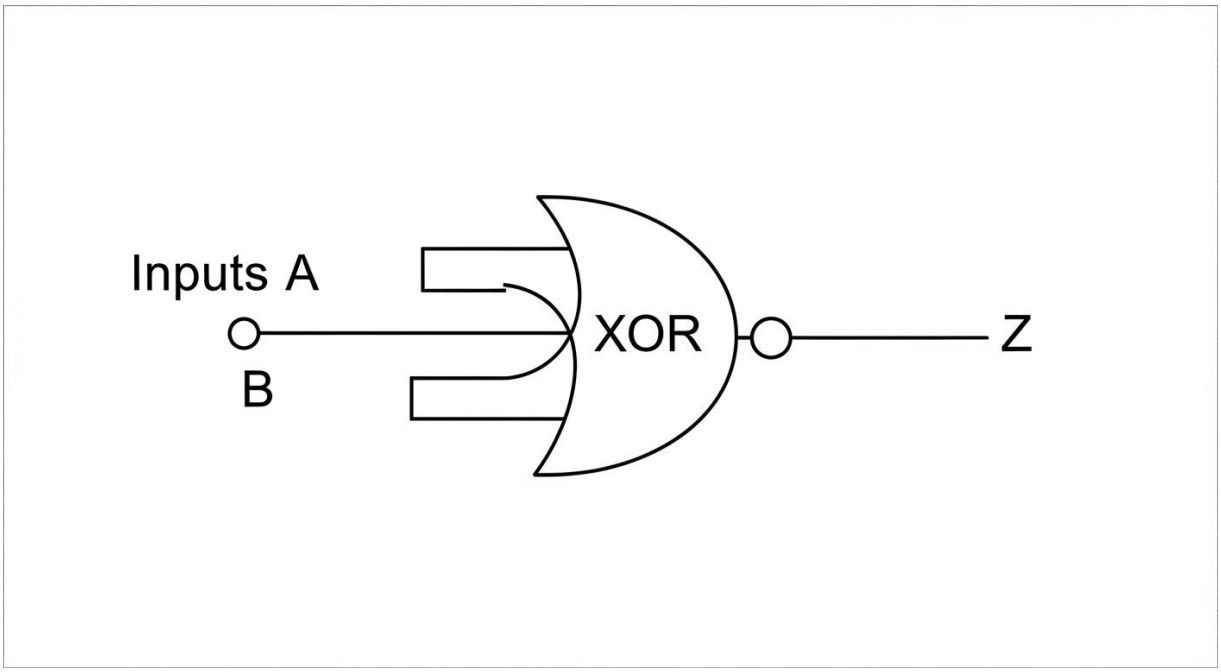
A. One after another in sequence

B. At random asynchronous times

C. Simultaneously by a common clock

D. Only by the master reset signal

101. For the logic circuit shown, what is the output Z when A = 1 and B = 1?



A. 1

B. Undefined

C. High impedance

D. 0

102. The binary instructions that a CPU can execute directly are collectively called:

A. Source code

B. Machine code

C. Pseudocode

D. Assembly mnemonics

103. In a computer, the bus that carries the location of data to be accessed is the:

A. Address bus

B. Data bus

C. Control bus

D. Power bus

104. Cache memory is typically located:

A. On a removable optical disc

B. On the magnetic hard disk drive

C. On or very close to the CPU

D. In the external power supply

105. Compared to a single-core processor at the same clock speed, a quad-core processor can:

A. Address four times as much memory

B. Execute up to four tasks in parallel

C. Run at four times the clock frequency

D. Store four times as much data on disk

106. The process of swapping pages between RAM and disk to support virtual memory is called:

A. Caching

B. Pipelining

C. Multiplexing

D. Paging

107. In Big-O notation, an algorithm that halves the problem size at each step typically has complexity:

A. O(n)

B. $O(n^2)$

C. O(log n)

D. O(1)

108. A "variable" in a program is best described as a:

A. Named storage location holding a value

B. Fixed constant that never changes

C. Block of executable instructions

D. Connection to a remote server

109. In object-oriented programming, a "class" serves as a:

A. Single running instance in memory

B. Temporary value passed to a function

C. Loop that repeats a fixed number of times

D. Blueprint defining objects' structure and behavior

110. The purpose of comments in source code is to:

A. Increase the program's execution speed

B. Explain the code for human readers

C. Allocate additional memory at runtime

D. Encrypt the program against copying

PRACTICE EXAM 15 — ANSWER KEY AND FULL ANSWER EXPLANATIONS

1. A — Differentiating term by term gives 6x + 2; the constant 1 vanishes. The power rule reduces each exponent by one and multiplies by the original power.

2. C — ∫6x dx = 6·(x²/2) + C = 3x² + C. The power rule raises the exponent and divides by the new power.

3. B — The reciprocal 1/j equals −j, found by multiplying numerator and denominator by −j. Since j·(−j) = 1, the inverse of j is −j.

4. D — Writing 1/8 as 2^{-3} shows that 2^x = 2^{-3}, so x = −3. Negative exponents represent reciprocals of positive powers.

5. C — sin(90°) = 1, its maximum value, where the sine curve reaches its peak. This is a standard reference-angle value.

6. A — The derivative of x^(1/2) is (1/2)x^(−1/2) = 1/(2√x). The power rule lowers the exponent to −1/2.

7. B — As x → 0, e^x ≈ 1 + x, so (e^x − 1)/x → x/x = 1. This limit is the derivative of e^x evaluated at zero.

8. D — Multiplying any matrix by the identity matrix leaves it unchanged, just as multiplying a number by one does. The identity is the multiplicative identity for matrices.

9. A — Multiplying 45° by π/180 gives π/4 radians. Degrees convert to radians through this constant factor.

10. C — The region under y = 2 from x = 0 to 3 is a rectangle of area 2 × 3 = 6. The integral of a constant equals the constant times the interval width.

11. B — The first derivative of sin(x) is cos(x), and differentiating again gives −sin(x). Two differentiations return the negative of the original function.

12. D — The vector sum is (3, 4), whose magnitude is √(3^2 + 4^2) = 5. The perpendicular components combine by the Pythagorean theorem.

13. A — A deck has 4 aces out of 52 cards, giving 4/52 = 1/13. Each card is equally likely to be drawn.

14. C — The mean is the sum 100 divided by the count 4, which is 25. For an evenly spaced set the mean equals the midpoint.

15. D — For independent events, P(A and B) = P(A)·P(B) = 0.5 × 0.4 = 0.2. Independence allows the probabilities to be multiplied.

16. B — The complement probability is 1 − 0.85 = 0.15. An event and its complement always sum to one.

17. C — The standard normal distribution has a mean of 0 and a standard deviation of 1. All normal distributions are standardized to this form using z-scores.

18. A — When a project requires expertise the engineer lacks, the NSPE Code calls for engaging or consulting qualified specialists. This keeps every part of the work within competent hands and protects the public.

19. D — Falsifying test results endangers the public and violates the Code's honesty requirement, so the engineer must decline and report the request where required. No fee justifies misrepresenting safety-related data.

20. B — In any conflict of duties, the engineer's paramount obligation is the safety, health, and welfare of the public. This first canon overrides employer and personal interests.

21. C — Public technical opinions must rest on competent knowledge and honest conviction, not employer or client preference. This safeguards the credibility of professional statements.

22. A — Future value is 2,000 × (1 + 0.10) = $2,200. One year of 10% compounding adds 10% to the principal.

23. A — A sunk cost has already been incurred and cannot be recovered, so it should not influence future decisions. Only future cash flows are relevant to an economic choice.

24. B — The capital recovery factor (A/P) converts a present amount into a series of equal annual payments. It is used to compute loan or equipment annual costs.

25. C — Opportunity cost is the value of the best alternative given up when a choice is made. It captures the benefit forgone rather than a direct cash outlay.

26. A — At a 0% interest rate there is no discounting, so present worth equals the future amount. Money neither grows nor loses value over time at zero interest.

27. B — Electrical conductivity is measured in siemens per meter (S/m), the reciprocal of resistivity's ohm-meter. It quantifies how readily a material conducts current.

28. D — Insulators have the largest forbidden energy gap, preventing electrons from reaching the conduction band. This wide gap is what blocks conduction.

29. C — Carrier mobility describes how easily charge carriers move through a semiconductor under an applied electric field. Higher mobility yields higher conductivity for a given carrier density.

30. D — A soft magnetic material has low coercivity and a narrow hysteresis loop, minimizing energy loss per cycle. This makes it efficient for transformer and motor cores driven by alternating fields.

31. D — Power is $V^2/R = 18^2/6 = 324/6 = 54$ W. This form uses the known voltage and resistance directly.

32. B — Two equal capacitors in series give $C/2 = 4/2 = 2$ μF. Series connection reduces the equivalent capacitance.

33. C — By Ohm's law, $I = V/R = 20/10 = 2$ A. Current is voltage divided by resistance.

34. A — Series resistances add: $2 + 2 + 2 = 6$ Ω. The same current flows through each in series.

35. B — Capacitive reactance $X_C = 1/(2\pi fC)$ decreases as frequency rises. A capacitor passes high frequencies more readily.

36. D — The two parallel 6 Ω resistors give 3 Ω, which adds to the 3 Ω series resistor for 6 Ω total, so $I = 18/6 = 3$ A. Parallel branches combine before the series element.

37. A — For superposition, an ideal voltage source is replaced by a short circuit while other sources act. This sets its contribution aside so the remaining sources can be analyzed.

38. C — An ideal resistor has a purely real impedance equal to its resistance, with no imaginary part. It introduces no phase shift between voltage and current.

39. B — The RMS value of a steady DC voltage equals the DC value itself, here 12 V. Without variation, the root-mean-square equals the constant level.

40. B — Two equal resistors in parallel give $R/2 = 100/2 = 50$ Ω. Parallel paths halve the resistance for equal values.

41. A — With a 0° phase angle, the power factor is $\cos(0°) = 1.0$. Voltage and current are in phase, as in a purely resistive load.

42. C — The energy stored in a capacitor is $\frac{1}{2}CV^2$, growing with the square of the voltage. This is the electrostatic energy held in its field.

43. D — At $t = 0^+$, an initially uncharged capacitor has zero voltage across it, so it behaves momentarily as a short circuit. Its voltage then builds up exponentially as it charges.

44. D — The Laplace transform of the unit ramp $t \cdot u(t)$ is $1/s^2$. Each integration in time adds a factor of $1/s$ relative to the step.

45. A — Scaling the input by a constant with no dependence on past or future values makes the system linear and memoryless. It satisfies superposition and responds only to the present input.

46. C — Poles are the values of s that make the denominator of the transfer function zero. They determine the system's natural response and stability.

47. B — A constant signal contains only a DC component, so its Fourier transform is an impulse at zero frequency. There is no energy at any nonzero frequency.

48. D — The difference $\delta[n] - \delta[n-1]$ computes a first difference, which emphasizes rapid changes and attenuates slow ones, acting as a high-pass operation. Differencing is the discrete analog of differentiation.

49. A — The Nyquist frequency is one-half of the sampling frequency. It is the highest frequency that can be represented without aliasing.

50. C — A pole at $s = 0$ corresponds to division by s, which is integration in the time domain. The system accumulates its input over time.

51. B — An ideal differentiator has transfer function s, equivalent to $j\omega$, which adds a constant $+90°$ phase shift. Differentiation advances the phase by a quarter cycle.

52. A — An anti-aliasing filter removes frequency components above the Nyquist limit before the signal is sampled. This prevents those components from folding into the baseband.

53. D — An FIR filter has no feedback, so its impulse response is finite and it is inherently stable. There are no poles outside the origin to cause instability.

54. C — Discrete-time convolution corresponds to multiplication of the z-transforms. This property simplifies the analysis of cascaded systems.

55. B — A system's bandwidth is inversely related to its step-response rise time; wider bandwidth gives a faster rise. Faster systems pass a broader range of frequencies.

56. A — An ideal op-amp has infinite differential (open-loop) voltage gain. This idealization underlies the virtual-short assumption used with feedback.

57. C — A diode's reverse saturation current rises strongly with junction temperature, roughly doubling every 10°C. This thermal sensitivity affects leakage in reverse bias.

58. D — For amplification, a transistor must be biased in the active (linear) region, where output varies proportionally with input. Cutoff and saturation are used for switching, not linear gain.

59. B — A voltage follower has a closed-loop gain of approximately 1, passing the input to the output unchanged. It provides buffering with high input and low output impedance.

60. A — A rectifier converts alternating current into direct current by allowing current in essentially one direction. It is the first stage of most DC power supplies.

61. C — The insulated gate of a MOSFET controls the channel through an electric field and draws negligible DC current. This high-impedance control terminal distinguishes it from a BJT base.

62. D — A series current-limiting resistor restricts the LED current to a safe value, preventing damage from excessive current. LEDs have a steep I-V curve and must not be driven directly.

63. B — Continuous positive humps for every half-cycle, with the negative halves flipped upward, are the signature of a full-wave rectifier. It uses both halves of the AC input.

64. A — Power is $P = V \times I = 480 \times 24 = 11{,}520$ W for a resistive load. Voltage times current gives the real power.

65. D — The turns ratio equals the voltage ratio: 120/24 = 5, or 5:1. The higher-voltage primary has five times the turns of the secondary.

66. C — In a wye connection the line current equals the phase current, since each line connects to one phase winding. Line and phase voltages differ by $\sqrt{3}$, but the currents are equal.

67. A — At synchronous speed the relative motion between rotor and field is zero, so the slip is zero. Real induction motors always run with some slip to develop torque.

68. B — A transformer's main role is to change AC voltage levels between circuits while transferring power. Stepping up or down enables efficient transmission and safe utilization.

69. C — Synchronous speed is 1,800 rpm, and a 5% slip gives a rotor speed of $1{,}800 \times (1 - 0.05) = 1{,}710$ rpm. Slip is the fractional shortfall below synchronous speed.

70. D — Core (iron) losses from hysteresis and eddy currents depend on voltage and frequency, not load, so they stay essentially constant. Copper losses, by contrast, vary with the square of the load current.

71. A — Current is $I = P/(V \cdot pf) = 10{,}000/(250 \times 1) = 40$ A. At unity power factor the real power equals the apparent power.

72. B — Power-factor correction supplies reactive power locally, reducing the current drawn from the supply. Lower current cuts line losses and frees up system capacity.

73. C — The right-hand rule for conventional current gives the circular direction of the magnetic field around a wire. Pointing the thumb along the current curls the fingers in the field's direction.

74. D — Inside a hollow conductor in electrostatic equilibrium the electric field is zero, since charges reside on the outer surface. This shielding is the basis of the Faraday cage.

75. A — Electric-field energy density is $u = \tfrac{1}{2}\varepsilon E^2$, proportional to the square of the field strength. Doubling the field quadruples the stored energy density.

76. C — The wavelength is $\lambda = c/f = (3 \times 10^8)/(150 \times 10^6) = 2$ m, so a half-wave dipole is about 1 m long. The antenna length is half the operating wavelength.

77. B — The transfer function is the Laplace transform of the impulse response, taken with zero initial conditions. It fully describes a linear time-invariant system's input-output behavior.

78. D — A sensor that measures the output and returns a comparison signal lies in the feedback path. Its signal is subtracted from the reference to form the error.

79. C — A larger phase margin indicates a more stable, well-damped response with less tendency to oscillate. It is a measure of how far the system is from instability.

80. A — A pure gain block scales the response amplitude without changing the system's order or pole count. It uniformly multiplies the output.

81. B — The final value theorem gives the steady-state value of a stable system's response from its Laplace transform. It evaluates the limit as s approaches zero of $s \cdot F(s)$.

82. D — An overdamped second-order system ($\zeta > 1$) approaches its final value slowly and without oscillation. Its two real poles produce a sluggish, monotonic response.

83. A — Gain margin and phase margin both quantify a feedback system's relative stability, indicating how much gain or phase change it can tolerate before instability. They are read from the open-loop frequency response.

84. C — Bandwidth efficiency is the data rate achieved per unit of bandwidth, expressed in bits per second per hertz. Higher-order modulation improves it.

85. B — Phase and frequency modulation encode information in timing rather than amplitude, giving greater immunity to amplitude noise than AM. Amplitude disturbances do not corrupt the message.

86. D — By the Shannon-Hartley theorem, channel capacity rises as the signal-to-noise ratio increases. A cleaner channel supports more bits per second.

87. C — Multi-level (M-ary) modulation assigns several bits to each symbol by using more than two states. This raises the data rate within a fixed bandwidth.

88. A — The carrier conveys the message at a frequency suitable for transmission and efficient antenna size. Modulation impresses the message onto this carrier.

89. B — The session layer establishes, manages, and terminates communication sessions between applications. It coordinates the dialogue between endpoints.

90. D — DNS translates human-readable domain names into the numerical IP addresses used for routing. It acts as the naming directory of the internet.

91. C — At the transport layer of the TCP/IP model the data unit is a segment. Lower layers use packets and frames.

92. A — Bandwidth is the maximum data transfer rate a channel can support, measured in bits per second. It reflects capacity, distinct from latency or distance.

93. D — Decimal 5 = 4 + 1 = 101 in binary. Summing the set powers of two confirms the value.

94. B — The Boolean sum A + A simplifies to A, since ORing a value with itself changes nothing. This is the idempotent law.

95. C — An AND gate outputs HIGH only when all of its inputs are HIGH. Any LOW input forces the output LOW.

96. A — An 8-to-1 multiplexer needs 3 select lines, since $2^3 = 8$ inputs. Each select line doubles the number of selectable inputs.

97. D — The decimal value 12 is represented by the hexadecimal digit C. Hex digits A through F stand for 10 through 15.

98. B — A half adder produces the sum and carry of two single bits. It lacks a carry-in, distinguishing it from a full adder.

99. A — A 4-bit unsigned number ranges up to $2^4 - 1 = 15$. The maximum is one less than the total count of values.

100. C — In a synchronous counter all flip-flops receive the same clock and change state simultaneously. This avoids the cumulative delay of ripple counters.

101. D — An XOR gate outputs HIGH only when its inputs differ, so with both inputs at 1 the output Z is 0. Equal inputs always yield a LOW XOR output.

102. B — The binary instructions a CPU executes directly are machine code. Higher-level source code must be translated into this form.

103. A — The address bus carries the location of the data to be accessed. The data bus then transfers the actual data to or from that address.

104. C — Cache memory sits on or very close to the CPU to provide fast access to frequently used data. Its proximity minimizes access delay.

105. B — A quad-core processor can execute up to four tasks in parallel, one per core. Performance gains come from concurrency rather than higher clock speed.

106. D — Paging is the process of swapping fixed-size pages between RAM and disk to implement virtual memory. It lets programs exceed the available physical memory.

107. C — An algorithm that halves the problem at each step has O(log n) complexity, as in binary search. The number of steps grows logarithmically with input size.

108. A — A variable is a named storage location that holds a value which can change during execution. The name lets the program reference and update that value.

109. D — A class is a blueprint that defines the structure and behavior of objects created from it. Objects are concrete instances of the class.

110. B — Comments explain the code for human readers and are ignored by the compiler or interpreter. They aid understanding and maintenance without affecting execution.