OJEE M Tech Electrical Sample Paper 01

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. In a series RLC circuit, if the resistance is doubled, the bandwidth of the circuit will:

A. Double

B. Halve

C. Remain unchanged

D. Quadruple

Q2. The Thevenin equivalent voltage V_{th} and resistance R_{th} across the terminals of a network are 10 V and 2Ω respectively. The maximum power that can be transferred to a variable load resistor is:

A. 12.5 W

B. 50 W

C. 25 W

D. 10 W

Q3. In a two-port network, the h-parameters are $h_{11} = 2\Omega$, $h_{12} = 0.5$, $h_{21} = -0.5$, $h_{22} = 1S$. The network is:

A. Reciprocal and passive

B. Non-reciprocal and active

C. Reciprocal and active

D. Non-reciprocal and passive

Q4. A continuous-time LTI system has impulse response $h(t) = e^{-at}u(t)$ with $a > 0$. The system is:

A. Causal and unstable

B. Non-causal and stable

C. Causal and stable

D. Non-causal and unstable

Q5. The region of convergence (ROC) of the z-transform of the sequence $x[n] = 2^n u[n] - 3^n u[-n-1]$ is:

A. $|z| > 2$

B. $|z| < 3$

C. $2 < |z| < 3$

D. $|z| > 3$

Q6. The fundamental period of the discrete-time signal $x[n] = \cos(\pi n/3) + \sin(\pi n/4)$ is:

A. 12

B. 24

C. 6

D. 8

Q7. A 3-phase, 50 Hz, 4-pole induction motor runs at 1440 rpm. The frequency of rotor currents is:

A. 50 Hz

B. 2 Hz

C. 4 Hz

D. 100 Hz

Q8. In a DC shunt motor, if the field flux is reduced by 20% while keeping the armature voltage and current constant, the speed will:

A. Decrease by 20%

B. Increase by 20%

C. Increase by 25%

D. Decrease by 25%

Q9. The efficiency of a transformer is maximum when:

A. Iron losses equal copper losses

B. Copper losses are zero

C. Iron losses are zero

D. Copper losses are half of iron losses

Q10. A synchronous generator is connected to an infinite bus. If its excitation is increased, it will:

A. Deliver more real power

B. Deliver more reactive power

C. Consume more reactive power

D. Consume more real power

Q11. In a Y-Y connected transformer, the presence of third harmonic currents is prevented if:

A. The primary neutral is grounded

B. The secondary neutral is grounded

C. Both neutrals are ungrounded

D. A tertiary delta winding is added

Q12. A single-phase fully controlled rectifier supplies a highly inductive load. If the firing angle is $\alpha = 60°$, the displacement factor is:

A. 0.5

B. 0.866

C. 1.0

D. 0.707

Q13. In a boost converter, the input voltage is 12 V and the duty cycle is 0.75. The output voltage is:

A. 16 V

B. 48 V

C. 36 V

D. 24 V

Q14. A single-phase voltage source inverter produces a square wave output. The ratio of the 3rd harmonic voltage to the fundamental voltage is:

A. 1/3

B. 1/9

C. 1/27

D. $1/\sqrt{3}$

Q15. The critical clearing angle of a power system is associated with:

A. Reactive power limit

B. Steady-state stability

C. Transient stability

D. Voltage stability

Q16. In load flow analysis, a slack bus is specified by:

A. $|V|$ and δ

B. P and Q

C. P and $|V|$

D. Q and δ

Q17. For a transmission line, if the surge impedance loading (SIL) is 100 MW and the line length is halved, the new SIL will be:

A. 50 MW

B. 200 MW

C. 100 MW

D. 141 MW

Q18. The zero-sequence current in a delta-connected load is:

A. Always zero in the line

B. Always zero in the phase

C. Equal to positive sequence

D. Equal to negative sequence

Q19. The characteristic equation of a closed-loop system is $s^3 + 3s^2 + Ks + 4 = 0$. For the system to be stable, K must be:

A. $K > 0$

B. $K > 4/3$

C. $K > 3$

D. $K < 4/3$

Q20. The transfer function $G(s) = \frac{1+0.5s}{1+s}$ represents a:

A. Lead compensator

B. Lag compensator

C. Lag-lead compensator

D. Proportional controller

Q21. The steady-state error of a type-1 system to a unit step input is:

A. 0

B. $1/K_p$

C. $1/K_v$

D. ∞

Q22. The Nyquist plot of an open-loop transfer function encircles the $(-1, 0)$ point twice in the clockwise direction. If there are no open-loop poles in the right half of the s-plane, the closed-loop system is:

A. Stable

B. Unstable with 2 poles in RHS

C. Unstable with 1 pole in RHS

D. Marginally stable

Q23. In an n-channel JFET, the pinch-off voltage is $V_p = -4$ V. If $V_{GS} = -2$ V, the JFET operates in the:

A. Cut-off region

B. Ohmic region (if V_{DS} is low)

C. Saturation region (if $V_{DS} > 2$ V)

D. Both B and C

Q24. An op-amp circuit acts as a differentiator. At high frequencies, it behaves as a:

A. Low-pass filter

B. High-pass filter

C. Band-pass filter

D. Band-reject filter

Q25. The common-mode rejection ratio (CMRR) of an ideal operational amplifier is:

A. 0

B. 1

C. 100

D. ∞

Q26. In a 4-bit synchronous counter, the maximum count is:

A. 15

B. 16

C. 7

D. 8

Q27. A JK flip-flop with $J = 1$ and $K = 1$ acts as a:

A. D flip-flop

B. T flip-flop

C. SR flip-flop

D. Latch

Q28. The number of multiplexers required to construct a 16×1 MUX using only 4×1 MUXs is:

A. 4

B. 5

C. 6

D. 3

Q29. The resolution of a 10-bit analog-to-digital converter with a 5V reference is approximately:

A. 5 mV

B. 4.88 mV

C. 9.76 mV

D. 2.44 mV

Q30. Which bridge is most suitable for measuring a capacitor with high dissipation factor (high dielectric loss)?

A. Schering bridge

B. Maxwell bridge

C. Hay bridge

D. Anderson bridge

Q31. In a PMMC instrument, the deflecting torque is directly proportional to:

A. Square of the current

B. Current

C. Square root of current

D. Inverse of current

Q32. A CRT has an accelerating voltage of 2000 V. If this voltage is doubled, the deflection sensitivity will:

A. Double

B. Halve

C. Remain same

D. Quadruple

Q33. The electric field **E** in a region is given by $2x\hat{i} - y\hat{j} + z\hat{k}$. The volume charge density at $(1, 1, 1)$ assuming free space is:

A. ϵ_0

B. $2\epsilon_0$

C. 0

D. $-\epsilon_0$

Q34. In a lossless transmission line, the reflection coefficient at the load is 0.5. The voltage standing wave ratio (VSWR) is:

A. 1.5

B. 2.0

C. 3.0

D. 4.0

Q35. The depth of penetration (skin depth) of an electromagnetic wave in a good conductor is proportional to:

A. $\sqrt{f}$

B. $1/\sqrt{f}$

C. f

D. $1/f$

Q36. A chopper circuit is operating at a frequency of 2 kHz with a duty cycle of 0.4. The ON time of the chopper is:

A. 0.2 ms

B. 0.4 ms

C. 0.8 ms

D. 1.0 ms

Q37. In a 3-phase semi-converter, the maximum firing angle delay is:

A. 90°

B. 120°

C. 180°

D. 210°

Q38. The latching current of a thyristor is 10 mA. Its holding current will most likely be:

A. 5 mA

B. 15 mA

C. 10 mA

D. 20 mA

Q39. A 100 kVA, 1000 V / 100 V, 50 Hz single-phase transformer has an eddy current loss of 100 W. If it is operated at 2000 V / 200 V, 100 Hz, the eddy current loss will be:

A. 100 W

B. 200 W

C. 400 W

D. 800 W

Q40. The starting torque of a split-phase induction motor is produced by:

A. Changing the number of poles

B. Introducing a phase difference between main and auxiliary winding currents

C. Adding a capacitor in series with the main winding

D. Reducing the supply voltage

Q41. The power angle characteristic of a salient pole synchronous machine contains a second harmonic term due to:

A. Reluctance torque

B. Field excitation

C. Armature reaction

D. Eddy currents

Q42. In a power system, a solid three-phase fault occurs at a bus. The voltage at that bus during the fault is:

A. 1.0 pu

B. 0.5 pu

C. 0 pu

D. ∞

Q43. The rate of rise of restriking voltage (RRRV) in a circuit breaker depends on:

A. System voltage only

B. Inductance and capacitance of the system

C. Resistance of the system

D. Power factor of the load

Q44. For economic dispatch, the penalty factor for a plant is exactly 1.0 when:

A. Transmission losses are zero

B. Incremental transmission loss is maximum

C. The plant is operating at its maximum limit

D. The plant is located at the load center (no loss derivative)

Q45. A PI controller is used to:

A. Decrease steady-state error without affecting stability

B. Eliminate steady-state error and decrease bandwidth

C. Improve transient response

D. Both A and B

Q46. The root locus of a system has 3 branches ending at infinity. The angles of asymptotes are:

A. $60°, 180°, 300°$

B. $90°, 180°, 270°$

C. $0°, 120°, 240°$

D. $45°, 135°, 225°$

Q47. In state-space representation, the matrix A determines:

A. The inputs to the system

B. The natural dynamics and stability of the system

C. The output observations

D. The feedforward path

Q48. A half-wave rectifier is followed by a capacitor filter. As the load resistance increases, the ripple factor:

A. Increases

B. Decreases

C. Remains the same

D. Becomes zero

Q49. An ideal op-amp circuit has a resistor R_f in the negative feedback path and a capacitor C connecting the inverting input to ground. This circuit acts as a:

A. Differentiator

B. Integrator

C. Non-inverting amplifier with frequency-dependent gain (high pass)

D. Low-pass filter

Q50. The output of a logic gate is 1 only when all its inputs are 0. The gate is a:

A. NAND

B. NOR

C. EX-OR

D. AND

Q51. In standard TTL logic, a floating input is considered as:

A. Logic 0

B. Logic 1

C. High impedance

D. Undefined

Q52. A 3-input majority gate produces a logic 1 output if:

A. All 3 inputs are 1

B. At least 2 inputs are 1

C. Exactly 1 input is 1

D. No inputs are 1

Q53. The magnetic flux density **B** and magnetic field intensity **H** are related by $\mathbf{B} = \mu\mathbf{H}$. In a ferromagnetic material, μ is:

A. Constant

B. Dependent on **H**

C. Zero

D. Negative

Q54. According to Faraday's law of electromagnetic induction, the induced EMF is proportional to:

A. Magnetic flux

B. Rate of change of magnetic flux

C. Magnetic field intensity

D. Permeability

Q55. A transmission line of characteristic impedance 50Ω is terminated by a 50Ω load. The reflection coefficient is:

A. 1

B. -1

C. 0

D. ∞

Q56. The torque equation of an electrodynamometer type wattmeter is proportional to:

A. $I_1^2 \frac{dM}{d\theta}$

B. $I_1 I_2 \frac{dM}{d\theta}$

C. $I_2^2 \frac{dM}{d\theta}$

D. $V \frac{dM}{d\theta}$

Q57. In a digital multimeter, the parameter that limits the speed of reading is typically:

A. The display

B. The ADC conversion time

C. The input impedance

D. The battery voltage

Q58. A current of $I = 10 + 10\sin(t)$ A is measured by a moving iron instrument. The reading will be:

A. 10 A

B. $10\sqrt{2}$ A

C. 12.24 A

D. 14.14 A

Q59. The sequence components of a balanced three-phase voltage are:

A. $V_1 \neq 0, V_2 = 0, V_0 = 0$

B. $V_1 = 0, V_2 \neq 0, V_0 = 0$

C. $V_1 = 0, V_2 = 0, V_0 \neq 0$

D. $V_1 \neq 0, V_2 \neq 0, V_0 \neq 0$

Q60. In a DC generator, the purpose of interpoles is to:

A. Increase the main flux

B. Cancel armature reaction at the magnetic neutral axis

C. Provide mechanical support

D. Reduce windage losses

Q61. The rank of a 4×4 skew-symmetric matrix can never be:

A. 2

B. 3

C. 4

D. 0

Q62. Let A be a 3×3 matrix with eigenvalues 1, -1, and 0. Then the determinant of $I + A^{100}$ is:

A. 2

B. 4

C. 0

D. 1

Q63. The system of linear equations $x + y + z = 1$, $2x + 2y + 2z = 2$, $3x + 3y + 3z = 3$ has:

A. Unique solution

B. No solution

C. Infinite solutions

D. Two solutions

Q64. If $u = x^2 + y^2 + z^2$, then the divergence of the gradient of u $(\nabla \cdot \nabla u)$ is:

A. 2

B. 4

C. 6

D. 0

Q65. The value of the integral $\int_{-\infty}^{\infty} e^{-x^2} dx$ is:

A. π

B. $\sqrt{\pi}$

C. $\pi/2$

D. $2\sqrt{\pi}$

Q66. The limit $\lim_{x\to 0} \frac{x-\sin x}{x^3}$ is equal to:

A. $1/6$

B. $1/3$

C. 0

D. ∞

Q67. The maximum value of the function $f(x) = x^3 - 3x$ on the interval $[-2, 2]$ is:

A. 2

B. -2

C. 0

D. 4

Q68. The solution to the differential equation $\frac{dy}{dx} + y = e^{-x}$ with $y(0) = 1$ is:

A. $y = (x+1)e^{-x}$

B. $y = xe^{-x}$

C. $y = e^{-x}$

D. $y = (x-1)e^{-x}$

Q69. The particular integral 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. $\frac{x}{2}\sin(2x)$

Q70. The Laplace transform of $t\sin(at)$ is:

A. $\frac{2as}{(s^2+a^2)^2}$

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

C. $\frac{2a}{(s^2+a^2)^2}$

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

Q71. If $f(z) = u(x,y) + iv(x,y)$ is an analytic function and $u(x,y) = x^2 - y^2$, then $v(x,y)$ can be:

A. $2xy + C$

B. $x^2 + y^2 + C$

C. $-2xy + C$

D. $x + y + C$

Q72. The value of the contour integral $\oint_C \frac{1}{z^2+1} dz$, where C is the circle $|z| = 2$ traversed counterclockwise, is:

A. πi

B. $-\pi i$

C. $2\pi i$

D. 0

Q73. The residue of $f(z) = \frac{e^z}{(z-1)^2}$ at $z = 1$ is:

A. e

B. 1

C. $e/2$

D. $2e$

Q74. A fair coin is tossed 3 times. The probability of getting exactly 2 heads is:

A. $1/8$

B. $3/8$

C. $1/2$

D. $5/8$

Q75. If X is a Poisson random variable with mean $\lambda = 2$, then $P(X = 0)$ is:

A. e^{-2}

B. $2e^{-2}$

C. $1 - e^{-2}$

D. 0.5

Q76. In a factory, machines A, B, and C produce 20%, 30%, and 50% of the products, respectively. The defect rates are 5%, 3%, and 2%. If a drawn product is defective, the probability it came from machine A is:

A. 10/29

B. 9/29

C. 10/19

D. 1/5

Q77. Two independent random variables X and Y have variances 3 and 4 respectively. The variance of $Z = 2X - Y$ is:

A. 2

B. 8

C. 16

D. 10

Q78. Using the Newton-Raphson method, the iterative formula to find the square root of a real number R is:

A. $x_{n+1} = \frac{1}{2}\left(x_n + \frac{R}{x_n}\right)$

B. $x_{n+1} = \frac{1}{2}\left(x_n - \frac{R}{x_n}\right)$

C. $x_{n+1} = x_n - \frac{R}{x_n}$

D. $x_{n+1} = 2x_n - R$

Q79. The Simpson's 1/3 rule for numerical integration is exact for polynomials of degree up to:

A. 1

B. 2

C. 3

D. 4

Q80. The local truncation error in the Euler method for solving ordinary differential equations is of the order:

A. $O(h)$

B. $O(h^2)$

C. $O(h^3)$

D. $O(h^4)$

Q81. If "ELECTRICAL" is coded as "FMFDUSJDBM", how will "MACHINE" be coded?

A. NBDJMOF

B. NBDJIOF

C. NCDIJOF

D. NBDKMOF

Q82. Find the next term in the series: 3, 7, 15, 31, 63, ...

A. 127

B. 125

C. 130

D. 121

Q83. Pointing to a photograph of a boy, Suresh said, "He is the son of the only son of my mother." How is Suresh related to that boy?

A. Brother

B. Uncle

C. Cousin

D. Father

Q84. Six persons A, B, C, D, E, F are sitting in a circle facing the center. B is between F and C. A is between E and D. F is to the immediate left of D. Who is sitting opposite to A?

A. B

B. C

C. E

D. F

Q85. A clock shows 3:15. What is the acute angle between the hour hand and the minute hand?

A. 0°

B. 7.5°

C. 15°

D. 22.5°

Q86. Statements: 1. All generators are motors. 2. Some motors are transformers. Conclusion I: Some generators are transformers. Conclusion II: No generator is a transformer.

A. Only I follows

B. Only II follows

C. Either I or II follows

D. Neither I nor II follows

Q87. A train 150 meters long is running at a speed of 90 km/hr. How much time will it take to cross a bridge 300 meters long?

A. 15 seconds

B. 18 seconds

C. 20 seconds

D. 25 seconds

Q88. If 10 engineers can design a circuit in 15 days, how many engineers are required to design the same circuit in 5 days?

A. 15

B. 20

C. 30

D. 50

Q89. The price of copper increases by 25%. By what percentage must a factory reduce its consumption of copper so that the expenditure remains the same?

A. 25%

B. 20%

C. 15%

D. 30%

Q90. A bag contains 4 red balls, 5 black balls, and 3 green balls. If one ball is drawn at random, what is the probability that it is not green?

A. 1/4

B. 3/4

C. 1/2

D. 5/12

Solutions

1. A
Explanation: In a series RLC circuit, the bandwidth is given by $BW = R/L$. Since bandwidth is directly proportional to the resistance R, doubling the resistance will double the bandwidth.

2. A
Explanation: Maximum power is transferred when the load resistance equals the Thevenin resistance ($R_L = R_{th}$). The maximum power is calculated as $P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{10^2}{4\times 2} = 12.5$ W.

3. A
Explanation: A network is reciprocal if $h_{12} = -h_{21}$, which is true here ($0.5 = -(-0.5)$). It is passive because the parameters imply that no internal power is generated and it strictly dissipates energy.

4. C
Explanation: The impulse response is $h(t) = e^{-at}u(t)$. Since $a > 0$, the pole is at $s = -a$ (in the left half-plane), making the system stable. The presence of $u(t)$ ensures the system is causal.

5. C
Explanation: The right-sided sequence $2^n u[n]$ has an ROC of $|z| > 2$. The left-sided sequence $-3^n u[-n-1]$ has an ROC of $|z| < 3$. The intersection of these two regions is $2 < |z| < 3$.

6. B
Explanation: The period of $\cos(\pi n/3)$ is $N_1 = 2\pi/(\pi/3) = 6$. The period of $\sin(\pi n/4)$ is $N_2 = 2\pi/(\pi/4) = 8$. The fundamental period of the combined signal is the LCM of 6 and 8, which is 24.

7. B
Explanation: The synchronous speed is $N_s = \frac{120\times 50}{4} = 1500$ rpm. The slip is $s = \frac{1500-1440}{1500} = 0.04$. The rotor frequency is $f_r = s \times f_s = 0.04 \times 50 = 2$ Hz.

8. C
Explanation: The speed of a DC motor is inversely proportional to the field flux ($N \propto 1/\Phi$). If the flux is reduced to 80% (0.8Φ), the new speed becomes $1/0.8 = 1.25$ times the original speed, an increase of 25%.

9. A
Explanation: The efficiency of a transformer reaches its maximum value when the variable losses (copper losses) become exactly equal to the constant losses (iron losses).

10. B
Explanation: When a synchronous generator is connected to an infinite bus, its real power is determined by the prime mover. Increasing the DC field excitation causes the generator to become over-excited and deliver more reactive power.

11. C
Explanation: Third harmonic currents are zero-sequence in nature and require a return path to flow. If both the primary and secondary neutral points are ungrounded, the return path is broken, preventing these currents.

12. A
Explanation: For a fully controlled single-phase rectifier with a highly inductive load, the displacement factor is the cosine of the firing angle. Thus, displacement factor = $\cos(\alpha) = \cos(60°) = 0.5$.

13. B
Explanation: For a step-up (boost) converter, the output voltage is given by $V_{out} = \frac{V_{in}}{1-D}$. Substituting the given values: $V_{out} = \frac{12}{1-0.75} = \frac{12}{0.25} = 48$ V.

14. A
Explanation: The Fourier series expansion of a square wave yields peak amplitudes of $4V/(n\pi)$ for the n-th harmonic. The ratio of the 3rd harmonic to the fundamental is therefore $(4V/3\pi)/(4V/\pi) = 1/3$.

15. C
Explanation: The critical clearing angle is a key concept in equal-area criterion analysis. It determines the maximum angle (and time) a fault can be sustained without the power system losing its transient stability.

16. A
Explanation: In load flow studies, the slack (or swing) bus compensates for the system losses. To serve as a reference, its voltage magnitude ($|V|$) and phase angle (δ, usually set to $0°$) are specified.

17. C
Explanation: Surge Impedance Loading (SIL) is defined as V^2/Z_c, where Z_c is the characteristic impedance of the line. Since Z_c depends only on line parameters (L and C) per unit length, SIL is independent of the line's length.

18. A
Explanation: Zero-sequence currents are co-phasal. In a delta connection, they circulate within the closed delta loop but cannot exit into the line conductors. Therefore, the zero-sequence line current is always zero.

19. B
Explanation: Applying the Routh-Hurwitz criterion to $s^3 + 3s^2 + Ks + 4 = 0$, the s^1 row evaluates to $\frac{3K-4}{3}$. For the system to be stable, this term must be positive, which requires $3K > 4$, or $K > 4/3$.

20. B
Explanation: The transfer function $G(s) = \frac{1+0.5s}{1+s}$ can be rewritten with a pole at $s = -1$ and a zero at $s = -2$. Since the pole is closer to the origin than the zero, it acts as a lag compensator.

21. A
Explanation: A type-1 control system has one pole at the origin (integrator). This integration forces the steady-state error to zero when the system is subjected to a constant (unit step) input.

22. B
Explanation: Using the Nyquist criterion $Z = P - N$, where $N = -2$ (two clockwise encirclements) and $P = 0$ (no right-half plane open-loop poles). Thus, $Z = 0-(-2) = 2$, meaning there are 2 closed-loop poles in the RHS, making it unstable.

23. D
Explanation: The pinch-off voltage $V_p = -4$ V and $V_{GS} = -2$ V. Since $V_{GS} > V_p$, the channel is open. It operates in the ohmic region if V_{DS} is low, and enters saturation when $V_{DS} \geq V_{GS} - V_p = 2$ V. Thus, both B and C are conditions for operation.

24. B
Explanation: An ideal differentiator's gain increases linearly with frequency. At high frequencies, it amplifies signals significantly while attenuating low frequencies, functionally behaving as a high-pass filter.

25. D
Explanation: The Common-Mode Rejection Ratio (CMRR) is the ratio of differential gain to common-mode gain. An ideal op-amp amplifies only differential signals and completely rejects common-mode signals, leading to an infinite CMRR.

26. A
Explanation: An n-bit counter has 2^n distinct states, typically counting from 0 to $2^n - 1$. For a 4-bit synchronous counter, the maximum count is $2^4 - 1 = 15$.

27. B
Explanation: When both J and K inputs are held at Logic 1, the JK flip-flop toggles its output state on every active clock edge. This is exactly the operational behavior of a T (Toggle) flip-flop.

28. B
Explanation: To build a 16×1 MUX, you need four 4×1 MUXs in the first stage to handle the 16 inputs. The 4 outputs from this stage feed into a single 4×1 MUX in the second stage. Total $= 4 + 1 = 5$ MUXs.

29. B
Explanation: The resolution is the smallest analog voltage change the ADC can detect, calculated as $V_{ref}/(2^n - 1)$. For $n = 10$ and $V_{ref} = 5$ V, resolution $= 5/1023 \approx 4.88$ mV.

30. A
Explanation: The Schering bridge is widely used in AC circuits to measure unknown capacitance, dielectric loss, and the dissipation factor of a capacitor with high precision.

31. B
Explanation: In a Permanent Magnet Moving Coil (PMMC) instrument, the deflecting torque is given by $T_d = BINA$. Since the magnetic field B, area A, and turns N are constant, T_d is directly proportional to the current I.

32. B
Explanation: Deflection sensitivity in a Cathode Ray Tube (CRT) is defined as the deflection on the screen per unit of deflecting voltage. It is inversely proportional to the accelerating voltage; thus, doubling the voltage halves the sensitivity.

33. B
Explanation: By Gauss's Law in differential form, $\nabla \cdot \mathbf{E} = \rho/\epsilon_0$. Calculating the divergence: $\frac{\partial}{\partial x}(2x) + \frac{\partial}{\partial y}(-y) + \frac{\partial}{\partial z}(z) = 2 - 1 + 1 = 2$. Therefore, $\rho = 2\epsilon_0$.

34. C
Explanation: The Voltage Standing Wave Ratio (VSWR) is calculated from the reflection coefficient $|\Gamma|$ using the formula $VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$. Substituting $|\Gamma| = 0.5$ gives $\frac{1.5}{0.5} = 3.0$.

35. B
Explanation: The skin depth (δ) of an electromagnetic wave in a good conductor is given by $\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$. Therefore, it is inversely proportional to the square root of the frequency ($\sqrt{f}$).

36. A
Explanation: The total time period of the chopper is $T = 1/f = 1/2000 = 0.5$ ms. The ON time is determined by the duty cycle (D), so $T_{on} = D \times T = 0.4 \times 0.5 = 0.2$ ms.

37. C
Explanation: In a 3-phase semi-converter, the presence of freewheeling action from the

diodes prevents negative voltage excursions. This allows the thyristors to be triggered up to a maximum delay angle of 180° before commutation fails.

38. A

Explanation: The holding current is the minimum current required to keep the thyristor in the ON state, and it is inherently lower than the latching current (the current needed to initially turn it ON). Thus, 5 mA is the most likely value.

39. C

Explanation: Eddy current loss is proportional to $f^2 B_{max}^2$. Since V/f ratio is constant $(1000/50 = 2000/100)$, B_{max} remains constant. When frequency doubles from 50 Hz to 100 Hz, the loss quadruples to 400 W.

40. B

Explanation: A single-phase induction motor has no starting torque. A split-phase motor uses an auxiliary winding with a different R/X ratio to create a phase difference between currents, producing a rotating magnetic field to start.

41. A

Explanation: In a salient pole synchronous machine, the air gap is non-uniform. The difference between direct-axis and quadrature-axis reactances $(X_d \neq X_q)$ produces a reluctance torque, which adds a second harmonic term to the power-angle curve.

42. C

Explanation: A solid three-phase fault is a symmetric short circuit with zero fault impedance. Because all three phases are directly shorted to ground (or each other) with zero resistance, the bus voltage drops entirely to 0 pu.

43. B

Explanation: When a circuit breaker opens to clear a fault, the transient restriking voltage oscillates across the contacts. The natural frequency of this oscillation, and thus the RRRV, depends entirely on the system's inductance (L) and capacitance (C).

44. D

Explanation: The penalty factor is defined as $L_i = \frac{1}{1-\partial P_L/\partial P_i}$. If a plant is at the load center, an increase in its generation does not increase transmission losses $(\partial P_L/\partial P_i = 0)$, making the penalty factor exactly 1.0.

45. B

Explanation: A Proportional-Integral (PI) controller adds a pole at the origin. This integration eliminates steady-state error for a step input. However, adding the pole reduces the system's overall bandwidth and can reduce relative stability.

46. A

Explanation: The angles of asymptotes for a root locus are given by $\theta = \frac{(2k+1)180^\circ}{P-Z}$. With 3 branches ending at infinity ($P-Z=3$), the angles for $k=0,1,2$ are $60^\circ, 180^\circ$, and 300°.

47. B
Explanation: In the state-space equation $\dot{x} = Ax + Bu$, the system matrix A contains the coefficients that dictate how the states evolve over time. Its eigenvalues correspond to the system's poles, determining natural dynamics and stability.

48. B
Explanation: A capacitor filter smooths the output voltage. As the load resistance R_L increases, the time constant R_LC becomes larger. This results in a slower discharge of the capacitor between peaks, thereby decreasing the ripple factor.

49. C
Explanation: With the input applied to the non-inverting terminal and an RC network (capacitor to ground, resistor in feedback) on the inverting side, the circuit's gain is $1 + R_f/(1/sC) = 1 + sR_fC$. This is a non-inverting high-pass filter configuration.

50. B
Explanation: Checking truth tables: An AND gate requires all 1s for a 1. An OR gate gives 1 if any input is 1. A NOR gate is the inverse of an OR gate, so it produces a Logic 1 exclusively when all its inputs are Logic 0.

51. B
Explanation: In standard Transistor-Transistor Logic (TTL) families, an unconnected or floating input behaves as if it is tied to V_{cc}. Therefore, the circuit interprets a floating input as a Logic 1 (High).

52. B
Explanation: A majority gate asserts a logic 1 output if more than half of its inputs are 1. For a 3-input gate, the majority threshold is reached when at least 2 of the 3 inputs are logic 1.

53. B
Explanation: In ferromagnetic materials, the relationship between $\mathbf{B}$ and $\mathbf{H}$ is highly non-linear, characterized by the hysteresis loop. Therefore, the permeability $\mu = \mathbf{B}/\mathbf{H}$ is not constant and depends heavily on the applied magnetic field intensity $\mathbf{H}$.

54. B
Explanation: Faraday's Law states that the induced electromotive force in a closed circuit is directly proportional to the time rate of change of the magnetic flux passing through it ($E = -d\Phi/dt$).

55. C

Explanation: The reflection coefficient is $\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$. Since the load impedance Z_L exactly matches the characteristic impedance Z_0 ($50\Omega = 50\Omega$), the numerator is zero, leading to a reflection coefficient of 0.

56. B

Explanation: In an electrodynamometer wattmeter, the fixed coils carry the line current I_1 and the moving coil carries current I_2 proportional to the voltage. The deflecting torque T_d is proportional to the product $I_1 I_2$ and the rate of change of mutual inductance $\frac{dM}{d\theta}$.

57. B

Explanation: A digital multimeter uses an Analog-to-Digital Converter (ADC) to translate the measured value for the display. The conversion process, especially in dual-slope integrating ADCs commonly used for accuracy, is the primary bottleneck for reading speed.

58. C

Explanation: A moving iron instrument reads the true RMS value of a complex waveform. For $I = 10 + 10\sin(t)$, the RMS value is $\sqrt{I_{dc}^2 + (I_m/\sqrt{2})^2} = \sqrt{10^2 + (10/\sqrt{2})^2} = \sqrt{100 + 50} = \sqrt{150} \approx 12.24$ A.

59. A

Explanation: Symmetrical component analysis splits unbalanced systems into sequence components. A perfectly balanced three-phase voltage system contains only positive sequence components ($V_1 \neq 0$), with zero negative (V_2) and zero-sequence (V_0) components.

60. B

Explanation: Interpoles are small poles placed between the main poles in a DC machine. Their winding is in series with the armature, and they generate a localized flux that exactly cancels armature reaction in the interpolar axis, enabling sparkless commutation.

61. B

Explanation: A key property of skew-symmetric matrices with real entries is that their rank must always be an even number. Therefore, a 4×4 skew-symmetric matrix can have a rank of 0, 2, or 4, but never an odd number like 3.

62. B

Explanation: The eigenvalues of A are $1, -1, 0$. The eigenvalues of A^{100} are $1^{100} = 1, (-1)^{100} = 1, 0^{100} = 0$. The eigenvalues of $I + A^{100}$ are $1 + 1 = 2, 1 + 1 = 2, 1 + 0 = 1$. The determinant is the product of these eigenvalues: $2 \times 2 \times 1 = 4$.

63. C

Explanation: Dividing the second equation by 2 yields $x + y + z = 1$. Dividing the third equation by 3 also yields $x + y + z = 1$. Since all three equations represent the exact same geometric plane, there are infinite solutions where they intersect.

64. C

Explanation: The gradient is $\nabla u = 2x\hat{i} + 2y\hat{j} + 2z\hat{k}$. The divergence of this gradient vector field is $\nabla \cdot \nabla u = \frac{\partial}{\partial x}(2x) + \frac{\partial}{\partial y}(2y) + \frac{\partial}{\partial z}(2z) = 2 + 2 + 2 = 6$.

65. B

Explanation: This is the standard Gaussian integral. Squaring the integral and converting to polar coordinates proves that the area under the bell curve e^{-x^2} from $-\infty$ to ∞ is exactly $\sqrt{\pi}$.

66. A

Explanation: Using the Maclaurin series expansion for $\sin(x) = x - x^3/3! + x^5/5! - \dots$. Substituting this into the limit gives $\lim_{x\to 0} \frac{x-(x-x^3/6+\dots)}{x^3} = \lim_{x\to 0} \frac{x^3/6}{x^3} = \frac{1}{6}$.

67. A

Explanation: Find critical points by setting the derivative to zero: $f'(x) = 3x^2 - 3 = 0 \Rightarrow x = \pm 1$. Evaluate $f(x)$ at critical points and endpoints: $f(1) = -2, f(-1) = 2, f(2) = 2, f(-2) = -2$. The maximum value on the interval is 2.

68. A

Explanation: This is a linear ODE of the form $y' + Py = Q$. The integrating factor is $IF = e^{\int 1dx} = e^x$. Multiplying through gives $(ye^x)' = 1$. Integrating yields $ye^x = x + C$. Using $y(0) = 1$, $C = 1$, so $y = (x + 1)e^{-x}$.

69. A

Explanation: For $(D^2 + a^2)y = \sin(ax)$, the standard formula for the particular integral is $PI = -\frac{x}{2a}\cos(ax)$. Here $a = 2$, so substituting gives $PI = -\frac{x}{2(2)}\cos(2x) = -\frac{x}{4}\cos(2x)$.

70. A

Explanation: Using the frequency differentiation property: $L\{tf(t)\} = -\frac{d}{ds}F(s)$. The Laplace transform of $\sin(at)$ is $\frac{a}{s^2+a^2}$. Taking the negative derivative with respect to s yields $\frac{2as}{(s^2+a^2)^2}$.

71. A

Explanation: Using the Cauchy-Riemann equations: $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} \Rightarrow 2x = \frac{\partial v}{\partial y} \Rightarrow v = 2xy + f(x)$. Also, $\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x} \Rightarrow -2y = -(2y + f'(x)) \Rightarrow f'(x) = 0$. Thus, $v(x, y) = 2xy + C$.

72. D

Explanation: The roots of $z^2 + 1 = 0$ are $z = \pm i$, both of which lie inside the contour $|z| = 2$. By Cauchy's Residue Theorem, the integral is $2\pi i$ times the sum of residues. The residues at i and $-i$ are $\frac{1}{2i}$ and $-\frac{1}{2i}$. Their sum is 0.

73. A
Explanation: For a pole of order $m = 2$ at $z = 1$, the residue is $\lim_{z\to 1} \frac{d}{dz}\left[(z-1)^2 \frac{e^z}{(z-1)^2}\right] = \lim_{z\to 1} \frac{d}{dz}(e^z)$. The derivative of e^z is e^z, and evaluating at $z = 1$ gives e.

74. B
Explanation: This follows a binomial distribution. The number of trials is $n = 3$, the probability of success (heads) is $p = 0.5$. The probability of getting exactly $k = 2$ heads is $\binom{3}{2}(0.5)^2(0.5)^1 = 3 \times 0.25 \times 0.5 = 0.375$ or $3/8$.

75. A
Explanation: The Probability Mass Function (PMF) for a Poisson distribution is $P(X = k) = \frac{e^{-\lambda}\lambda^k}{k!}$. Plugging in $\lambda = 2$ and $k = 0$, we get $P(X = 0) = \frac{e^{-2}\times 2^0}{0!} = e^{-2}$.

76. A
Explanation: Let D be a defective part. By Bayes' Theorem: $P(A|D) = \frac{P(D|A)P(A)}{P(D|A)P(A)+P(D|B)P(B)+P(D|C)P(}$
This equals $\frac{0.2\times 0.05}{(0.2\times 0.05)+(0.3\times 0.03)+(0.5\times 0.02)} = \frac{0.01}{0.029} = \frac{10}{29}$.

77. C
Explanation: For independent random variables, the variance of a linear combination $aX + bY$ is $a^2Var(X) + b^2Var(Y)$. Thus, $Var(2X - Y) = (2)^2Var(X) + (-1)^2Var(Y) = 4(3) + 1(4) = 12 + 4 = 16$.

78. A
Explanation: To find the square root of R, we find the root of $f(x) = x^2 - R = 0$. Using the Newton-Raphson update $x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$, we get $x_{n+1} = x_n - \frac{x_n^2 - R}{2x_n} = \frac{x_n}{2} + \frac{R}{2x_n} = \frac{1}{2}\left(x_n + \frac{R}{x_n}\right)$.

79. C
Explanation: Simpson's 1/3 rule inherently fits a quadratic parabola to three consecutive points to estimate the integral. Interestingly, due to symmetry, the error term for cubics cancels out, making the method exact for polynomials up to degree 3.

80. B
Explanation: The local truncation error is the error made in a single step of the numerical method. For the standard Euler method (a first-order Taylor method), the error in one step is proportional to the square of the step size, $O(h^2)$.

81. A
Explanation: The logic behind the coding is shifting each letter forward by one alphabetical position (+1 shift). Applying this to "MACHINE": M becomes N, A becomes B, C becomes D, H becomes I, I becomes J, N becomes O, and E becomes F. Result: NBDJMOF.

82. A
Explanation: The sequence follows the pattern $x_{n+1} = (x_n \times 2) + 1$. Applying this to the sequence: $(3 \times 2) + 1 = 7$, $(7 \times 2) + 1 = 15$, $(15 \times 2) + 1 = 31$, $(31 \times 2) + 1 = 63$. The next term is $(63 \times 2) + 1 = 127$.

83. D
Explanation: Break down the statement: "the only son of my mother" refers to Suresh himself. Therefore, the statement simplifies to "He is the son of me (Suresh)." This means Suresh is the father of the boy in the photograph.

84. A
Explanation: Placing the persons in a circle: B is between F and C (sequence F-B-C or C-B-F). F is to the immediate left of D. A is between E and D. Constructing the circle clockwise yields the arrangement: C, B, F, D, A, E. The person opposite A is B.

85. B
Explanation: At 3:15, the minute hand points exactly at 3 (representing 0° from the 3 o'clock mark). In 15 minutes, the hour hand moves $(15/60) \times 30° = 7.5°$ past the 3 o'clock mark. The angle between them is 7.5°.

86. C
Explanation: This is a classic syllogism. We know some motors are transformers, and all generators are motors, but the relationship between generators and transformers is unknown. The conclusions "Some are" and "None are" form a complementary Either/Or pair.

87. B
Explanation: The total distance to be covered is the length of the train plus the length of the bridge ($150 + 300 = 450$ m). The speed in m/s is $90 \times (5/18) = 25$ m/s. Time required = Distance / Speed = $450/25 = 18$ seconds.

88. C
Explanation: This is an inverse proportion problem involving man-days. Let E be the number of engineers. Total work is constant: 10 engineers $\times$ 15 days $= E$ engineers $\times$ 5 days. Solving for E gives $150/5 = 30$ engineers.

89. B
Explanation: Let the initial price and consumption both be 100. New price is 125. To keep expenditure at the original 10000 (100×100), the new consumption must be $10000/125 = 80$. A drop from 100 to 80 is a 20% reduction.

90. B
Explanation: The total number of balls is 4 (red) + 5 (black) + 3 (green) = 12. The number of balls that are not green is $4 + 5 = 9$. The probability of drawing a ball that is not green is $9/12$, which simplifies to $3/4$.