OJEE M Tech Electrical Sample Paper 03

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. For a symmetrical two-port network, the ABCD parameters must satisfy:

A. A = D

B. AD - BC = 1

C. B = C

D. A = 1/D

Q2. The principle of superposition is applicable to:

A. Linear circuits only

B. Non-linear circuits only

C. Both linear and non-linear circuits

D. Active circuits only

Q3. In an AC circuit, the active power is given by $VI\cos\phi$. The term $\cos\phi$ represents:

A. Form factor

B. Peak factor

C. Power factor

D. Crest factor

Q4. A network has 10 nodes and 17 branches. The number of fundamental cut-sets is:

A. 7

B. 9

C. 10

D. 17

Q5. The transient response of a system is primarily due to:

A. Internal forces

B. Stored energy

C. Friction

D. Source voltage

Q6. A unit step function $u(t)$ has a Laplace transform of:

A. $1/s^2$

B. $1/s$

C. s

D. 1

Q7. For a stable closed-loop system, the roots of the characteristic equation must lie:

A. In the right half of the s-plane

B. On the imaginary axis

C. In the left half of the s-plane

D. At the origin

Q8. The angle of departure from a complex open-loop pole in a root locus is given by:

A. $180° - \phi$

B. $180° + \phi$

C. $90° + \phi$

D. $270° - \phi$

Q9. In a Bode plot, a simple zero at the origin produces a slope of:

A. -20 dB/decade

B. +20 dB/decade

C. -40 dB/decade

D. +40 dB/decade

Q10. A lead compensator improves the system's:

A. Transient response

B. Steady-state error

C. Both transient and steady-state

D. Neither

Q11. The core of a transformer is laminated to reduce:

A. Copper loss

B. Hysteresis loss

C. Eddy current loss

D. Friction loss

Q12. In a 3-phase induction motor, the mechanical power developed is maximum when the slip is:

A. R_2/X_2

B. X_2/R_2

C. 1

D. 0

Q13. The synchronizing power of a synchronous machine is inversely proportional to:

A. Synchronous reactance

B. Terminal voltage

C. Excitation voltage

D. Load angle

Q14. Which motor is preferred for traction applications?

A. DC shunt motor

B. AC series motor

C. DC series motor

D. Synchronous motor

Q15. In a synchronous generator, a leading power factor load causes:

A. Magnetizing armature reaction

B. Demagnetizing armature reaction

C. Cross-magnetizing armature reaction

D. No armature reaction

Q16. The Jacobian matrix in the Newton-Raphson load flow method for an n-bus system with 1 slack bus and m PV buses has the dimension:

A. $2n - 2 - m$

B. $2n - 2 + m$

C. $2(n - 1 - m)$

D. $n - 1 - m$

Q17. Buchholz relay is used for the protection of:

A. Alternators

B. Transmission lines

C. Transformers

D. Busbars

Q18. The characteristic of a mho relay on an R-X diagram is:

A. A straight line

B. A circle passing through the origin

C. An ellipse

D. A hyperbola

Q19. Skin effect in a transmission line depends on:

A. Frequency only

B. Conductor diameter only

C. Permeability only

D. All of the above

Q20. Ferranti effect on a long transmission line is experienced when the line is:

A. Lightly loaded or open-circuited

B. Fully loaded

C. Short-circuited

D. Loaded at unity power factor

Q21. An IGBT combines the advantages of:

A. BJT and MOSFET

B. BJT and SCR

C. MOSFET and SCR

D. UJT and MOSFET

Q22. In a fully controlled three-phase bridge converter, the output voltage is negative if the firing angle α is:

A. $< 60°$

B. $< 90°$

C. $> 90°$

D. Always positive

Q23. A boost converter operates with a duty cycle of 0.5. The ratio of output to input voltage is:

A. 0.5

B. 1.0

C. 2.0

D. 4.0

Q24. The purpose of a freewheeling diode in a controlled rectifier is to:

A. Increase the output voltage

B. Prevent reversal of load current

C. Protect thyristors from overvoltage

D. Dissipate stored energy and prevent negative voltage

Q25. In Pulse Width Modulation (PWM) inverters, the primary goal is to:

A. Increase the output frequency

B. Eliminate lower order harmonics

C. Increase power factor

D. Reduce input voltage

Q26. The Fourier transform of a unit impulse $\delta(t)$ is:

A. 1

B. ω

C. $1/\omega$

D. $j\omega$

Q27. A discrete-time system is strictly causal if its impulse response $h[n]$ is zero for:

A. $n > 0$

B. $n < 0$

C. $n = 0$

D. $n \neq 0$

Q28. Which theorem is used to determine the initial value of a signal from its z-transform?

A. Final value theorem

B. Convolution theorem

C. Initial value theorem

D. Parseval's theorem

Q29. The region of convergence (ROC) of a causal stable discrete-time LTI system:

A. Includes the unit circle

B. Is inside the unit circle

C. Is outside the unit circle

D. Is a ring in the z-plane

Q30. The common-mode rejection ratio (CMRR) of an op-amp is defined as the ratio of:

A. Differential gain to common-mode gain

B. Common-mode gain to differential gain

C. Input impedance to output impedance

D. Open-loop gain to closed-loop gain

Q31. Barkhausen criterion for sustained oscillations states that the loop gain $|A\beta|$ must be:

A. 0

B. 0.5

C. 1

D. Infinite

Q32. A 555 timer configured in astable mode produces:

A. A single pulse

B. A continuous square wave

C. A triangular wave

D. A sine wave

Q33. The number of bits required to represent the decimal number 25 in straight binary is:

A. 4

B. 5

C. 6

D. 8

Q34. Which logic gate produces a HIGH output only when its inputs are different?

A. AND

B. OR

C. XOR

D. XNOR

Q35. A master-slave flip-flop is primarily used to eliminate:

A. Race-around condition

B. Propagation delay

C. Power dissipation

D. Clock skew

Q36. In 8085 microprocessor, the ALE signal is used to:

A. Enable arithmetic logic

B. Latch the lower 8 bits of the address

C. Acknowledge an interrupt

D. Enable the accumulator

Q37. An analog-to-digital converter (ADC) with a 12-bit resolution can distinguish how many discrete voltage levels?

A. 1024

B. 2048

C. 4096

D. 8192

Q38. The material typically used for making the filament of an incandescent lamp is:

A. Copper

B. Aluminum

C. Tungsten

D. Nichrome

Q39. The unit of luminous flux is:

A. Lux

B. Candela

C. Lumen

D. Foot-candle

Q40. In induction heating, the depth of heating can be decreased by:

A. Increasing the frequency

B. Decreasing the frequency

C. Increasing the voltage

D. Decreasing the voltage

Q41. A piezoelectric crystal generates a voltage in response to:

A. Temperature change

B. Light intensity

C. Mechanical stress

D. Magnetic field

Q42. Which of the following bridges is suitable for measuring frequencies in the audio range?

A. Maxwell bridge

B. Wien bridge

C. Schering bridge

D. Kelvin double bridge

Q43. The scale of a moving iron instrument is:

A. Uniform

B. Logarithmic

C. Cramped at the beginning and end

D. Exponential

Q44. A 1 mA meter movement has a resistance of 100Ω. To use it as a 10 V voltmeter, the series multiplier resistance required is:

A. 900Ω

B. 9900Ω

C. 1000Ω

D. 10000Ω

Q45. Gauss's law for magnetism states that the surface integral of the magnetic field over a closed surface is:

A. Equal to the enclosed current

B. Equal to the enclosed charge

C. Zero

D. Infinite

Q46. The characteristic impedance of a coaxial cable depends on:

A. Its length

B. The applied voltage

C. The ratio of outer to inner diameter and the dielectric constant

D. The frequency of the signal

Q47. Maxwell's addition to Ampere's law was the introduction of:

A. Magnetic monopoles

B. Displacement current

C. Conduction current

D. Electromagnetic induction

Q48. For a distortionless transmission line, the attenuation constant α is:

A. Zero

B. Dependent on frequency

C. Independent of frequency

D. Equal to the phase constant β

Q49. Which of the following DC motors has the poorest speed regulation?

A. Shunt motor

B. Series motor

C. Cumulative compound motor

D. Differential compound motor

Q50. The condition for maximum power transfer in an AC circuit is that the load impedance Z_L must be:

A. Equal to the source impedance Z_S

B. The complex conjugate of the source impedance Z_S^*

C. Zero

D. Purely resistive

Q51. A synchronous motor is operating at no-load with normal excitation. If the load is increased, the power factor will:

A. Become leading

B. Become lagging

C. Remain unity

D. Become zero

Q52. The bundling of conductors in EHV lines primarily reduces:

A. Radio interference and corona

B. Line charging current

C. Line sag

D. Wind loading

Q53. The transfer function of a zero-order hold (ZOH) is:

A. $(1 - e^{-sT})/s$

B. $(1 + e^{-sT})/s$

C. e^{-sT}/s

D. $1/s$

Q54. In a fully controlled bridge rectifier with a continuous current, if the firing angle $\alpha = 0°$, it acts as a:

A. Controlled inverter

B. Diode bridge rectifier

C. Cycloconverter

D. Chopper

Q55. An inductor with an initial current I_0 can be modeled in the Laplace domain as:

A. An impedance sL in series with a voltage source LI_0

B. An impedance sL in parallel with a current source LI_0

C. An impedance $1/sL$ in series with a voltage source I_0/s

D. Only an impedance sL

Q56. The output of a logic gate is 0 only when all its inputs are 1. The gate is a:

A. NAND

B. NOR

C. AND

D. OR

Q57. The ripple factor of a full-wave rectifier is approximately:

A. 1.21

B. 0.48

C. 0.12

D. 0.01

Q58. In an intrinsic semiconductor at room temperature, the Fermi level lies:

A. Close to the conduction band

B. Close to the valence band

C. Exactly in the middle of the forbidden gap

D. Inside the conduction band

Q59. Which parameter limits the high-frequency response of a bipolar junction transistor (BJT)?

A. Early effect

B. Base transit time and parasitic capacitances

C. Collector-emitter breakdown voltage

D. Thermal runway

Q60. In a star-delta starter for an induction motor, the starting voltage applied to each phase of the stator is reduced by a factor of:

A. $1/3$

B. $1/\sqrt{3}$

C. $1/2$

D. $\sqrt{3}$

Q61. If the determinant of an $n \times n$ matrix A is zero, then:

A. A is invertible

B. The system $Ax = 0$ has only the trivial solution

C. The rows of A are linearly dependent

D. All eigenvalues of A are non-zero

Q62. The eigenvalues of an idempotent matrix ($A^2 = A$) can only be:

A. 0 or -1

B. 1 or -1

C. 0 or 1

D. Complex numbers

Q63. The maximum rate of change of a scalar function $f(x, y, z)$ at a given point occurs in the direction of:

A. The x-axis

B. The normal to the surface

C. The gradient of f

D. The curl of f

Q64. The directional derivative of $f(x, y) = x^2y$ at $(1, 2)$ in the direction of the vector $\hat{i} + \hat{j}$ is:

A. $3/\sqrt{2}$

B. $4/\sqrt{2}$

C. $5/\sqrt{2}$

D. $6/\sqrt{2}$

Q65. The value of the integral $\int_0^{\pi/2} \sin^3 x \cos^2 x dx$ is:

A. $2/15$

B. $4/15$

C. $1/15$

D. $8/15$

Q66. The solution of the differential equation $\frac{d^2y}{dx^2} + 9y = 0$ is of the form:

A. $c_1e^{3x} + c_2e^{-3x}$

B. $c_1 \sin 3x + c_2 \cos 3x$

C. $(c_1 + c_2x)e^{3x}$

D. c_1e^{9x}

Q67. An integrating factor for the linear differential equation $\frac{dy}{dx} + \frac{y}{x} = x^2$ is:

A. x

B. $1/x$

C. x^2

D. e^x

Q68. The Laplace transform of $e^{2t}\cos 3t$ is:

A. $\frac{s-2}{(s-2)^2+9}$

B. $\frac{s}{(s-2)^2+9}$

C. $\frac{3}{(s-2)^2+9}$

D. $\frac{s-2}{(s+2)^2+9}$

Q69. If $f(z) = z^2$, then the Cauchy-Riemann equations imply that its real part $u(x, y)$ and imaginary part $v(x, y)$ are:

A. $u = x^2 + y^2, v = 2xy$

B. $u = x^2 - y^2, v = 2xy$

C. $u = x^2 - y^2, v = xy$

D. $u = 2xy, v = x^2 - y^2$

Q70. The residue of the function $f(z) = \frac{1}{z^2+4}$ at the pole $z = 2i$ is:

A. $1/4i$

B. $-1/4i$

C. $1/2i$

D. $1/4$

Q71. Two cards are drawn sequentially from a standard 52-card deck without replacement. The probability that both are Aces is:

A. $1/169$

B. $1/221$

C. $1/13$

D. $4/52$

Q72. If a random variable X has a uniform distribution over $[0, 10]$, its variance is:

A. $100/12$

B. 10

C. 100

D. $10/12$

Q73. The Newton-Raphson iteration formula for finding the reciprocal of a number N is:

A. $x_{n+1} = x_n(2 - Nx_n)$

B. $x_{n+1} = x_n(2 + Nx_n)$

C. $x_{n+1} = 2x_n - N$

D. $x_{n+1} = x_n/N$

Q74. Simpson's 3/8 rule for numerical integration requires the number of sub-intervals to be a multiple of:

A. 2

B. 3

C. 4

D. 5

Q75. The divergence of the vector field $\mathbf{V} = x^2\hat{i} + y^2\hat{j} + z^2\hat{k}$ is:

A. $2(x + y + z)$

B. $x + y + z$

C. $2xyz$

D. 0

Q76. Which of the following functions is a solution to the one-dimensional wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$?

A. $f(x - ct)$

B. $f(x)g(t)$

C. $e^{-cx} \sin t$

D. $x^2 + c^2t^2$

Q77. Let X be a binomial random variable with parameters $n = 10$ and $p = 0.4$. The expected value $E(X)$ is:

A. 10

B. 4

C. 6

D. 2.4

Q78. The partial differential equation $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ is known as:

A. Heat equation

B. Wave equation

C. Laplace's equation

D. Poisson's equation

Q79. The rank of a 3×3 matrix with all entries equal to 1 is:

A. 0

B. 1

C. 2

D. 3

Q80. If C is a closed curve enclosing an area A, then by Green's Theorem, the line integral $\oint_C (xdy - ydx)$ is equal to:

A. A

B. $2A$

C. 0

D. $A/2$

Q81. If 'ORANGE' is called 'BUTTER', 'BUTTER' is called 'SOAP', 'SOAP' is called 'INK', and 'INK' is called 'HONEY', which is used for washing clothes?

A. HONEY

B. BUTTER

C. INK

D. SOAP

Q82. Find the odd one out: 8, 27, 64, 100, 125, 216

A. 27

B. 64

C. 100

D. 125

Q83. A man walks 5 km toward South, then turns right and walks 3 km. He then turns right again and walks 5 km. In which direction is he from the starting point?

A. West

B. South

C. North-West

D. East

Q84. A father is 30 years older than his son. In 5 years, the father will be three times as old as his son. What is the present age of the son?

A. 10

B. 15

C. 12

D. 8

Q85. In a row of 40 students, Rahul is 14th from the left end. What is his position from the right end?

A. 26th

B. 27th

C. 25th

D. 28th

Q86. Statements: All pens are pencils. No pencil is an eraser. Conclusions: I. No pen is an eraser. II. Some pencils are pens.

A. Only Conclusion I follows

B. Only Conclusion II follows

C. Both I and II follow

D. Neither I nor II follows

Q87. A train 200m long passes a platform 100m long in 15 seconds. What is the speed of the train?

A. 72 km/hr

B. 54 km/hr

C. 90 km/hr

D. 60 km/hr

Q88. If A + B means A is the brother of B, A - B means A is the sister of B, and A * B means A is the father of B. What does P + Q * R mean?

A. P is the uncle of R

B. P is the brother of R

C. P is the father of R

D. P is the son of R

Q89. Insert the missing character: A, C, F, J, O, ?

A. S

B. T

C. U

D. V

Q90. A pipe can fill a tank in 10 hours and another pipe can empty it in 15 hours. If both are opened together, how long will it take to fill the tank?

A. 25 hours

B. 30 hours

C. 6 hours

D. 12 hours

Solutions

1. A
Explanation: In ABCD parameters, symmetry requires the input and output ports to be interchangeable without affecting port voltages and currents, which gives A = D.

2. A
Explanation: Superposition theorem relies on the property of additivity and homogeneity, which are exclusive characteristics of linear systems.

3. C
Explanation: The cosine of the phase angle between voltage and current is defined as the power factor of the AC circuit.

4. B
Explanation: The number of fundamental cut-sets in a network is equal to the number of tree branches (twigs), which is $N - 1 = 10 - 1 = 9$.

5. B
Explanation: Transient response occurs because of the energy stored in the reactive elements (inductors and capacitors) of the system.

6. B
Explanation: The Laplace transform of $u(t)$ is $\int_0^\infty 1 \cdot e^{-st} dt = 1/s$.

7. C
Explanation: For absolute stability, all roots of the characteristic equation (closed-loop poles) must have negative real parts, placing them in the left half of the s-plane.

8. A
Explanation: The angle of departure from a complex pole is $180° - (\text{sum of angles from other poles} - \text{sum of angles from zeros}) = 180° - \phi$.

9. B
Explanation: A zero at the origin (s) contributes a magnitude of $20\log(\omega)$, which represents a line with a slope of +20 dB/decade.

10. A
Explanation: A lead compensator adds a positive phase angle, which increases the phase margin, thereby improving the transient response and stability.

11. C
Explanation: Laminations increase the resistance of the path for eddy currents, thereby significantly reducing eddy current losses in the core.

12. A
Explanation: Maximum torque and corresponding max mechanical power occur when the rotor resistance equals the rotor standstill reactance, i.e., $s = R_2/X_2$.

13. A
Explanation: Synchronizing power coefficient is proportional to $EV/X_s \cos\delta$. Therefore, it is inversely proportional to the synchronous reactance X_s.

14. C
Explanation: DC series motors have a high starting torque and variable speed characteristics, making them ideal for electric traction.

15. A
Explanation: A purely leading power factor load produces a magnetizing armature reaction, which increases the main flux and terminal voltage.

16. A
Explanation: For n buses, we have $n-1$ PQ/PV buses for ΔP equations, and $n-1-m$ PQ buses for ΔQ equations. Total size is $(n-1)+(n-1-m) = 2n-2-m$.

17. C
Explanation: Buchholz relay is a gas-actuated relay installed in oil-immersed transformers to protect against incipient internal faults.

18. B
Explanation: A mho (admittance) relay has a circular characteristic on the R-X plane that passes through the origin, making it inherently directional.

19. D
Explanation: Skin effect is proportional to frequency, conductor diameter (area), and the permeability of the conductor material.

20. A
Explanation: Ferranti effect is the phenomenon where the receiving end voltage becomes higher than the sending end voltage under light or no-load conditions due to line capacitance.

21. A
Explanation: The Insulated Gate Bipolar Transistor (IGBT) combines the high input impedance of a MOSFET with the low ON-state conduction losses of a BJT.

22. C
Explanation: For a fully controlled converter feeding a continuous current load, the

average output voltage $V_o = \frac{3\sqrt{3}V_m}{\pi}\cos\alpha$. If $\alpha > 90°$, $\cos\alpha$ is negative, so V_o is negative (inverter mode).

23. C
Explanation: For a boost converter, $V_o/V_{in} = 1/(1-D)$. With $D = 0.5$, the ratio is $1/(1-0.5) = 2.0$.

24. D
Explanation: In highly inductive loads, the freewheeling diode prevents the output voltage from going negative by providing a path for the inductive energy to discharge.

25. B
Explanation: PWM techniques are primarily employed to shift harmonics to higher frequencies, effectively eliminating or minimizing lower-order harmonics for easier filtering.

26. A
Explanation: The Fourier transform of the Dirac delta function is 1, indicating that it contains all frequencies equally across the spectrum.

27. B
Explanation: A system is causal if the output depends only on present and past inputs, meaning the impulse response $h[n]$ must be zero for all negative time indices ($n < 0$).

28. C
Explanation: The Initial Value Theorem for z-transforms states that $x[0] = \lim_{z\to\infty} X(z)$.

29. A
Explanation: For a discrete-time LTI system to be both causal and stable, its poles must lie strictly inside the unit circle, and its ROC must include the unit circle.

30. A
Explanation: CMRR $= |A_d/A_c|$, which measures the op-amp's ability to reject signals that are common to both input terminals.

31. C
Explanation: For an oscillator to produce sustained oscillations, the Barkhausen criterion requires the magnitude of the loop gain to be unity ($|A\beta| = 1$) and the phase shift to be 360° or 0°.

32. B
Explanation: In astable multivibrator mode, the 555 timer continuously triggers itself, generating a continuous train of square wave pulses.

33. B

Explanation: Decimal 25 is 11001_2 in binary. It requires 5 bits.

34. C
Explanation: The Exclusive-OR (XOR) gate outputs a logic 1 only when the two inputs are not equal ($A \neq B$).

35. A
Explanation: The master-slave configuration isolates the output from the input during the clock transition, effectively preventing the race-around condition common in JK level-triggered flip-flops.

36. B
Explanation: The Address Latch Enable (ALE) signal is pulsed high during the first clock cycle of a machine cycle to latch the lower 8 bits of the multiplexed address/data bus (AD0-AD7).

37. C
Explanation: A 12-bit ADC has $2^{12} = 4096$ discrete output states or quantization levels.

38. C
Explanation: Tungsten is used because it has a very high melting point and low vapor pressure at high temperatures.

39. C
Explanation: The SI unit of luminous flux, which measures the total quantity of visible light emitted by a source per unit of time, is the lumen (lm).

40. A
Explanation: Due to the skin effect, higher frequencies result in a smaller depth of penetration, localizing the heat closer to the surface.

41. C
Explanation: The piezoelectric effect is the generation of an electric charge (or voltage) across a solid material in response to applied mechanical stress.

42. B
Explanation: The Wien bridge balance condition depends heavily on the source frequency, making it ideal for measuring audio frequencies.

43. C
Explanation: In moving iron instruments, the deflecting torque is proportional to the square of the current (I^2), resulting in a non-uniform scale that is cramped at the lower end.

44. B
Explanation: Total resistance required $R_t = V/I = 10/0.001 = 10000\Omega$. The multiplier resistance $R_m = R_t - R_m = 10000 - 100 = 9900\Omega$.

45. C
Explanation: $\oint \mathbf{B} \cdot d\mathbf{A} = 0$. This indicates that there are no magnetic monopoles; magnetic field lines always form closed loops.

46. C
Explanation: $Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10}(D/d)$, so it strictly depends on the physical dimensions and the dielectric material, not the length or voltage.

47. B
Explanation: Maxwell corrected Ampere's Law by adding the displacement current term $(\epsilon_0 \frac{\partial \mathbf{E}}{\partial t})$ to account for changing electric fields producing magnetic fields.

48. C
Explanation: For a distortionless line $(R/L = G/C)$, the attenuation constant $\alpha = \sqrt{RG}$ is completely independent of the operating frequency.

49. B
Explanation: A DC series motor's speed is inversely proportional to its load current. Its speed drops drastically as load increases, making its speed regulation the poorest.

50. B
Explanation: The Maximum Power Transfer Theorem for AC circuits states that maximum real power is transferred when $Z_L = Z_S^*$, cancelling reactive components.

51. B
Explanation: When load is added at normal excitation, the motor draws more active current. The excitation is now insufficient for the new load, making the motor underexcited and the PF lagging.

52. A
Explanation: Bundled conductors increase the effective radius of the line, which lowers the surface electric field gradient, substantially reducing corona loss and radio interference.

53. A
Explanation: A zero-order hold keeps the sampled value constant for one sampling period T. Its impulse response is a rectangular pulse of width T, giving the transfer function $(1 - e^{-sT})/s$.

54. B

Explanation: At $\alpha = 0°$, the thyristors conduct exactly when they become forward-biased, making the circuit behave identically to an uncontrolled diode bridge rectifier.

55. A
Explanation: In the s-domain, the initial condition of an inductor translates to an impedance sL in series with an independent voltage source of magnitude LI_0 opposing the assumed current direction.

56. A
Explanation: A NAND gate outputs 0 exclusively when all its inputs are logic 1. For any other input combination, it outputs a 1.

57. B
Explanation: The ripple factor $\gamma = \sqrt{(V_{rms}/V_{dc})^2 - 1}$. For a full-wave rectifier, this calculates to approximately 0.482 or 48.2
58. C
Explanation: For an intrinsic (pure) semiconductor, the number of electrons equals the number of holes, placing the Fermi energy level squarely in the center of the bandgap.

59. B
Explanation: At high frequencies, the parasitic junction capacitances and the time it takes for minority carriers to cross the base (transit time) limit the switching speed and gain of the BJT.

60. B
Explanation: The motor is initially connected in star, so the phase voltage is $V_L/\sqrt{3}$. This reduces the starting current to 1/3 of what it would be in direct delta starting.

61. C
Explanation: A zero determinant implies the matrix is singular, meaning its rank is less than n, and thus its rows (or columns) are linearly dependent vectors.

62. C
Explanation: If $A^2 = A$, then for an eigenvalue λ and eigenvector x, $A^2x = Ax \Rightarrow \lambda^2 x = \lambda x \Rightarrow \lambda^2 - \lambda = 0 \Rightarrow \lambda(\lambda - 1) = 0$. Thus $\lambda = 0$ or 1.

63. C
Explanation: The gradient vector ∇f points in the direction of the greatest rate of increase of the scalar field f at any given point.

64. C
Explanation: $\nabla f = 2xy\hat{i} + x^2\hat{j}$. At $(1, 2)$, $\nabla f = 4\hat{i} + \hat{j}$. The unit vector is $(\hat{i} + \hat{j})/\sqrt{2}$. The directional derivative is $(4)(1/\sqrt{2}) + (1)(1/\sqrt{2}) = 5/\sqrt{2}$.

65. A
Explanation: Using the Beta function formula for $\int_0^{\pi/2} \sin^p x \cos^q x dx = \frac{\Gamma((p+1)/2)\Gamma((q+1)/2)}{2\Gamma((p+q+2)/2)}$. Here $p = 3, q = 2$. Result is $\frac{\Gamma(2)\Gamma(1.5)}{2\Gamma(3.5)} = \frac{1\times(0.5)\sqrt{\pi}}{2\times(2.5)(1.5)(0.5)\sqrt{\pi}} = \frac{1}{2\times3.75} = \frac{2}{15}$.

66. B
Explanation: The auxiliary equation is $m^2 + 9 = 0 \Rightarrow m = \pm 3i$. The roots are purely imaginary, resulting in a trigonometric solution $y = c_1 \cos 3x + c_2 \sin 3x$.

67. A
Explanation: The equation is of the form $y' + P(x)y = Q(x)$ where $P(x) = 1/x$. The integrating factor is $e^{\int (1/x)dx} = e^{\ln x} = x$.

68. A
Explanation: The Laplace transform of $\cos 3t$ is $s/(s^2 + 9)$. Using the first shifting theorem, multiplying by e^{2t} replaces s with $s - 2$, yielding $\frac{s-2}{(s-2)^2+9}$.

69. B
Explanation: Let $z = x + iy$. $z^2 = (x + iy)^2 = x^2 - y^2 + i(2xy)$. Therefore, the real part $u = x^2 - y^2$ and the imaginary part $v = 2xy$.

70. B
Explanation: The poles are at $\pm 2i$. The residue at the simple pole $z = 2i$ is $\lim_{z\to 2i}(z - 2i)\frac{1}{(z-2i)(z+2i)} = \frac{1}{4i} = -\frac{i}{4}$.

71. B
Explanation: The probability is $P(\text{1st Ace})\times P(\text{2nd Ace} \mid \text{1st Ace}) = (4/52)\times(3/51) = (1/13) \times (1/17) = 1/221$.

72. A
Explanation: For a uniform distribution over $[a, b]$, the variance is $(b - a)^2/12$. Here, $(10 - 0)^2/12 = 100/12$.

73. A
Explanation: To find the reciprocal, we find the root of $f(x) = 1/x - N = 0$. $f'(x) = -1/x^2$. The Newton-Raphson formula is $x_{n+1} = x_n - f(x_n)/f'(x_n) = x_n - (1/x_n - N)/(-1/x_n^2) = x_n + x_n^2(1/x_n - N) = x_n + x_n - Nx_n^2 = x_n(2 - Nx_n)$.

74. B
Explanation: Simpson's 3/8 rule uses cubic polynomials for interpolation, which requires groups of 4 points, meaning the number of segments (sub-intervals) must be a multiple of 3.

75. A
Explanation: $\nabla \cdot \mathbf{V} = \frac{\partial}{\partial x}(x^2) + \frac{\partial}{\partial y}(y^2) + \frac{\partial}{\partial z}(z^2) = 2x + 2y + 2z = 2(x + y + z)$.

76. A
Explanation: By D'Alembert's formula, any function of the form $f(x-ct)$ or $g(x+ct)$ represents a traveling wave and is a direct solution to the one-dimensional wave equation.

77. B
Explanation: For a binomial distribution, the expected value (mean) is given by $E(X) = n \times p$. Thus, $E(X) = 10 \times 0.4 = 4$.

78. C
Explanation: This is the classic two-dimensional Laplace equation, which describes steady-state heat conduction, electrostatics, and ideal fluid flow.

79. B
Explanation: All rows are identical (linearly dependent on the first row). Using row operations, all rows except the first can be reduced to zero. Thus, the rank is 1.

80. B
Explanation: By Green's Theorem, $\oint_C (Pdx + Qdy) = \iint_R (\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y})dA$. Here $P = -y, Q = x$. The integrand becomes $\frac{\partial}{\partial x}(x) - \frac{\partial}{\partial y}(-y) = 1 - (-1) = 2$. Integral is $\iint 2dA = 2A$.

81. C
Explanation: We use soap for washing clothes. According to the given coding scheme, 'SOAP' is called 'INK'.

82. C
Explanation: The sequence represents perfect cubes: $2^3 = 8, 3^3 = 27, 4^3 = 64, 5^3 = 125, 6^3 = 216$. The number 100 is 10^2 (a perfect square, not a cube), making it the odd one out.

83. A
Explanation: He walks South (5km), turns right (faces West) and walks 3km. Turns right again (faces North) and walks 5km. He is now exactly 3km West of his starting position.

84. A
Explanation: Let son's age be S. Father's age is $S + 30$. In 5 years: $(S + 30) + 5 = 3(S + 5)$. $S + 35 = 3S + 15 \Rightarrow 2S = 20 \Rightarrow S = 10$.

85. B
Explanation: Position from right = (Total students - Position from left) + 1. So, $(40 - 14) + 1 = 26 + 1 = 27$th.

86. C
Explanation: Since all pens are pencils and no pencil is an eraser, no pen can be an eraser (I is true). Since all pens are pencils, some pencils must be pens (II is true). Both follow.

87. A
Explanation: Total distance = 200 + 100 = 300m. Time = 15s. Speed = 300/15 = 20 m/s. Convert to km/hr: $20 \times (18/5) = 72$ km/hr.

88. A
Explanation: P + Q means P is the brother of Q. Q * R means Q is the father of R. Therefore, P is the brother of R's father, which means P is the uncle of R.

89. C
Explanation: The pattern of alphabetical shifts is: A (+2) = C (+3) = F (+4) = J (+5) = O (+6) = U.

90. B
Explanation: Net work done in 1 hour = $(1/10) - (1/15) = (3-2)/30 = 1/30$. It takes 30 hours to fill the tank.