PRACTICE EXAM 9: 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 $f(x) = \sin(x)$?

A. $-\cos(x)$

B. $-\sin(x)$

C. $\sin(x)$

D. $\cos(x)$

2. Evaluate $\int (1/x)\,dx$ for $x > 0$.

A. $-1/x^2 + C$

B. $\ln(x) + C$

C. $1 + C$

D. $x \cdot \ln(x) + C$

3. Express the complex number $5\angle 90°$ in rectangular form.

A. $5 + j0$

B. $-5 + j0$

C. 0 + j5

D. 0 − j5

4. In the right triangle shown, what is the measure of angle θ to two decimal places?

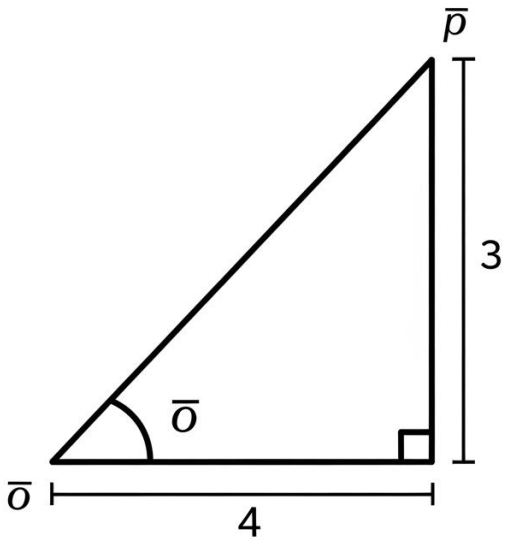


FIGURE PQ-1

A. 36.87°

B. 53.13°

C. 45.00°

D. 30.00°

5. The dot product of two perpendicular nonzero vectors is:

A. Equal to the product of their magnitudes

B. A vector perpendicular to both

C. Undefined for perpendicular vectors

D. Zero

6. Solve for x: $2x + 6 = 14$.

A. 10

B. 2

C. 4

D. 8

7. What is the value of 0! (zero factorial)?

A. 0

B. 1

C. Undefined

D. Infinite

8. Evaluate the derivative $d/dx [x^2 + 3x + 2]$ at $x = 1$.

A. 5

B. 6

C. 2

D. 3

9. The sum of the interior angles of a triangle is:

A. 90°

B. 360°

C. 180°

D. 270°

10. Evaluate $\log_{10}(1000)$.

A. 100

B. 10

C. 1

D. 3

11. If a function f(x) has a local maximum at x = a, then at that point its first derivative f'(a) is:

A. Positive and increasing

B. Equal to zero

C. Negative and decreasing

D. Equal to the function value

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

A. 13

B. 19

C. 7

D. 169

13. The probability of rolling an even number on a fair six-sided die is:

A. 1/6

B. 1/3

C. 2/3

D. 1/2

14. A jar holds 4 red, 3 green, and 5 blue marbles. What is the probability of drawing a green marble?

A. 1/3

B. 5/12

C. 1/4

D. 3/5

15. The mode of the data set 3, 7, 7, 9, 9, 9, 12 is:

A. 9

B. 7

C. 8

D. 12

16. Two events A and B are mutually exclusive. The probability P(A and B) is:

A. $P(A) \times P(B)$

B. 0

C. $P(A) + P(B)$

D. 1

17. The number of ways to choose 3 items from 5 distinct items, where order does not matter, is:

A. 60

B. 15

C. 120

D. 10

18. Under the NSPE Code, an engineer should undertake assignments only when:

A. The compensation offered meets the firm's minimum rate

B. A senior colleague has already reviewed the project scope

C. Qualified by education or experience in the specific field

D. The client has waived all liability for the engineer's work

19. An engineer is pressured by a supervisor to approve substandard work to meet a deadline. Under the NSPE Code, the engineer should:

A. Approve it since the supervisor holds final authority

B. Refuse to approve work that does not meet standards

C. Approve it but request a deadline extension afterward

D. Delegate the approval decision to a junior colleague

20. Under the NSPE Code, when an engineer reuses a design previously prepared for another client, the engineer must:

A. Respect the ownership rights and confidentiality of the original client

B. Charge the new client the same fee as the original client paid

C. Notify the public that the design has been used before

D. Destroy all records of the original client's project files

21. The fundamental purpose of professional engineering licensure (the PE license) is to:

A. Guarantee higher salaries for licensed engineers

B. Restrict competition within the engineering profession

C. Provide marketing credentials for engineering firms

D. Protect the public by ensuring engineer competence

22. A nominal annual interest rate of 12% compounded quarterly gives an effective quarterly rate of:

A. 12%

B. 1%

C. 3%

D. 4%

23. The future worth of $1,000 invested for 2 years at 10% compounded annually is:

A. $1,210

B. $1,200

C. $1,100

D. $1,331

24. In a cash-flow diagram, an arrow pointing downward typically represents a:

A. Cash inflow (receipt) to the investor

B. Cash outflow (disbursement) by the investor

C. Zero net transaction at that period

D. Interest earned on the principal balance

25. Two alternatives with equal benefits are compared. The economically preferred choice is the one with the:

A. Higher initial first cost

B. Longer expected service life

C. Lower equivalent total cost

D. Greater salvage value alone

26. The present worth of a perpetual uniform annual income of $2,000 at an interest rate of 8% is:

A. $16,000

B. $2,160

C. $160,000

D. $25,000

27. The resistivity of a typical conductor such as copper, compared to that of an insulator, is:

A. Many orders of magnitude smaller

B. Approximately equal in magnitude

C. Many orders of magnitude larger

D. Exactly twice as large

28. The energy band gap of a semiconductor at room temperature is:

A. Extremely large, preventing all conduction

B. Small enough to allow some thermal conduction

C. Exactly zero, like that of a metal

D. Negative, indicating overlapping bands

29. The Curie temperature of a ferromagnetic material is the temperature above which it:

A. Becomes a perfect electrical conductor

B. Reaches its maximum magnetic permeability

C. Develops permanent magnetization spontaneously

D. Loses its ferromagnetic properties

30. A photoconductive material changes its electrical conductivity in response to:

A. Applied mechanical pressure

B. Changes in ambient temperature

C. Incident light (illumination)

D. An external magnetic field

31. A 6 V source is connected to a 2 Ω and a 1 Ω resistor in series. What is the voltage across the 2 Ω resistor?

A. 4 V

B. 2 V

C. 6 V

D. 3 V

32. The total capacitance of three 3 µF capacitors connected in parallel is:

A. 1 µF

B. 9 µF

C. 3 µF

D. 27 µF

33. The current through an ideal inductor in DC steady state is limited only by the:

A. Inductance value in henries

B. Frequency of the source

C. Reactance of the inductor

D. Resistance of the circuit

34. A 100 W light bulb operates from a 120 V supply. What is its operating resistance?

A. 1.2 Ω

B. 12 Ω

C. 0.83 Ω

D. 144 Ω

35. In a series RLC circuit operating below the resonant frequency, the circuit behaves as:

A. A net capacitive (current-leading) load

B. A net inductive (current-lagging) load

C. A purely resistive load always

D. An open circuit at all frequencies

36. The peak-to-peak value of a sinusoid with an amplitude (peak) of 10 V is:

A. 10 V

B. 7.07 V

C. 14.14 V

D. 20 V

37. Mesh analysis is based on the application of:

A. Kirchhoff's current law at each node

B. Kirchhoff's voltage law around each loop

C. The superposition of independent sources

D. Thévenin equivalents at each branch

38. The admittance of a circuit element is the reciprocal of its:

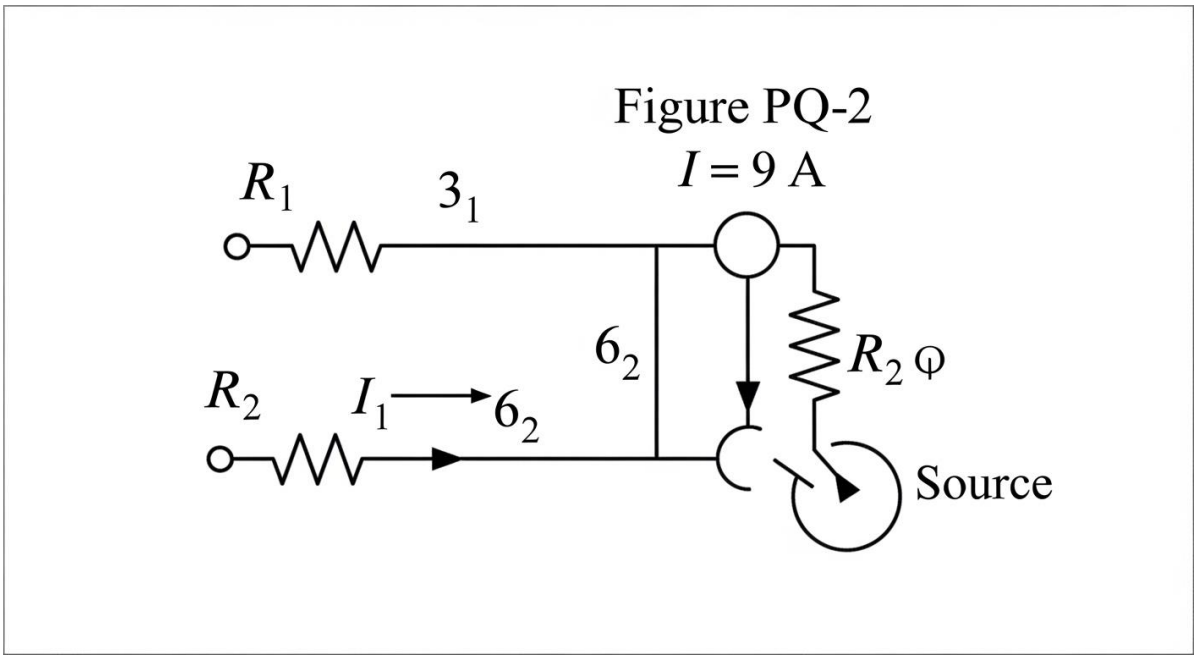
A. Capacitance

B. Inductance

C. Impedance

D. Resistance only

39. In the circuit shown, use the current-divider rule to find the current I_2 through the 6 Ω resistor.



A. 3 A

B. 6 A

C. 4.5 A

D. 1.5 A

40. The voltage across a 0.5 H inductor is 10 V. The rate of change of current through it is:

A. 5 A/s

B. 20 A/s

C. 0.05 A/s

D. 10 A/s

41. The power factor of a circuit is defined as the cosine of the:

A. Ratio of reactance to resistance

B. Resonant frequency phase shift

C. Angle between current and ground

D. Phase angle between voltage and current

42. A short circuit placed across a resistor causes the resistor's:

A. Power dissipation to increase sharply

B. Voltage to rise to the source value

C. Voltage drop to fall to zero

D. Resistance to double instantly

43. In a circuit, the equivalent resistance of two equal resistors R in parallel is:

A. 2R

B. R/2

C. R

D. R^2

44. The Laplace transform of the cosine function $\cos(\omega t)\cdot u(t)$ is:

A. $s/(s^2 + \omega^2)$

B. $\omega/(s^2 + \omega^2)$

C. $1/(s + \omega)$

D. $s/(s^2 - \omega^2)$

45. A system is time-invariant if a time shift in the input produces:

A. A scaled version of the output

B. A frequency shift in the output

C. An identical shift in the output

D. No change in the output at all

46. The poles of a stable, causal discrete-time system in the z-plane must lie:

A. Outside the unit circle

B. On the unit circle exactly

C. Inside the unit circle

D. Along the real axis only

47. A signal sampled at 20 kHz contains a 12 kHz component. After sampling, this component will:

A. Alias to an apparent frequency of 8 kHz

B. Appear correctly at 12 kHz

C. Be completely removed by the sampler

D. Double to an apparent 24 kHz

48. The convolution of any signal x(t) with a unit impulse $\delta(t)$ yields:

A. The derivative of x(t)

B. The original signal x(t) unchanged

C. A constant equal to the area of x(t)

D. The time-reversed signal $x(-t)$

49. The Fourier series can be used to represent any signal that is:

A. Aperiodic and of finite energy

B. Random with zero mean value

C. Periodic and satisfies the Dirichlet conditions

D. Causal and absolutely integrable

50. A digital filter described entirely by $y[n] = (x[n] + x[n-1])/2$ is an example of a:

A. Finite impulse response (FIR) filter

B. Infinite impulse response (IIR) filter

C. Nonlinear filter with memory

D. Time-varying recursive filter

51. The group delay of a filter is defined as the negative derivative of its:

A. Magnitude response with respect to frequency

B. Phase response with respect to frequency

C. Impulse response with respect to time

D. Step response with respect to amplitude

52. Multiplying two signals in the time domain corresponds, in the frequency domain, to:

A. Addition of their spectra

B. Multiplication of their spectra

C. Subtraction of their spectra

D. Convolution of their spectra

53. The unit impulse $\delta(t)$ can be viewed as the derivative of the:

A. Ramp function

B. Sinusoidal function

C. Unit step function

D. Exponential function

54. A causal LTI system has a transfer function with more poles than zeros. Such a system is described as:

A. Strictly proper

B. Improper

C. Marginally stable

D. All-pass

55. To prevent aliasing, an anti-aliasing filter is placed:

A. After the quantizer in the converter

B. Inside the digital signal processor

C. After the sample-and-hold circuit

D. Before the sampler at the input

56. The open-loop gain of a practical operational amplifier is typically:

A. Less than unity at all frequencies

B. Very high (tens of thousands or more) at DC

C. Exactly equal to one at DC

D. Negative across the entire spectrum

57. In an ideal op-amp circuit, the two input terminals draw no current and sit at nearly equal voltage. These two assumptions are known as the:

A. Virtual short and infinite input impedance

B. Slew-rate and bandwidth limitations

C. Common-mode and differential gains

D. Offset voltage and bias current effects

58. In a common-source MOSFET amplifier, the output signal is:

A. In phase with the gate input signal

B. Phase shifted by exactly 90 degrees

C. Inverted (180 degrees) from the input

D. Equal in amplitude to the input

59. A diode connected in series with a load to allow current in only one direction performs the function of:

A. Voltage amplification of the signal

B. Frequency multiplication of the input

C. Impedance matching to the load

D. Rectification of the AC waveform

60. The quiescent (Q) operating point of a transistor amplifier is set by its:

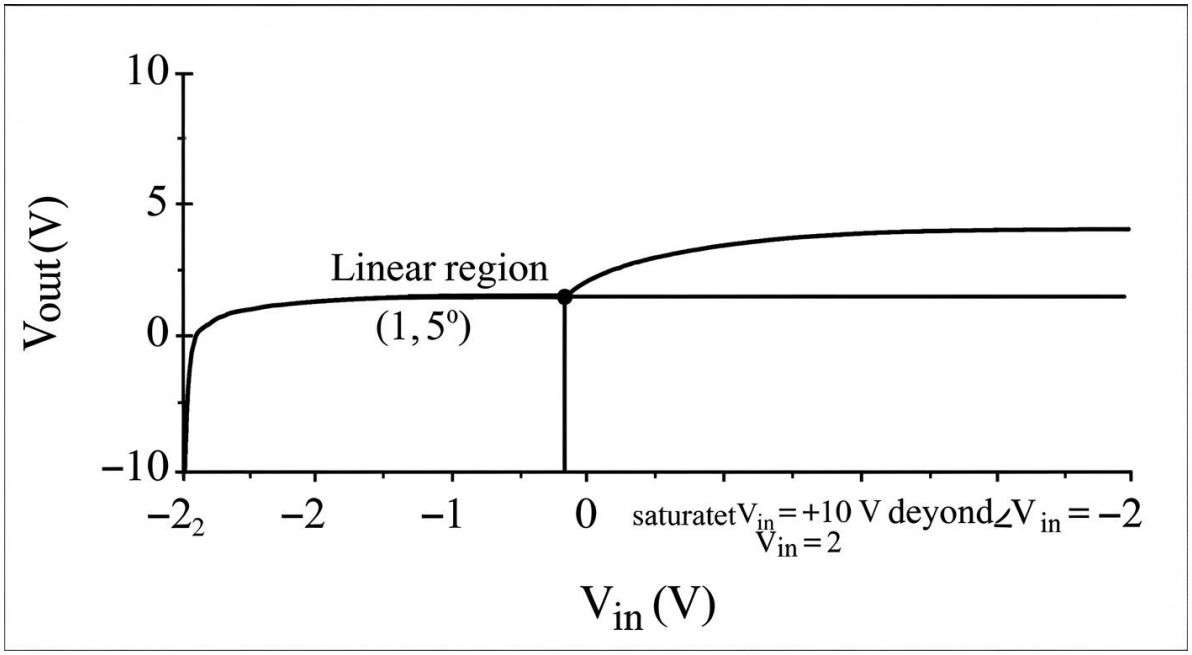
A. Input signal amplitude alone

B. DC bias conditions with no signal applied

C. Output load resistance only

D. Operating frequency of the signal

61. The figure shows the input-output transfer characteristic of an amplifier. What is its voltage gain in the linear region?



A. 5

B. 10

C. 0.2

D. 2

62. A bypass capacitor placed across an amplifier's emitter resistor is used to:

A. Set the DC bias point of the stage

B. Provide protection against overvoltage

C. Increase the AC gain of the stage

D. Filter the DC power supply ripple

63. A Schottky diode is preferred over a standard silicon diode in high-speed switching because it has:

A. A much higher reverse breakdown voltage

B. A larger forward voltage drop

C. Greater current-handling capacity

D. A lower forward voltage and faster recovery

64. A purely resistive 240 V circuit draws 5 A. What is the apparent power?

A. 48 VA

B. 1200 VA

C. 1200 W only

D. 600 VA

65. The efficiency of a transformer is highest when:

A. Copper losses equal the iron (core) losses

B. The load is disconnected entirely

C. The secondary is short-circuited

D. The primary voltage is doubled

66. A three-phase induction motor's rotor rotates:

A. Faster than the stator's synchronous speed

B. At exactly the synchronous speed always

C. Slightly slower than the synchronous speed

D. In the opposite direction to the field

67. The primary winding of a transformer is the winding that is:

A. Always wound with thicker gauge wire

B. Connected to the input power source

C. Connected directly to the load

D. Located on the transformer's outer core leg

68. A 50 Hz, 8-pole synchronous motor runs at a synchronous speed of:

A. 3000 rpm

B. 1500 rpm

C. 1000 rpm

D. 750 rpm

69. The function of a motor's starter circuit is primarily to:

A. Improve the running power factor of the motor

B. Reverse the direction of rotation on command

C. Limit the high inrush current at startup

D. Regulate the output torque under full load

70. In a long-distance power transmission system, high voltage is used primarily to:

A. Reduce line current and resistive (I^2R) losses

B. Increase the current carried by the line

C. Lower the insulation requirements on towers

D. Eliminate the need for transformers entirely

71. A load of (8 + j6) Ω is connected to a 100 V RMS source. What is the magnitude of the current?

A. 12.5 A

B. 10 A

C. 8 A

D. 16.7 A

72. A synchronous generator's output frequency is determined by its:

A. Field excitation current magnitude

B. Output load impedance value

C. Terminal voltage at the windings

D. Rotor speed and number of poles

73. The magnetic field inside a long ideal solenoid is:

A. Uniform and directed along the solenoid's axis

B. Zero everywhere within the coil interior

C. Strongest near the inner wall of the coil

D. Directed radially outward from the center

74. Two point charges of the same sign placed near each other will experience a force that is:

A. Attractive, pulling them together

B. Zero, since like charges do not interact

C. Repulsive, pushing them apart

D. Perpendicular to the line joining them

75. The displacement current term added by Maxwell to Ampère's law accounts for:

A. The drift of free electrons in a conductor

B. A changing electric field acting as a current

C. The leakage of charge through an insulator

D. The motion of magnetic monopoles in space

76. The standing-wave ratio (SWR) on a perfectly matched transmission line is:

A. 1

B. 0

C. Infinite

D. 0.5

77. A system's transfer function is the ratio of the Laplace transform of the output to that of the input, assuming:

A. The input is a unit step function

B. The system is operating at resonance

C. The feedback path gain is unity

D. All initial conditions are zero

78. A pole located exactly on the imaginary axis of the s-plane (with no others in the right half) corresponds to a system that is:

A. Asymptotically stable

B. Unstable with growing output

C. Marginally stable with sustained oscillation

D. Overdamped and slow to respond

79. The steady-state error of a Type 0 unity-feedback system to a step input is:

A. Always exactly zero

B. A finite nonzero value

C. Infinite and unbounded

D. Negative and growing

80. Adding a pole closer to the imaginary axis in the s-plane generally makes a system's response:

A. Faster and better damped

B. Slower and more sluggish

C. Completely unaffected

D. Instantly unstable

81. The damped natural frequency ω_d of an underdamped second-order system relates to ω_n and ζ by:

A. $\omega_d = \omega_n(1 + \zeta)$

B. $\omega_d = \omega_n \cdot \zeta$

C. $\omega_d = \omega_n \cdot \sqrt{(1 - \zeta^2)}$

D. $\omega_d = \omega_n / \zeta$

82. A derivative (D) control action responds to the:

A. Accumulated error over past time

B. Magnitude of the present error only

C. Square of the instantaneous error

D. Rate of change of the error signal

83. The characteristic equation of a feedback control system is obtained by setting:

A. $1 + G(s)H(s) = 0$

B. $G(s)H(s) = 1$

C. $G(s) - H(s) = 0$

D. $G(s) + H(s) = 1$

84. In digital modulation, the constellation diagram displays the:

A. Time-domain waveform of each symbol

B. Amplitude and phase of each symbol as points

C. Frequency spectrum of the carrier signal

D. Bit error rate versus signal-to-noise ratio

85. The Nyquist criterion for zero intersymbol interference specifies a condition on the:

A. Carrier frequency stability of the transmitter

B. Total transmit power of the signal

C. Antenna gain of the receiving station

D. Pulse shape and symbol timing

86. Compared to analog communication, a key advantage of digital communication is its:

A. Lower required transmission bandwidth always

B. Simpler transmitter and receiver hardware

C. Ability to regenerate signals and resist noise accumulation

D. Continuous, infinitely fine amplitude resolution

87. The process of recovering the original message signal from a modulated carrier at the receiver is called:

A. Demodulation (detection)

B. Multiplexing of channels

C. Quantization of samples

D. Channel encoding

88. In spread-spectrum communication, the transmitted signal occupies a bandwidth that is:

A. Much narrower than the message bandwidth

B. Much wider than the message bandwidth

C. Exactly equal to the message bandwidth

D. Independent of the message bandwidth

89. In the TCP/IP model, the application-layer protocol used for sending email between mail servers is:

A. HTTP

B. FTP

C. SMTP

D. ARP

90. A device that forwards data packets between two or more different networks based on IP addresses is a:

A. Hub

B. Repeater

C. Bridge

D. Router

91. The loopback IP address used by a host to refer to itself is:

A. 127.0.0.1

B. 192.168.0.1

C. 255.255.255.255

D. 0.0.0.0

92. The unit of data handled at the data link layer of the OSI model is commonly called a:

A. Packet

B. Frame

C. Segment

D. Datagram

93. Convert the hexadecimal number 1A to decimal.

A. 110

B. 16

C. 20

D. 26

94. The Boolean expression A · A' (A AND NOT A) always equals:

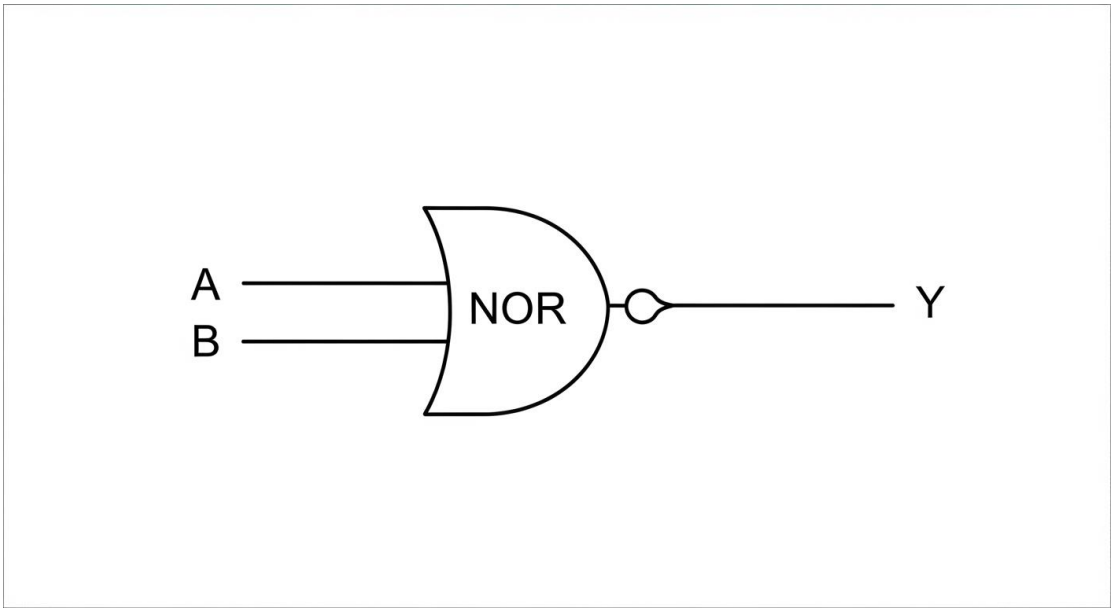
A. A

B. 1

C. 0

D. A'

95. The logic gate shown in the figure produces a HIGH output for which single input combination?



A. A = 0, B = 0

B. A = 1, B = 0

C. A = 0, B = 1

D. A = 1, B = 1

96. A full adder has how many inputs in total?

A. 1

B. 5

C. 2

D. 3

97. The number of distinct outputs produced by a 3-to-8 decoder is:

A. 3

B. 4

C. 8

D. 16

98. A shift register is a digital circuit used primarily to:

A. Perform arithmetic addition of two numbers

B. Store and move binary data bit by bit

C. Generate a fixed reference clock signal

D. Convert analog signals to digital form

99. In positive logic, a logic "1" is represented by the:

A. Higher of the two voltage levels

B. Lower of the two voltage levels

C. Absence of any applied voltage

D. Negative supply rail voltage only

100. The minimum number of bits required to represent the decimal number 100 in binary is:

A. 5

B. 6

C. 7

D. 8

101. A tri-state buffer differs from an ordinary buffer in that it can also output a:

A. Logic level halfway between 0 and 1

B. High-impedance (disconnected) state

C. Negative voltage on the output

D. Sustained oscillating signal

102. The fetch-decode-execute cycle is the basic operating sequence of the:

A. Hard disk drive controller

B. Random access memory module

C. Display graphics processor

D. Central processing unit (CPU)

103. Compared to main memory (RAM), a CPU register is:

A. Smaller in capacity but much faster to access

B. Larger in capacity but slower to access

C. Non-volatile and used for permanent storage

D. Located on the hard disk drive platter

104. In a memory hierarchy, moving from registers toward disk storage, the capacity generally:

A. Decreases while access speed increases

B. Stays constant at every level

C. Increases while access speed decreases

D. Increases along with the access speed

105. The system bus of a computer typically consists of three groups of lines: the:

A. Cache, register, and accumulator buses

B. Input, output, and processing buses

C. Serial, parallel, and optical buses

D. Address, data, and control buses

106. A multi-core processor improves performance primarily by:

A. Increasing the clock frequency of a single core

B. Executing multiple threads in parallel

C. Eliminating the need for cache memory

D. Reducing the instruction word length

107. In Big-O notation, the worst-case time complexity of the bubble sort algorithm is:

A. O(n log n)

B. $O(n^2)$

C. O(n)

D. O(log n)

108. A "queue" data structure follows which ordering principle?

A. Last-in, first-out (LIFO)

B. Random access by index

C. First-in, first-out (FIFO)

D. Highest-priority-first removal

109. In programming, a variable's "scope" refers to:

A. The data type the variable can hold

B. The total memory size it occupies

C. The initial value assigned to it

D. The region of code where it is accessible

110. The software development phase in which the system is checked against its requirements before release is called:

A. Testing and validation

B. Requirements gathering

C. Initial design specification

D. Source code compilation

PRACTICE EXAM 9 – ANSWER KEY AND FULL ANSWER EXPLANATIONS

1. D — The derivative of sin(x) is cos(x), a fundamental trigonometric result. The cosine gives the slope of the sine curve at every point, peaking where sine crosses zero.

2. B — The integral of 1/x for positive x is ln(x) + C, the defining antiderivative of the natural logarithm. This is the one power-rule exception, since dividing by zero exponent is undefined.

3. C — A magnitude of 5 at 90° lies entirely on the imaginary axis, giving 0 + j5. The angle of 90° means there is no real component.

4. A — With the side opposite θ equal to 3 and the adjacent side 4, tan θ = 3/4, so θ = arctan(0.75) ≈ 36.87°. This is the smaller acute angle of the 3-4-5 right triangle.

5. D — The dot product equals |A||B|cos θ, and for perpendicular vectors θ = 90°, so cos θ = 0 and the product is zero. A zero dot product is the test for orthogonality.

6. C — Subtracting 6 gives 2x = 8, so x = 4. Isolating the variable solves the linear equation directly.

7. B — Zero factorial is defined as 1, a convention that keeps combinatorial formulas consistent. It ensures expressions like C(n, n) evaluate correctly.

8. A — The derivative is 2x + 3, and at x = 1 this equals 2 + 3 = 5. Evaluating the derivative gives the instantaneous slope at that point.

9. C — The interior angles of any triangle sum to 180°, a basic theorem of Euclidean geometry. This holds regardless of the triangle's shape or size.

10. D — Since $10^3 = 1000$, $\log_{10}(1000) = 3$. The base-10 logarithm returns the exponent that produces the argument.

11. B — At a local maximum the tangent is horizontal, so the first derivative equals zero. This stationary-point condition is the basis for optimization.

12. A — The magnitude is $\sqrt{(3^2 + 4^2 + 12^2)} = \sqrt{169} = 13$. The three-dimensional length is the square root of the sum of squared components.

13. D — Three of the six faces (2, 4, 6) are even, giving 3/6 = 1/2. Even and odd outcomes are equally likely on a fair die.

14. C — There are 3 green marbles out of 12 total, so the probability is 3/12 = 1/4. Each marble is equally likely to be drawn.

15. A — The mode is the most frequently occurring value, and 9 appears three times, more than any other. It identifies the peak of the data's frequency.

16. B — Mutually exclusive events cannot occur together, so P(A and B) = 0. Their joint occurrence is impossible by definition.

17. D — The number of combinations is $C(5, 3) = 5!/(3!\cdot 2!) = 10$. Order does not matter, so this is a combination rather than a permutation.

18. C — The NSPE Code requires engineers to accept assignments only when qualified by education or experience in the relevant field. This competence rule protects the public from unqualified work.

19. B — An engineer must refuse to approve work that fails to meet accepted standards, regardless of schedule pressure. The duty to the public's safety outweighs a supervisor's deadline.

20. A — Reusing a prior design requires respecting the original client's ownership rights and confidentiality. Designs prepared for one client are not freely transferable to another.

21. D — Professional licensure exists to protect the public by verifying that licensed engineers meet competence and ethical standards. It is a safeguard, not a marketing or salary mechanism.

22. C — The effective periodic rate is the nominal rate divided by the number of periods: 12%/4 = 3% per quarter. Compounding frequency sets the per-period rate.

23. A — Future worth is $1{,}000 \times (1.10)^2 = 1{,}000 \times 1.21 = \$1{,}210$. Compound interest applies the growth factor each year.

24. B — By the standard sign convention, a downward arrow on a cash-flow diagram denotes a cash outflow or disbursement. Upward arrows represent receipts.

25. C — When benefits are equal, the alternative with the lowest equivalent total cost is preferred. Cost becomes the sole deciding factor.

26. D — Present worth of a perpetuity is A/i = 2,000/0.08 = $25,000. This is the principal whose interest alone funds the income forever.

27. A — A conductor's resistivity is many orders of magnitude smaller than an insulator's, which is why it carries current readily. This vast difference defines the two material classes.

28. B — A semiconductor's band gap is small enough that thermal energy promotes some electrons into the conduction band at room temperature. This intermediate gap distinguishes it from insulators and conductors.

29. D — Above the Curie temperature, thermal agitation destroys the aligned magnetic domains and the material loses its ferromagnetism. It then behaves paramagnetically.

30. C — A photoconductor's conductivity rises when illuminated, as incident photons generate additional charge carriers. This effect underlies light sensors and photodetectors.

31. A — Series current is I = 6/(2 + 1) = 2 A, so the 2 Ω resistor drops V = 2 × 2 = 4 V. The larger series resistor takes the larger voltage share.

32. B — Capacitors in parallel add: 3 + 3 + 3 = 9 μF. Parallel connection effectively increases the total plate area.

33. D — In DC steady state an ideal inductor behaves as a short circuit, so the current is limited only by the circuit resistance. The inductor's reactance is zero at zero frequency.

34. D — Operating resistance is R = V^2/P = $120^2/100$ = 144 Ω. This relates the bulb's rated power and supply voltage.

35. A — Below resonance the capacitive reactance dominates the inductive reactance, so the circuit appears capacitive and the current leads the voltage. The reactances are equal only at resonance.

36. D — Peak-to-peak value is twice the amplitude: 2 × 10 = 20 V. It spans the full swing from positive to negative peak.

37. B — Mesh analysis applies Kirchhoff's voltage law around each independent loop. Solving the resulting loop equations yields the mesh currents.

38. C — Admittance is the reciprocal of impedance, Y = 1/Z, measured in siemens. It expresses how readily an element passes AC current.

39. A — By the current divider, the current splits inversely with resistance, so $I_2 = I \times R_1/(R_1 + R_2) = 9 \times 3/9 = 3$ A. The smaller resistor carries the larger share, leaving 3 A in the 6 Ω branch.

40. B — The rate of change of current is di/dt = V/L = 10/0.5 = 20 A/s. The inductor's voltage is proportional to how fast its current changes.

41. D — Power factor is the cosine of the phase angle between the voltage and current. It indicates the fraction of apparent power that is real power.

42. C — A short circuit across a resistor provides a zero-resistance path, forcing the voltage across the resistor to zero. Current diverts through the short instead of the resistor.

43. B — Two equal resistors in parallel give R/2, since the equivalent is the product over the sum. Parallel paths halve the resistance for equal values.

44. A — The Laplace transform of $\cos(\omega t)\cdot u(t)$ is $s/(s^2 + \omega^2)$. The s in the numerator distinguishes the cosine transform from the sine transform.

45. C — Time-invariance means a delay in the input causes an identical delay in the output, with the shape unchanged. The system's behavior does not depend on absolute time.

46. C — A causal, stable discrete-time system requires all poles inside the unit circle of the z-plane. Poles on or outside the circle would make the response non-decaying or growing.

47. A — The Nyquist frequency is 10 kHz, so the 12 kHz component aliases to 20 − 12 = 8 kHz. Frequencies above half the sample rate fold back into the baseband.

48. B — Convolving any signal with the unit impulse returns the original signal unchanged, the sifting property of δ(t). The impulse acts as the identity element for convolution.

49. C — The Fourier series represents periodic signals that satisfy the Dirichlet conditions for convergence. Periodicity is required because the series is built from harmonically related sinusoids.

50. A — The output depends only on present and past inputs with no feedback, making this a finite impulse response filter. Averaging two input samples is a simple FIR low-pass operation.

51. B — Group delay is the negative derivative of the phase response with respect to frequency. It measures the time delay imparted to the signal's envelope.

52. D — Multiplication in the time domain corresponds to convolution of the spectra in the frequency domain. This duality is central to modulation analysis.

53. C — The unit impulse is the time derivative of the unit step, since the step's instantaneous jump produces an impulse. Equivalently, integrating the impulse yields the step.

54. A — Having more poles than zeros makes the transfer function strictly proper, which guarantees the response rolls off at high frequency. This is typical of physically realizable systems.

55. D — The anti-aliasing filter must precede the sampler to remove frequencies above the Nyquist limit before sampling occurs. Filtering after sampling cannot undo aliasing that has already happened.

56. B — A practical op-amp has a very high open-loop gain at DC, often tens of thousands or more. This large gain is what makes negative-feedback configurations accurate.

57. A — The ideal op-amp model assumes a virtual short (equal input voltages) and infinite input impedance (no input current). These two assumptions drive standard op-amp circuit analysis.

58. C — The common-source MOSFET amplifier inverts the signal, producing a 180° phase shift between gate and drain. It is the MOSFET analog of the common-emitter stage.

59. D — A series diode conducts in only one direction, converting alternating current into unidirectional current—rectification. This is the basis of every power-supply rectifier.

60. B — The quiescent operating point is established by the DC bias network with no input signal present. Proper biasing keeps the device in its active region for undistorted amplification.

61. A — In the linear region the slope is $\Delta V_{out}/\Delta V_{in} = 5/1 = 5$, read from the marked point. The flat regions beyond ±2 V represent output saturation.

62. C — An emitter bypass capacitor shorts the emitter resistor at signal frequencies, raising the stage's AC gain while leaving the DC bias intact. It provides a low-impedance path for the AC signal.

63. D — A Schottky diode has a low forward voltage drop and very fast reverse recovery, making it ideal for high-speed switching. Its metal-semiconductor junction stores little charge.

64. B — Apparent power is $S = V \times I = 240 \times 5 = 1{,}200$ VA. Apparent power is always expressed in volt-amperes regardless of the load type.

65. A — Transformer efficiency peaks when the variable copper losses equal the fixed iron (core) losses. This balance condition sets the load at which efficiency is maximum.

66. C — An induction motor's rotor runs slightly slower than synchronous speed, the difference being the slip. Some slip is required to induce rotor current and produce torque.

67. B — The primary winding is the one connected to the input power source, while the secondary feeds the load. This defines the direction of energy flow through the transformer.

68. D — Synchronous speed is $120f/P = 120 \times 50/8 = 750$ rpm. More poles produce a lower synchronous speed for a given frequency.

69. C — A motor starter limits the large inrush current that occurs when an idle motor first energizes. This protects the windings and reduces voltage dips on the supply.

70. A — Transmitting at high voltage lowers the line current for a given power, sharply reducing resistive I^2R losses. This is why long transmission lines operate at hundreds of kilovolts.

71. B — The impedance magnitude is $\sqrt{(8^2 + 6^2)} = 10\ \Omega$, so the current is $100/10 = 10$ A. The resistance and reactance combine as perpendicular components.

72. D — A synchronous generator's frequency is set by $f = P \cdot n/120$, depending on rotor speed and pole count. Field current controls voltage, not frequency.

73. A — The field inside a long ideal solenoid is uniform and aligned with the coil's axis. The contributions of the turns reinforce along the axis and cancel elsewhere.

74. C — Like charges repel, so two same-sign charges push each other apart along the line joining them. Coulomb's law gives a repulsive force for charges of identical sign.

75. B — Maxwell's displacement current represents a time-varying electric field acting as a source of magnetic field, just like a real current. It completes Ampère's law and predicts electromagnetic waves.

76. A — On a perfectly matched line there are no reflections, so the standing-wave ratio is 1. A higher SWR indicates an impedance mismatch and reflected power.

77. D — The transfer function is defined as the output-to-input Laplace ratio with all initial conditions set to zero. This isolates the system's intrinsic input-output behavior.

78. C — A pole on the imaginary axis (with none in the right half) produces sustained, undamped oscillation, the definition of marginal stability. The response neither grows nor decays.

79. B — A Type 0 system has a finite position error constant, leaving a nonzero steady-state error to a step input. Adding an integrator (Type 1) would eliminate it.

80. B — A pole nearer the imaginary axis has a smaller magnitude time constant's reciprocal, so it dominates with a slow decay. This dominant pole makes the overall response more sluggish.

81. C — The damped natural frequency is $\omega_d = \omega_n \cdot \sqrt{(1 - \zeta^2)}$, which is lower than ω_n for any damping. Increasing damping reduces the oscillation frequency.

82. D — Derivative control acts on the rate of change of the error, anticipating future error and adding damping. It improves transient response but does not affect steady-state error.

83. A — The characteristic equation is found by setting $1 + G(s)H(s) = 0$, whose roots are the closed-loop poles. Their locations determine system stability and dynamics.

84. B — A constellation diagram plots each modulation symbol as a point whose coordinates represent its amplitude and phase. The spacing of points relates directly to noise immunity.

85. D — The Nyquist ISI criterion places conditions on the pulse shape and symbol timing so that pulses do not interfere at sampling instants. Proper shaping ensures zero interference between symbols.

86. C — Digital communication can regenerate clean signals at repeaters, preventing noise from accumulating over distance. This resilience is a primary advantage over analog transmission.

87. A — Demodulation, or detection, recovers the original message from the modulated carrier at the receiver. It reverses the modulation performed at the transmitter.

88. B — Spread-spectrum systems deliberately occupy a bandwidth far wider than the message requires, improving resistance to interference and interception. The spreading code distributes the energy across the band.

89. C — SMTP is the application-layer protocol used to transfer email between mail servers. It handles the sending and relaying of messages.

90. D — A router forwards packets between different networks based on their destination IP addresses. It operates at the network layer to choose paths.

91. A — The loopback address 127.0.0.1 lets a host send traffic to itself for testing. It never leaves the local machine.

92. B — The data link layer encapsulates data into frames, which include addressing and error-checking fields. Packets and segments belong to higher layers.

93. D — Hexadecimal 1A equals $1 \times 16 + 10 = 26$ in decimal. The digit A represents 10 in the units place.

94. C — The Boolean product $A \cdot A'$ is always 0, since a variable and its complement cannot both be true. This is the complement law of Boolean algebra.

95. A — A NOR gate outputs HIGH only when both inputs are 0, since it inverts the OR result. Any HIGH input forces the output LOW.

96. D — A full adder has three inputs: the two operand bits and a carry-in. This distinguishes it from a half adder, which has only two.

97. C — A 3-to-8 decoder produces $2^3 = 8$ distinct outputs, activating one line per input code. Each output corresponds to a unique input combination.

98. B — A shift register stores binary data and moves it bit by bit on each clock pulse. It is used for serial data transfer and temporary storage.

99. A — In positive logic, logic 1 is assigned to the higher voltage level and logic 0 to the lower. This is the standard convention in most digital systems.

100. C — Since $2^6 = 64$ is too small and $2^7 = 128$ exceeds 100, seven bits are required. The minimum bit count is the smallest n with 2^n greater than the value.

101. B — A tri-state buffer adds a high-impedance state that electrically disconnects its output from the bus. This lets multiple devices share a common bus without conflict.

102. D — The fetch-decode-execute cycle is the fundamental operating sequence of the CPU. It repeatedly retrieves, interprets, and carries out instructions.

103. A — A CPU register holds very little data but is the fastest storage available, residing inside the processor. Its speed is why active operands are kept there.

104. C — Moving down the memory hierarchy toward disk, capacity increases while access speed decreases. This trade-off balances cost, size, and performance.

105. D — A system bus comprises address, data, and control lines that together coordinate transfers between components. Each group carries a distinct type of information.

106. B — A multi-core processor runs multiple threads in parallel across its cores, increasing throughput. Performance gains come from concurrency rather than higher clock speed.

107. B — Bubble sort has a worst-case time complexity of $O(n^2)$ because of its nested comparison passes. Its quadratic growth makes it inefficient for large data sets.

108. C — A queue follows first-in, first-out ordering, removing elements in the order they were added. This models waiting lines and buffering.

109. D — A variable's scope is the region of code in which it is defined and accessible. Scope rules prevent unintended access from outside that region.

110. A — Validation testing checks the completed system against its requirements before release. It confirms the software does what the specification intended.