OJEE M Tech Electronics Sample Paper 02

A) Mode and Time: The exam is a Computer Based Test (CBT) lasting 120 minutes.
B) Total Questions: The exam contains 90 questions.
C) Marking Scheme & Rules:

- +4 for correct answers and -1 for incorrect responses.

Q1. At 300 K, the bandgap energy of Silicon is approximately:

A. 0.66 eV

B. 0.72 eV

C. 1.12 eV

D. 1.43 eV

Q2. The Hall effect is primarily used to determine the:

A. Carrier concentration and carrier type

B. Mobility of carriers only

C. Conductivity of the material only

D. Carrier lifetime

Q3. For a BJT to operate in the forward active region, the junctions must be biased as:

A. EB forward, CB forward

B. EB forward, CB reverse

C. EB reverse, CB forward

D. EB reverse, CB reverse

Q4. In an n-channel JFET, the pinch-off voltage (V_p) is -4V. If $V_{GS} = -1$V, the device operates in:

A. Ohmic region for small V_{DS}

B. Cut-off region

C. Breakdown region

D. Depletion region only

Q5. The Miller effect in an amplifier circuit leads to an increase in:

A. Input resistance

B. Output resistance

C. Equivalent input capacitance

D. Voltage gain

Q6. A diode ring modulator is primarily used to generate:

A. Standard AM signal

B. SSB-SC signal

C. DSB-SC signal

D. VSB signal

Q7. The common-mode rejection ratio (CMRR) of an ideal operational amplifier is:

A. Zero

B. Unity

C. Infinite

D. Depends on the feedback

Q8. Which oscillator is most suitable for generating radio frequency (RF) signals?

A. Wein bridge oscillator

B. Phase-shift oscillator

C. Colpitts oscillator

D. 555 Astable multivibrator

Q9. In a Class B push-pull amplifier, cross-over distortion occurs due to:

A. High input impedance

B. Low power supply

C. The 0.7V cut-in voltage of transistors

D. Transformer core saturation

Q10. The Boolean function $F(A, B, C) = \sum m(0, 2, 4, 6)$ simplifies to:

A. $\overline{A}$

B. $\overline{B}$

C. $\overline{C}$

D. $A\overline{C}$

Q11. Which logic family has the lowest propagation delay?

A. TTL

B. CMOS

C. ECL

D. I^2L

Q12. A 4-to-16 line decoder can be constructed using how many 3-to-8 line decoders (with enable inputs)?

A. 2

B. 3

C. 4

D. 8

Q13. In a synchronous sequential circuit, the maximum clock frequency is limited by:

A. Setup time only

B. Hold time only

C. Propagation delay and setup time

D. Pulse width only

Q14. The number of unused states in a 4-bit Johnson counter is:

A. 2

B. 4

C. 8

D. 12

Q15. In the 8085 microprocessor, the register used as the default accumulator for arithmetic operations is:

A. Register B

B. Register C

C. Register A

D. Register H

Q16. The Fourier transform of the signal $x(t) = \delta(t - t_0)$ is:

A. 1

B. $e^{-j\omega t_0}$

C. $e^{j\omega t_0}$

D. $\delta(\omega - \omega_0)$

Q17. The system $y(t) = x(t)\cos(100t)$ is:

A. Linear and Time-Invariant

B. Linear and Time-Varying

C. Non-linear and Time-Invariant

D. Non-linear and Time-Varying

Q18. The z-transform of the unit step sequence $u[n]$ is:

A. $\frac{1}{1-z^{-1}}$ for $|z| > 1$

B. $\frac{1}{1-z^{-1}}$ for $|z| < 1$

C. $\frac{z^{-1}}{1-z^{-1}}$ for $|z| > 1$

D. $\frac{1}{1+z^{-1}}$ for $|z| > 1$

Q19. If the sampling frequency is exactly twice the maximum frequency of the signal, the sampling is called:

A. Oversampling

B. Undersampling

C. Nyquist sampling

D. Critical sampling

Q20. For a closed-loop system, the characteristic equation is $s^2 + 4s + 16 = 0$. The undamped natural frequency (ω_n) is:

A. 2 rad/s

B. 4 rad/s

C. 8 rad/s

D. 16 rad/s

Q21. In the above system ($s^2 + 4s + 16 = 0$), the damping ratio (ζ) is:

A. 0.25

B. 0.5

C. 1.0

D. 2.0

Q22. A system is said to be marginally stable if its closed-loop poles lie:

A. In the left half of the s-plane

B. In the right half of the s-plane

C. On the real axis

D. On the imaginary axis as non-repeated roots

Q23. In control systems, a lead compensator is basically a:

A. Low-pass filter

B. High-pass filter

C. Band-pass filter

D. Band-stop filter

Q24. The intersection of root locus branches with the imaginary axis can be determined using:

A. Nyquist criterion

B. Bode plot

C. Routh-Hurwitz criterion

D. Polar plot

Q25. In Amplitude Modulation, if the modulation index is 1.0, the power in the sidebands is what fraction of the total power?

A. 1/2

B. 1/3

C. 2/3

D. 1/4

Q26. The pre-emphasis circuit in FM broadcasting is used to:

A. Improve the signal-to-noise ratio at high modulating frequencies

B. Increase the carrier frequency

C. Decrease the bandwidth

D. Eliminate amplitude variations

Q27. The channel capacity of a noiseless channel with bandwidth B and M signal levels is given by:

A. $2B\log_2(M)$

B. $B\log_2(1+M)$

C. $B\log_2(M)$

D. $2B\log_2(1+M)$

Q28. Which multiplexing technique is used specifically for optical fiber communication?

A. TDM

B. FDM

C. WDM

D. CDMA

Q29. The minimum bandwidth required to transmit a 56 kbps PCM signal using BPSK modulation is:

A. 28 kHz

B. 56 kHz

C. 112 kHz

D. 14 kHz

Q30. According to Ampere's circuital law with Maxwell's correction, the curl of magnetic field intensity ($\nabla \times \mathbf{H}$) is equal to:

A. $\mathbf{J}$

B. $\frac{\partial \mathbf{D}}{\partial t}$

C. $\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$

D. $-\frac{\partial \mathbf{B}}{\partial t}$

Q31. The intrinsic impedance of free space (η_0) is approximately:

A. $120\pi\ \Omega$

B. $377\ \Omega$

C. Both A and B

D. $50\ \Omega$

Q32. In a lossless transmission line, the velocity of wave propagation is given by:

A. $\sqrt{LC}$

B. $1/\sqrt{LC}$

C. L/C

D. C/L

Q33. A transmission line is terminated in a short circuit. The input impedance at a distance of $\lambda/4$ from the load is:

A. Zero

B. Infinite (Open circuit)

C. Z_0

D. $Z_0/2$

Q34. The dominant mode in a circular waveguide is:

A. TE_{10}

B. TE_{11}

C. TM_{01}

D. TE_{01}

Q35. The reflex klystron operates on the principle of:

A. Velocity modulation

B. Density modulation

C. Current modulation

D. Voltage modulation

Q36. A directional coupler has a coupling factor of 10 dB. If the input power is 100 mW, the coupled power is:

A. 100 mW

B. 50 mW

C. 10 mW

D. 1 mW

Q37. Thevenin's equivalent resistance (R_{th}) is found by:

A. Short-circuiting all independent voltage and current sources

B. Opening all independent voltage and current sources

C. Short-circuiting independent voltage sources and opening independent current sources

D. Opening independent voltage sources and short-circuiting independent current sources

Q38. In a parallel RLC circuit at resonance, the power factor is:

A. Zero

B. Unity

C. 0.707 leading

D. 0.707 lagging

Q39. A two-port network is reciprocal if its Y-parameters satisfy:

A. $Y_{11} = Y_{22}$

B. $Y_{12} = Y_{21}$

C. $Y_{11}Y_{22} - Y_{12}Y_{21} = 1$

D. $Y_{12} = -Y_{21}$

Q40. In a star-connected 3-phase load, the line voltage (V_L) and phase voltage (V_{ph}) are related by:

A. $V_L = V_{ph}$

B. $V_L = \sqrt{3}V_{ph}$

C. $V_L = V_{ph}/\sqrt{3}$

D. $V_L = 3V_{ph}$

Q41. The built-in potential barrier of a pn-junction:

A. Increases with an increase in temperature

B. Decreases with an increase in temperature

C. Is independent of temperature

D. Is zero at room temperature

Q42. An SCR (Silicon Controlled Rectifier) turns off when:

A. Gate current is removed

B. Anode current drops below the holding current

C. Anode voltage exceeds the breakover voltage

D. Gate voltage is reversed

Q43. In an optical fiber, the condition for total internal reflection at the core-cladding interface is:

A. $n_{core} > n_{cladding}$ and angle of incidence $>$ critical angle

B. $n_{core} < n_{cladding}$ and angle of incidence $>$ critical angle

C. $n_{core} > n_{cladding}$ and angle of incidence $<$ critical angle

D. $n_{core} < n_{cladding}$ and angle of incidence $<$ critical angle

Q44. The numerical aperture (NA) of a step-index fiber is defined as:

A. $\sqrt{n_{core}^2 + n_{cladding}^2}$

B. $\sqrt{n_{core}^2 - n_{cladding}^2}$

C. $n_{core}/n_{cladding}$

D. $n_{cladding}/n_{core}$

Q45. A 12-bit DAC has a step size of 10 mV. The full-scale output voltage is approximately:

A. 10.0 V

B. 20.48 V

C. 40.95 V

D. 81.9 V

Q46. Which type of memory uses a single transistor and a capacitor per bit?

A. SRAM

B. DRAM

C. EEPROM

D. Flash Memory

Q47. The number of address lines required to access a 64K $\times$ 8 bit memory chip is:

A. 12

B. 14

C. 16

D. 8

Q48. In a pipelined processor, a 'data hazard' occurs when:

A. Two instructions attempt to use the same ALU in the same cycle

B. An instruction depends on the result of a previous instruction still in the pipeline

C. A branch instruction causes the pipeline to flush

D. An interrupt occurs

Q49. The discrete-time system described by $y[n] = x[-n]$ is:

A. Causal

B. Non-causal

C. Memoryless

D. Unstable

Q50. A 256-point Radix-2 FFT algorithm requires how many complex multiplications?

A. 1024

B. 2048

C. 512

D. 65536

Q51. In digital filter design, the bilinear transformation method maps the $j\omega$-axis of the s-plane onto the:

A. Real axis of the z-plane

B. Entire z-plane

C. Unit circle in the z-plane

D. Origin of the z-plane

Q52. What is the steady-state error of a Type-0 system for a step input of magnitude A?

A. 0

B. $A/(1 + K_p)$

C. A/K_v

D. Infinity

Q53. In a PID controller, the integral action is primarily used to:

A. Improve the transient response

B. Eliminate steady-state error

C. Increase the bandwidth

D. Reduce noise amplification

Q54. The Nyquist plot of $G(s)H(s)$ encircles the point $(-1, j0)$ twice in the clockwise direction. If $G(s)H(s)$ has one pole in the right half of the s-plane, the number of closed-loop poles in the right half of the s-plane is:

A. 0

B. 1

C. 2

D. 3

Q55. A superheterodyne receiver has an IF of 10.7 MHz and is tuned to 90 MHz. The local oscillator frequency (assuming high-side injection) is:

A. 100.7 MHz

B. 79.3 MHz

C. 111.4 MHz

D. 90 MHz

Q56. In QAM (Quadrature Amplitude Modulation), information is transmitted by varying both the:

A. Amplitude and Frequency

B. Frequency and Phase

C. Amplitude and Phase

D. Amplitude and Polarization

Q57. Which antenna is commonly used for satellite tracking and has circular polarization?

A. Yagi-Uda antenna

B. Helical antenna

C. Parabolic reflector

D. Dipole antenna

Q58. The cutoff frequency of a TEM wave is:

A. Infinity

B. Zero

C. Dependent on waveguide dimensions

D. Dependent on dielectric material

Q59. In a Y-parameter equivalent circuit of a transistor, Y_{21} represents the:

A. Input admittance

B. Forward transfer admittance

C. Reverse transfer admittance

D. Output admittance

Q60. For an intrinsic semiconductor, the hole mobility μ_p is typically:

A. Equal to electron mobility μ_n

B. Greater than electron mobility μ_n

C. Less than electron mobility μ_n

D. Zero

Q61. If A is an orthogonal matrix, the value of the determinant $|A|$ is:

A. 0

B. 1 or -1

C. Infinity

D. Cannot be determined

Q62. The eigenvalues of a skew-symmetric matrix with real entries are:

A. Always real

B. Always zero

C. Purely imaginary or zero

D. Complex conjugates with non-zero real parts

Q63. The directional derivative of $\phi(x, y, z) = x^2yz$ at the point $(1, 1, 1)$ in the direction of the vector $\mathbf{i} + 2\mathbf{j} + 2\mathbf{k}$ is:

A. 1

B. 2

C. 5

D. 3

Q64. The curl of the gradient of any scalar field ϕ is always:

A. $\nabla^2\phi$

B. A non-zero constant

C. Zero

D. ϕ

Q65. The solution to the differential equation $\frac{dy}{dx} = y\tan(x)$ is:

A. $y = C\sin(x)$

B. $y = C\cos(x)$

C. $y = C\sec(x)$

D. $y = C\csc(x)$

Q66. The particular integral (PI) of the differential equation $(D^2 + 4)y = \sin(2x)$ is:

A. $\frac{-x}{4}\cos(2x)$

B. $\frac{x}{4}\sin(2x)$

C. $\frac{-x}{2}\cos(2x)$

D. $\frac{1}{8}\sin(2x)$

Q67. The function $f(z) = |z|^2$ is analytic at:

A. All points in the complex plane

B. Only the origin

C. No point

D. Only on the real axis

Q68. The value of $\oint_C \frac{e^z}{z-2}dz$ around the contour $C : |z| = 1$ is:

A. $2\pi j e^2$

B. e^2

C. $2\pi j$

D. 0

Q69. If a random variable X has a uniform distribution over $[a, b]$, its variance is:

A. $\frac{b-a}{2}$

B. $\frac{(b-a)^2}{12}$

C. $\frac{a+b}{2}$

D. $\frac{(b-a)^2}{6}$

Q70. The probability of drawing an ace from a standard deck of 52 cards given that the card is black is:

A. 1/13

B. 2/13

C. 1/26

D. 1/52

Q71. In the Newton-Raphson method, the iterative formula to find the root of $f(x) = 0$ is $x_{n+1} =$

A. $x_n + \frac{f(x_n)}{f'(x_n)}$

B. $x_n - \frac{f'(x_n)}{f(x_n)}$

C. $x_n - \frac{f(x_n)}{f'(x_n)}$

D. $x_n - f(x_n)f'(x_n)$

Q72. Simpson's 1/3 rule provides an exact value of the integral for polynomials of degree up to:

A. 1

B. 2

C. 3

D. 4

Q73. Which of the following functions is a solution to Laplace's equation $\nabla^2 u = 0$ in 2D?

A. $u = x^2 + y^2$

B. $u = x^2 - y^2$

C. $u = e^x \sin(y)$

D. Both B and C

Q74. If $L\{f(t)\} = F(s)$, then the initial value theorem states that $\lim_{t\to 0} f(t)$ equals:

A. $\lim_{s\to 0} sF(s)$

B. $\lim_{s\to \infty} sF(s)$

C. $\lim_{s\to \infty} F(s)$

D. $\lim_{s\to 0} F(s)$

Q75. The inverse Laplace transform of $\frac{1}{(s-1)^3}$ is:

A. $e^t t^2$

B. $\frac{t^2}{2} e^t$

C. $\frac{t^3}{6} e^t$

D. te^t

Q76. A box contains 3 red, 4 white, and 5 blue balls. If two balls are drawn at random without replacement, the probability that they are of the same color is:

A. 19/66

B. 1/3

C. 20/66

D. 5/22

Q77. The maximum value of the function $f(x) = -x^2 + 4x + 5$ is:

A. 5

B. 7

C. 9

D. 10

Q78. The area of the region bounded by $y = x^2$ and $y = x$ is:

A. 1/2

B. 1/3

C. 1/6

D. 1/4

Q79. The line integral $\int_{(0,0)}^{(1,1)}(ydx + xdy)$ is:

A. 0

B. 1

C. 2

D. 1/2

Q80. For what value of k will the vectors $\mathbf{A} = 2\mathbf{i} + 3\mathbf{j} - \mathbf{k}$ and $\mathbf{B} = 4\mathbf{i} + k\mathbf{j} + 2\mathbf{k}$ be orthogonal?

A. -2

B. 0

C. 2

D. 4

Q81. Find the missing term in the series: 5, 11, 23, 47, ..., 191.

A. 93

B. 95

C. 97

D. 99

Q82. If 'REASON' is coded as '5' and 'BELIEVED' as '7', what is the code for 'GOVERNMENT'?

A. 8

B. 9

C. 10

D. 11

Q83. Pointing to a girl, Amit said, 'She is the daughter of my grandfather's only son.' How is the girl related to Amit?

A. Sister

B. Cousin

C. Aunt

D. Daughter

Q84. A man is facing North. He turns 135 degrees in the clockwise direction and then 45 degrees in the anticlockwise direction. Which direction is he facing now?

A. East

B. West

C. North-East

D. South

Q85. Statements: I. Some cars are buses. II. All buses are trains. Conclusions: I. Some cars are trains. II. No car is a train.

A. Only conclusion I follows

B. Only conclusion II follows

C. Both conclusions follow

D. Neither conclusion follows

Q86. P, Q, R, S, and T are sitting in a line facing North. T is at the extreme left. R is sitting next to T. Q is sitting next to S but not next to R. P is sitting on the extreme right. Who sits in the middle?

A. Q

B. R

C. S

D. P

Q87. The angle between the minute hand and the hour hand of a clock when the time is 8:30 is:

A. 60 degrees

B. 75 degrees

C. 80 degrees

D. 105 degrees

Q88. If the 4th of a month falls on Friday, what day will it be on the 25th of the same month?

A. Monday

B. Tuesday

C. Thursday

D. Friday

Q89. In a row of 40 students, Rahul is 14th from the left end and Rohan is 9th from the right end. How many students are there between Rahul and Rohan?

A. 15

B. 16

C. 17

D. 18

Q90. Which word does NOT belong with the others?

A. Copper

B. Iron

C. Brass

D. Aluminum

Solutions

1. C
Explanation: At room temperature (300 K), the bandgap energy (E_g) of Silicon is approximately 1.12 eV, while for Germanium it is about 0.66 eV.

2. A
Explanation: The Hall coefficient is inversely proportional to carrier concentration, and its sign indicates the type of majority charge carriers (electrons or holes).

3. B
Explanation: In the active region, the Emitter-Base (EB) junction is forward-biased to inject carriers, and the Collector-Base (CB) junction is reverse-biased to collect them.

4. A
Explanation: Since $V_{GS} > V_p$ ($-1\text{V} > -4\text{V}$), the channel is open. For small values of V_{DS}, it acts as a voltage-variable resistor (Ohmic region).

5. C
Explanation: The Miller effect multiplies the feedback capacitance by $(1-A_v)$, significantly increasing the effective input capacitance and reducing the high-frequency bandwidth.

6. C
Explanation: A diode ring modulator acts as a balanced modulator, suppressing the carrier and producing a Double Sideband Suppressed Carrier (DSB-SC) signal.

7. C
Explanation: An ideal op-amp amplifies only the differential input and completely rejects any common-mode signal, leading to an infinite CMRR.

8. C
Explanation: LC oscillators like the Colpitts and Hartley oscillators are typically used for high-frequency (RF) signal generation, unlike RC oscillators which are for audio frequencies.

9. C
Explanation: Transistors in Class B require a base-emitter voltage of about 0.7V to turn on. The gap between -0.7V and $+0.7\text{V}$ where neither conducts causes cross-over distortion.

10. C
Explanation: The minterms $0, 2, 4, 6$ represent states where $C = 0$. Grouping them in a K-map yields $F = \overline{C}$.

11. C
Explanation: Emitter-Coupled Logic (ECL) prevents transistors from entering deep saturation, making it the fastest standard logic family.

12. A
Explanation: Two 3-to-8 decoders can be used. The 4th input variable controls the enable lines (one active high, one active low) to select between the two decoders.

13. C

Explanation: The clock period T_{clk} must be greater than or equal to $t_{pd} + t_{setup}$. Thus, maximum frequency is limited by flip-flop propagation delay and setup time.

14. C
Explanation: A 4-bit Johnson counter has $2N = 8$ valid states. A 4-bit system has $2^4 = 16$ total states. Unused states $= 16 - 8 = 8$.

15. C
Explanation: Register A is the Accumulator in the 8085 architecture, acting as the primary register for ALU operations and storing the result.

16. B
Explanation: By the time-shifting property of the Fourier transform, $\mathcal{F}\{\delta(t - t_0)\} = 1 \cdot e^{-j\omega t_0} = e^{-j\omega t_0}$.

17. B
Explanation: The system satisfies the superposition principle (Linear). However, the explicit time dependence $\cos(100t)$ makes it Time-Varying.

18. A
Explanation: The infinite geometric series $\sum_{n=0}^{\infty} z^{-n}$ converges to $\frac{1}{1-z^{-1}}$ provided the ROC is $|z| > 1$.

19. D
Explanation: Sampling at exactly $f_s = 2f_{max}$ is called Nyquist rate or critical sampling. Any lower rate causes aliasing.

20. B
Explanation: Comparing with the standard form $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$, we get $\omega_n^2 = 16 \implies \omega_n = 4$ rad/s.

21. B
Explanation: Since $2\zeta\omega_n = 4$ and $\omega_n = 4$, we have $2\zeta(4) = 4 \implies \zeta = 4/8 = 0.5$.

22. D
Explanation: Non-repeated poles strictly on the $j\omega$-axis result in a bounded oscillatory response, defining marginal stability.

23. B
Explanation: A lead compensator adds positive phase angle to the system, primarily amplifying high frequencies, thus acting like a high-pass filter.

24. C
Explanation: By forming the Routh array and setting a complete row to zero, the auxiliary equation yields the intersection points on the $j\omega$-axis.

25. B
Explanation: Total power $P_t = P_c(1 + m^2/2)$. For $m = 1$, $P_{sidebands} = P_c(1/2)$. $P_t = P_c(1.5)$. Ratio $= 0.5/1.5 = 1/3$.

26. A
Explanation: Noise spectral density in FM increases with frequency. Pre-emphasis boosts high-frequency signals at the transmitter to improve SNR, which is later de-emphasized at the receiver.

27. A

Explanation: Nyquist theorem for a noiseless channel states that the maximum data rate $C = 2B \log_2(M)$ bps.

28. C
Explanation: Wavelength Division Multiplexing (WDM) multiplexes multiple optical carrier signals onto a single optical fiber using different wavelengths (colors) of laser light.

29. B
Explanation: For BPSK, the null-to-null bandwidth is $2R_b$, but the Nyquist minimum transmission bandwidth is equal to the bit rate R_b, which is 56 kHz.

30. C
Explanation: Maxwell added the displacement current density ($\frac{\partial \mathbf{D}}{\partial t}$) to the conduction current density ($\mathbf{J}$) to satisfy the continuity equation.

31. C
Explanation: The intrinsic impedance of free space is $\eta_0 = \sqrt{\mu_0/\epsilon_0} = 120\pi \approx 377\ \Omega$.

32. B
Explanation: The phase velocity of a wave on a lossless transmission line with distributed inductance L and capacitance C per unit length is $v_p = 1/\sqrt{LC}$.

33. B
Explanation: A quarter-wave ($\lambda/4$) line transforms a short circuit ($Z_L = 0$) into an open circuit ($Z_{in} = \infty$) because $Z_{in} = Z_0^2/Z_L$.

34. B
Explanation: In a circular waveguide, the mode with the lowest cutoff frequency (the dominant mode) is the TE_{11} mode.

35. A
Explanation: A reflex klystron is a microwave tube oscillator that uses velocity modulation to group electrons into bunches before they transfer energy to the cavity.

36. C
Explanation: Coupling factor (dB) $= 10 \log_{10}(P_{in}/P_{coupled})$. $10 = 10 \log_{10}(100/P_{coupled}) \implies P_{coupled} = 10$ mW.

37. C
Explanation: To find the passive equivalent resistance, voltage sources are reduced to zero (shorted) and current sources to zero (opened).

38. B
Explanation: At resonance, the imaginary parts of the admittance cancel out (inductive susceptance equals capacitive susceptance), leaving a purely resistive circuit with a power factor of 1.

39. B
Explanation: For a passive, linear, bilateral network to be reciprocal, the off-diagonal transfer admittances must be equal: $Y_{12} = Y_{21}$.

40. B
Explanation: In a balanced Wye (Star) system, the line-to-line voltage is $\sqrt{3}$

times the line-to-neutral (phase) voltage, leading it by 30°.

41. B
Explanation: Built-in potential $V_{bi} = \frac{kT}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right)$. Since n_i^2 grows exponentially with temperature, V_{bi} effectively decreases as temperature increases.

42. B
Explanation: Once triggered, an SCR stays ON until the forward current (anode current) drops below a specific threshold called the holding current (I_H).

43. A
Explanation: Light must travel from a denser medium (n_{core}) to a rarer medium ($n_{cladding}$) and strike the boundary at an angle greater than the critical angle.

44. B
Explanation: NA defines the light-gathering ability of the fiber and is mathematically given by $\sqrt{n_{core}^2 - n_{cladding}^2}$.

45. C
Explanation: Full scale voltage V_{FS} = Step Size $\times (2^n - 1) = 10$ mV $\times (4096 - 1) = 10 \times 4095 = 40950$ mV $= 40.95$ V.

46. B
Explanation: Dynamic RAM (DRAM) relies on a capacitor to store charge (representing a bit) and a single pass transistor to access it, requiring periodic refreshing.

47. C
Explanation: 64K $= 64 \times 1024 = 65536 = 2^{16}$. Therefore, 16 address lines are required to uniquely identify each byte.

48. B
Explanation: Data hazards arise when instructions exhibit data dependence (e.g., Read-After-Write) and are close together in the pipeline.

49. B
Explanation: For $n < 0$ (e.g., $n = -2$), the output $y[-2]$ depends on $x[2]$, which is a future value. Thus, the system is non-causal.

50. A
Explanation: The number of complex multiplications in a Radix-2 FFT is $(N/2)\log_2(N)$. For $N = 256$, it is $(256/2)\log_2(256) = 128 \times 8 = 1024$.

51. C
Explanation: The bilinear transform maps the entire left half of the s-plane into the interior of the unit circle and the $j\omega$-axis exactly onto the unit circle $|z| = 1$.

52. B
Explanation: For a Type-0 system, the position error constant K_p is finite. The steady-state error to a step input is $\frac{A}{1+K_p}$.

53. B
Explanation: Integral control accumulates error over time, increasing the control signal until the steady-state error is driven to precisely zero.

54. D
Explanation: Nyquist equation $N = Z - P$. Here, $N = 2$ (clockwise), $P = 1$. So,

$2 = Z - 1 \implies Z = 3$ closed-loop unstable poles.

55. A
Explanation: For high-side injection, $f_{LO} = f_s + f_{IF} = 90 + 10.7 = 100.7$ MHz.

56. C
Explanation: QAM combines both amplitude shift keying (ASK) and phase shift keying (PSK), altering both the amplitude and phase of the carrier wave.

57. B
Explanation: A helical antenna operating in the axial mode produces a highly directional, circularly polarized beam, ideal for satellite communications.

58. B
Explanation: Transverse Electromagnetic (TEM) waves have no cutoff frequency ($f_c = 0$) and can propagate at any frequency down to DC (e.g., in coaxial cables).

59. B
Explanation: By definition, $Y_{21} = \frac{I_2}{V_1}$ when $V_2 = 0$, which is the forward transfer admittance (gain parameter).

60. C
Explanation: Due to the effective mass of holes being larger than that of electrons, hole mobility μ_p is significantly less than electron mobility μ_n in typical semiconductors like Si and Ge.

61. B
Explanation: For an orthogonal matrix, $A^T A = I$. Taking determinants, $|A^T||A| = |I| \implies |A|^2 = 1 \implies |A| = \pm 1$.

62. C
Explanation: A standard property of real skew-symmetric matrices ($A^T = -A$) is that their eigenvalues are either purely imaginary or exactly zero.

63. B
Explanation: $\nabla\phi = \langle 2xyz, x^2z, x^2y\rangle$. At $(1,1,1)$, $\nabla\phi = 2\mathbf{i} + \mathbf{j} + \mathbf{k}$. Direction vector $\mathbf{u} = \frac{\mathbf{i}+2\mathbf{j}+2\mathbf{k}}{3}$. Directional derivative $= \nabla\phi \cdot \mathbf{u} = \frac{2(1)+1(2)+1(2)}{3} = \frac{6}{3} = 2$.

64. C
Explanation: A fundamental vector calculus identity states that the curl of a gradient field is identically zero ($\nabla \times (\nabla\phi) = 0$).

65. C
Explanation: Separating variables: $\frac{dy}{y} = \tan(x)dx \implies \ln(y) = \ln(\sec(x)) + \ln(C) \implies y = C\sec(x)$.

66. A
Explanation: Since $\sin(2x)$ is part of the complementary function, PI $= x\frac{1}{\frac{d}{dD}(D^2+4)}\sin(2x) = x\frac{1}{2D}\sin(2x) = \frac{x}{2}\int \sin(2x)dx = \frac{-x}{4}\cos(2x)$.

67. C
Explanation: $f(z) = x^2 + y^2$. Here $u = x^2 + y^2$ and $v = 0$. The Cauchy-Riemann equations ($u_x = v_y$, $u_y = -v_x$) give $2x = 0$ and $2y = 0$. They hold only at origin, but neighborhood analyticity is required, so it is analytic nowhere.

68. D

Explanation: The pole is at $z = 2$, which lies outside the contour $|z| = 1$. By Cauchy's Integral Theorem, the integral over the closed path is 0.

69. B
Explanation: The standard formula for the variance of a continuous uniform distribution on $[a, b]$ is $E[(X - \mu)^2] = \frac{(b-a)^2}{12}$.

70. A
Explanation: There are 26 black cards in the deck, and 2 of them are aces (Spades and Clubs). Probability $= 2/26 = 1/13$.

71. C
Explanation: The standard Newton-Raphson update formula is derived from the first-order Taylor expansion: $x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$.

72. C
Explanation: Simpson's 1/3 rule fits a parabola (degree 2) but surprisingly integrates cubics (degree 3) exactly due to error cancellation of the odd derivative term.

73. D
Explanation: For $x^2 - y^2$, $\nabla^2 u = 2 - 2 = 0$. For $e^x \sin(y)$, $\nabla^2 u = e^x \sin(y) - e^x \sin(y) = 0$. Both satisfy Laplace's equation.

74. B
Explanation: The Initial Value Theorem relates the limits in the time and s-domains as: $\lim_{t\to 0} f(t) = \lim_{s\to\infty} sF(s)$.

75. B
Explanation: We know $\mathcal{L}^{-1}\left\{\frac{1}{s^3}\right\} = \frac{t^2}{2!}$. Using the first shifting theorem, $\mathcal{L}^{-1}\left\{\frac{1}{(s-1)^3}\right\} = e^t \frac{t^2}{2}$.

76. A
Explanation: Total ways $= \binom{12}{2} = 66$. Favorable ways $= \binom{3}{2} + \binom{4}{2} + \binom{5}{2} = 3 + 6 + 10 = 19$. Prob $= 19/66$.

77. C
Explanation: $f'(x) = -2x + 4 = 0 \implies x = 2$. $f''(x) = -2$ (concave down, so maximum). $f(2) = -4 + 8 + 5 = 9$.

78. C
Explanation: The curves intersect at $x = 0$ and $x = 1$. Area $= \int_0^1 (x - x^2)dx = [x^2/2 - x^3/3]_0^1 = 1/2 - 1/3 = 1/6$.

79. B
Explanation: The integrand $ydx + xdy$ is exactly $d(xy)$. Thus, the integral is $[xy]$ evaluated from $(0, 0)$ to $(1, 1)$, which is $1 \times 1 - 0 \times 0 = 1$.

80. A
Explanation: Vectors are orthogonal if their dot product is zero. $\mathbf{A} \cdot \mathbf{B} = (2)(4) + (3)(k) + (-1)(2) = 8 + 3k - 2 = 0 \implies 3k = -6 \implies k = -2$.

81. B
Explanation: The pattern is $\times 2 + 1$. $5 \times 2 + 1 = 11$. $11 \times 2 + 1 = 23$. $23 \times 2 + 1 = 47$. $47 \times 2 + 1 = 95$. Check: $95 \times 2 + 1 = 191$.

82. B
Explanation: The code represents the number of letters in the word minus one. 'REASON' has 6 letters $\rightarrow$ 5. 'BELIEVED' has 8 letters $\rightarrow$ 7. 'GOVERNMENT' has 10 letters $\rightarrow$ 9.

83. A
Explanation: Amit's grandfather's only son is Amit's father. The daughter of Amit's father is Amit's sister.

84. A
Explanation: Net movement = 135° CW $- 45^\circ$ ACW = 90° CW. 90° CW from North is East.

85. A
Explanation: Since some cars are buses and all buses are inside the train circle, the cars that are buses must also be trains. Hence, Conclusion I is true. Conclusion II is definitively false.

86. C
Explanation: T is at the extreme left. So, T ... ... P. R is next to T: T R ... ... P. Q and S must occupy the middle two. Since Q is not next to R, S must be next to R. Arrangement: T R S Q P. The middle person is S.

87. B
Explanation: Hour hand angle = $8 \times 30 + 30/2 = 240 + 15 = 255^\circ$. Minute hand angle = $30 \times 6 = 180^\circ$. Difference = $255 - 180 = 75^\circ$.

88. D
Explanation: The 25th is 21 days after the 4th. Since 21 is exactly divisible by 7 (3 weeks), the 25th will be the exact same day of the week, which is Friday.

89. C
Explanation: Number of students between them = Total$-$(Rahul's pos+Rohan's pos) = $40 - (14 + 9) = 40 - 23 = 17$.

90. C
Explanation: Copper, Iron, and Aluminum are pure elements (metals), whereas Brass is an alloy (mixture of Copper and Zinc).