OJEE LE Tech (Diploma) Sample Paper 02

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

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

Q1. If the eigenvalues of a 3×3 matrix A are $1, 2,$ and -3, what is the determinant of A^{-1}?

A. -6

B. 6

C. -1/6

D. 1/6

Q2. For a system of non-homogeneous linear equations $AX = B$, if the rank of A equals the rank of the augmented matrix $[A|B]$ but is less than the number of unknowns, the system has:

A. A unique solution

B. No solution

C. Infinite solutions

D. Trivial solution only

Q3. The value of $\lim_{x\to 0}(\cos x)^{1/x^2}$ is:

A. e

B. $e^{-1/2}$

C. $e^{1/2}$

D. 1

Q4. If $u = x^y$, then the partial derivative $\partial u/\partial x$ is:

A. yx^{y-1}

B. $x^y \ln x$

C. yx^y

D. $x^{y-1} \ln y$

Q5. For a scalar function $\phi(x, y, z)$, the curl of its gradient $(\nabla \times \nabla\phi)$ is always:

A. 1

B. 0

C. $\nabla^2\phi$

D. Undefined

Q6. The integrating factor of the differential equation $x\frac{dy}{dx} - y = x^2$ is:

A. x

B. $1/x$

C. $-x$

D. $-1/x$

Q7. The orthogonal trajectories of the family of straight lines $y = mx$ passing through the origin are:

A. Concentric circles

B. Parallel lines

C. Parabolas

D. Hyperbolas

Q8. The Laplace transform of $t\sin(at)$ is:

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

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

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

D. $\frac{2as}{s^2+a^2}$

Q9. If $\mathcal{L}\{f(t)\} = F(s)$, 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. $\lim_{s\to 0} F(s)$

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

Q10. A box contains 2 defective and 8 good items. If two items are drawn at random without replacement, the probability that both are defective is:

A. 1/25

B. 1/45

C. 2/45

D. 1/50

Q11. In a Poisson distribution, if the mean is 4, then its variance is:

A. 2

B. 4

C. 16

D. 8

Q12. The analytic function $f(z) = u(x, y) + iv(x, y)$ satisfies the Cauchy-Riemann equations, which are:

A. $u_x = v_y, u_y = v_x$

B. $u_x = v_y, u_y = -v_x$

C. $u_x = -v_y, u_y = v_x$

D. $u_x = -v_y, u_y = -v_x$

Q13. The residue of the complex function $f(z) = \frac{1}{(z-1)(z-2)}$ at the pole $z = 1$ is:

A. 1

B. -1

C. 2

D. -2

Q14. If r is the correlation coefficient between two variables, the relation it satisfies is:

A. $0 \leq r \leq 1$

B. $-1 \leq r \leq 1$

C. $r > 1$

D. $r < -1$

Q15. The Newton-Raphson method for finding roots of an equation generally has an order of convergence of:

A. Linear

B. Fractional

C. Quadratic

D. Cubic

Q16. Simpson's 1/3 rule for numerical integration gives exact results for polynomials of degree up to:

A. 1

B. 2

C. 3

D. 4

Q17. In a Fourier series expansion of an even function $f(x)$ over the interval $(-\pi, \pi)$, which terms strictly vanish?

A. Sine terms

B. Cosine terms

C. Constant term

D. Both Sine and Cosine terms

Q18. The value of the integral $\int_0^{\pi/2} \frac{\sqrt{\sin x}}{\sqrt{\sin x}+\sqrt{\cos x}}\,dx$ is:

A. π

B. $\pi/2$

C. $\pi/4$

D. 0

Q19. If A is an orthogonal matrix, then A^{-1} is equal to:

A. A

B. A^T

C. $-A$

D. $|A|$

Q20. The general solution of the differential equation $d^2y/dx^2 + 4y = 0$ is:

A. $y = c_1e^{2x} + c_2e^{-2x}$

B. $y = c_1 \cos 2x + c_2 \sin 2x$

C. $y = (c_1 + c_2 x)e^{2x}$

D. $y = c_1 \cosh 2x + c_2 \sinh 2x$

Q21. The directional derivative of $\phi = x^2yz$ at $(1, 1, 1)$ in the direction of $\mathbf{i} + \mathbf{j} + \mathbf{k}$ is:

A. $4/\sqrt{3}$

B. $\sqrt{3}$

C. 4

D. $2/\sqrt{3}$

Q22. Green's theorem mathematically relates a line integral over a closed plane curve to a:

A. Surface integral

B. Volume integral

C. Double integral

D. Triple integral

Q23. The stationary points of $f(x, y) = x^2 + y^2 - 2x - 4y + 5$ are at:

A. $(1, 2)$

B. $(2, 1)$

C. $(0, 0)$

D. $(-1, -2)$

Q24. The radius of curvature of the curve $y = e^x$ at the point $(0, 1)$ is:

A. $2\sqrt{2}$

B. $\sqrt{2}$

C. 2

D. 1

Q25. The inverse Laplace transform of $1/(s^2 - a^2)$ is:

A. $\frac{1}{a} \sin at$

B. $\frac{1}{a} \sinh at$

C. $\cos at$

D. $\cosh at$

Q26. The standard deviation of a dataset is definitively independent of:

A. Change of origin

B. Change of scale

C. Both origin and scale

D. Neither origin nor scale

Q27. The value of $\Gamma(n+1)$ for a positive integer n is precisely:

A. n

B. $n-1$

C. $n!$

D. $(n-1)!$

Q28. If matrix A is nilpotent of index 2, then:

A. $A^2 = A$

B. $A^2 = I$

C. $A^2 = 0$

D. $A = 0$

Q29. The sum of the series $1 - 1/2 + 1/3 - 1/4 + \ldots \infty$ converges to:

A. $\ln 2$

B. 1

C. e

D. $\pi/4$

Q30. The particular integral of $(D^2 - 3D + 2)y = e^{3x}$ is:

A. $e^{3x}/2$

B. $e^{3x}/6$

C. e^{3x}

D. $e^{3x}/3$

Q31. A differential equation $M\,dx + N\,dy = 0$ is exact if and only if:

A. $\partial M/\partial y = \partial N/\partial x$

B. $\partial M/\partial x = \partial N/\partial y$

C. $\partial M/\partial y = -\partial N/\partial x$

D. $M = N$

Q32. The divergence of the position vector $\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ is:

A. 0

B. 1

C. 3

D. $\mathbf{r}$

Q33. The modulus of the analytic function e^z where $z = x + iy$ is:

A. e^x

B. e^y

C. e^{x+y}

D. 1

Q34. The probability of throwing exactly two heads in three tosses of a fair coin is:

A. 1/8

B. 3/8

C. 1/2

D. 5/8

Q35. By Cayley-Hamilton theorem, if $A = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$, then $A^2 - 5A$ equals:

A. $2I$

B. $3I$

C. I

D. 0

Q36. The value of $\int_C \frac{dz}{z}$ where C is the unit circle $|z| = 1$ traversed counterclockwise is:

A. 0

B. $2\pi i$

C. πi

D. 1

Q37. The Runge-Kutta method of 4th order requires evaluating the function how many times per step?

A. 2

B. 3

C. 4

D. 5

Q38. If the roots of the auxiliary equation are real and equal ($m_1 = m_2 = m$), the complementary function is:

A. $y = (c_1 + c_2)e^{mx}$

B. $y = c_1e^{mx} + c_2e^{-mx}$

C. $y = (c_1 + c_2x)e^{mx}$

D. $y = c_1 \cos mx + c_2 \sin mx$

Q39. The line integral $\int \mathbf{F} \cdot d\mathbf{r}$ is perfectly independent of the path if $\mathbf{F}$ is:

A. Solenoidal

B. Irrotational

C. Rotational

D. A constant vector

Q40. If $P(A) = 0.4$, $P(B|A) = 0.3$, then $P(A \cap B)$ is:

A. 0.12

B. 0.7

C. 0.8

D. 0.43

Q41. A system of coplanar non-concurrent forces is in equilibrium if:

A. $\sum F_x = 0$ and $\sum F_y = 0$

B. $\sum M = 0$

C. $\sum F_x = 0, \sum F_y = 0,$ and $\sum M = 0$

D. The force polygon closes

Q42. Varignon's theorem states that the moment of a force about any point is strictly equal to:

A. The sum of the forces

B. The algebraic sum of the moments of its components about that point

C. Zero if the body is in equilibrium

D. The couple produced by the force

Q43. In a belt drive, the ratio of tensions T_1/T_2 on the tight and slack sides is given by:

A. $e^{\mu\theta}$

B. $\mu\theta$

C. $\sin(\mu\theta)$

D. $1 - e^{-\mu\theta}$

Q44. The centroid of a quarter circular area of radius R from its bounding straight edges is located at:

A. $4R/3\pi$

B. $2R/\pi$

C. $3R/4\pi$

D. $R/2$

Q45. The polar moment of inertia (J) of a solid circular shaft of diameter D is:

A. $\pi D^4/64$

B. $\pi D^4/32$

C. $\pi D^3/16$

D. $\pi D^4/128$

Q46. The mass moment of inertia of a solid sphere of mass M and radius R about its diameter is:

A. $\frac{1}{2}MR^2$

B. $\frac{2}{3}MR^2$

C. $\frac{2}{5}MR^2$

D. MR^2

Q47. According to the principle of virtual work, for a system in static equilibrium, the total virtual work done by all active forces is:

A. Maximum

B. Minimum

C. Zero

D. Positive

Q48. In a plane truss, if a joint connects exactly two non-collinear members and no external load acts on that joint, the forces in both members are:

A. Equal and opposite

B. Tensile

C. Compressive

D. Strictly zero

Q49. A particle moves along a curve. Its acceleration has two components: tangential (a_t) and normal (a_n). The normal acceleration represents the change in:

A. Magnitude of velocity

B. Direction of velocity

C. Both magnitude and direction

D. Position

Q50. The kinetic energy of a rigid body of mass M and centroidal moment of inertia I_G rolling without slipping with velocity v and angular velocity ω is:

A. $\frac{1}{2}Mv^2$

B. $\frac{1}{2}I_G\omega^2$

C. $\frac{1}{2}Mv^2 + \frac{1}{2}I_G\omega^2$

D. $Mv^2 + I_G\omega^2$

Q51. In an oblique elastic collision between two perfectly smooth spheres, the component of velocity that remains unchanged is:

A. The component along the line of impact

B. The component perpendicular to the line of impact

C. The absolute resultant velocity

D. The relative velocity

Q52. In Simple Harmonic Motion (SHM), the velocity of the particle is mathematically maximum at the:

A. Extreme positions

B. Mean position

C. Midway between mean and extreme

D. It remains constant

Q53. If two springs of stiffness k_1 and k_2 are connected in series, the equivalent stiffness k_{eq} is:

A. $k_1 + k_2$

B. $\frac{k_1 k_2}{k_1 + k_2}$

C. $\sqrt{k_1 k_2}$

D. $k_1 - k_2$

Q54. The time period of a compound pendulum is given by $T = 2\pi\sqrt{L/g}$, where the equivalent length L is (k is radius of gyration about centroid, h is distance from pivot to centroid):

A. k^2/h

B. $h + k^2/h$

C. k^2/h^2

D. $h + k/h$

Q55. Coriolis acceleration strictly acts on a particle moving in a frame that is:

A. Translating uniformly

B. Translating with constant acceleration

C. Rotating

D. Stationary

Q56. The maximum efficiency of a screw jack operating with a friction angle ϕ is strictly given by:

A. $\frac{1-\sin\phi}{1+\sin\phi}$

B. $\frac{1+\sin\phi}{1-\sin\phi}$

C. $\frac{\cos\phi}{1+\sin\phi}$

D. $\frac{\tan\phi}{1+\tan\phi}$

Q57. A beam which is fixed at one end and completely free at the other is designated as a:

A. Simply supported beam

B. Fixed beam

C. Continuous beam

D. Cantilever beam

Q58. For a uniformly distributed load (UDL) acting over the entire span of a simply supported beam, the corresponding Bending Moment diagram forms a:

A. Rectangle

B. Triangle

C. Parabola

D. Cubic curve

Q59. A ladder rests against a smooth vertical wall and a rough horizontal floor. The total number of reaction force components to consider is:

A. 2

B. 3

C. 4

D. 5

Q60. Coefficient of restitution (e) is defined experimentally as the absolute ratio of:

A. Relative velocity of approach to relative velocity of separation

B. Relative velocity of separation to relative velocity of approach

C. Initial kinetic energy to final kinetic energy

D. Final momentum to initial momentum

Q61. When a wheel rolls perfectly without slipping on a horizontal surface, the velocity of the point of contact with the surface is:

A. Maximum

B. Equal to the translational velocity

C. Zero

D. Twice the translational velocity

Q62. The instantaneous center of zero velocity for a rigidly translating body physically lies at:

A. The center of gravity

B. The geometric center

C. Infinity

D. The point of applied force

Q63. A projectile is fired up an inclined plane. The maximum range up the incline is obtained when the angle of projection bisects the angle between the vertical and the:

A. Horizontal

B. Inclined plane

C. Line of greatest slope

D. Line of flight

Q64. Newton's law of universal gravitation mathematically asserts that the force between two masses is strictly inversely proportional to:

A. The sum of their masses

B. The product of their masses

C. The square of the distance between them

D. The distance between them

Q65. The absolute maximum bending moment for a simply supported beam of span L carrying a central point load W is strictly:

A. $WL/2$

B. $WL/4$

C. $WL/8$

D. $WL^2/8$

Q66. D'Alembert's principle effectively converts a rigid dynamic problem into an equivalent static problem by formally introducing:

A. Frictional forces

B. Inertia forces

C. Centrifugal forces

D. Restoring forces

Q67. Work done by a non-conservative force (like friction) along a closed path is perfectly:

A. Zero

B. Positive

C. Negative

D. Dependent on velocity

Q68. The product of inertia (I_{xy}) of an area that possesses at least one axis of symmetry is strictly:

A. Positive

B. Negative

C. Zero

D. Infinite

Q69. When a rigid body undergoes pure rotation about a fixed axis, all particles within the body strictly have the same:

A. Linear velocity

B. Linear acceleration

C. Angular velocity

D. Centripetal acceleration

Q70. The condition for a lifting machine to be completely reversible is that its mechanical efficiency must strictly be:

A. Less than 50 per cent

B. Exactly 50per cent

C. Greater than 50 per cent

D. Exactly 100 per cent

Q71. Hooke's law strictly holds robustly valid only up to the material's:

A. Yield point

B. Ultimate tensile strength

C. Breaking point

D. Proportionality limit

Q72. The physical unit of the modulus of elasticity (Young's Modulus) is strictly identical to that of:

A. Strain

B. Force

C. Pressure

D. Work

Q73. A completely redundant truss structure is geometrically classified as one that has:

A. Exactly enough members to retain its shape

B. Fewer members than required

C. More members than required for static stability

D. No diagonal members

Q74. The law of conservation of angular momentum fundamentally holds definitively true when the net external:

A. Force is zero

B. Torque is zero

C. Work done is zero

D. Energy is zero

Q75. If the kinetic energy of a particle is doubled, its corresponding linear momentum is mathematically increased by a strict factor of:

A. 2

B. 4

C. $\sqrt{2}$

D. $1/\sqrt{2}$

Q76. A block of mass m slides down a rough incline of angle θ with constant velocity. The coefficient of kinetic friction μ_k is exactly:

A. $\sin\theta$

B. $\cos\theta$

C. $\tan\theta$

D. $\cot\theta$

Q77. A flywheel effectively stores mechanical energy in the form of:

A. Potential energy

B. Translational kinetic energy

C. Rotational kinetic energy

D. Strain energy

Q78. In the systematic method of sections for truss analysis, a section plane should ideally cut at most how many members with unknown forces?

A. 1

B. 2

C. 3

D. 4

Q79. The strict mathematical relation between the coefficient of friction μ and the friction angle ϕ is rigidly:

A. $\mu = \sin\phi$

B. $\mu = \cos\phi$

C. $\mu = \tan\phi$

D. $\mu = \sec\phi$

Q80. For a particle undergoing uniform circular motion, the work done strictly by the centripetal force over one complete revolution is:

A. $2\pi rF$

B. $\pi r^2 F$

C. Zero

D. Negative

Q81. Thevenin's equivalent circuit definitively consists of a single ideal voltage source in:

A. Series with a voltage source

B. Parallel with a resistor

C. Series with a resistor

D. Parallel with a current source

Q82. According to the Maximum Power Transfer Theorem, the maximum power is seamlessly transferred to a DC load when the load resistance strictly equals the:

A. Zero

B. Infinite

C. Source equivalent resistance

D. Half of the source resistance

Q83. When maximum power is successfully transferred from a DC source to a load, the overall efficiency of the source circuit is exactly:

A. 100 per cent

B. 50 per cent

C. 25 per cent

D. 75 per cent

Q84. The precise time constant (τ) of a series RL transient circuit is mathematically given by:

A. R/L

B. L/R

C. $1/(RL)$

D. RL

Q85. In a series RLC resonant circuit, the electrical bandwidth (Δf) is strictly mathematically defined as:

A. $R/(2\pi L)$

B. $L/(2\pi R)$

C. $1/(2\pi\sqrt{LC})$

D. R/C

Q86. The Quality Factor (Q) of an inductive coil having resistance R and inductance L at frequency ω is exactly:

A. $R/(\omega L)$

B. $\omega L/R$

C. ωCR

D. $R/(\omega C)$

Q87. In the Two-Wattmeter method for measuring 3-phase power, if one wattmeter strictly reads exactly zero, the load power factor is precisely:

A. 1.0

B. 0.866

C. 0.5

D. 0

Q88. In a perfectly balanced 3-phase Delta (Δ) connection, the mathematical relation between line current (I_L) and phase current (I_{ph}) is:

A. $I_L = I_{ph}$

B. $I_L = I_{ph}/\sqrt{3}$

C. $I_L = 3I_{ph}$

D. $I_L = \sqrt{3}I_{ph}$

Q89. A highly efficient transformer mathematically operates at its absolute maximum efficiency exactly when its:

A. Copper losses equal zero

B. Iron losses equal zero

C. Copper losses equal Iron losses

D. Load is fully disconnected

Q90. The fundamental physical unit of magnetic reluctance is structurally strictly equivalent to:

A. Ampere-turns

B. Weber/Ampere-turn

C. Ampere-turns/Weber

D. Henry

Q91. The mechanical commutator in a conventional DC machine structurally acts as a physical:

A. Amplifier

B. Rotary full-wave rectifier/inverter

C. Transformer

D. Voltage regulator

Q92. In a heavily loaded DC generator, the distorting and demagnetizing effect of armature current on the main field flux is termed:

A. Commutation

B. Eddy current effect

C. Armature reaction

D. Hysteresis

Q93. The fundamental back emf (E_b) equation for a rotating DC motor is rigorously given by:

A. $E_b = (P\Phi ZN)/(60A)$

B. $E_b = (P\Phi Z)/(60AN)$

C. $E_b = (60A)/(P\Phi ZN)$

D. $E_b = (PAZN)/(60\Phi)$

Q94. To actively achieve rotor speeds physically above the base speed in a DC shunt motor, the standard control method used is strictly:

A. Armature voltage control

B. Armature resistance control

C. Field flux weakening control

D. Supply frequency control

Q95. In a standard 3-phase induction motor, the crucial fractional slip (s) is defined rigorously by the formula:

A. $(N_s - N_r)/N_s$

B. $(N_r - N_s)/N_s$

C. $N_s/(N_s - N_r)$

D. $(N_s - N_r)/N_r$

Q96. Permanent Magnet Moving Coil (PMMC) measuring instruments are exclusively utilized for accurately measuring strictly:

A. AC quantities only

B. DC quantities only

C. Both AC and DC quantities

D. High frequency signals

Q97. The physical scale of a standard Moving Iron (MI) measuring instrument is inherently:

A. Perfectly uniform

B. Logarithmic

C. Non-uniform (cramped at the beginning)

D. Exponential

Q98. In a heavily doped N-type semiconductor at thermal equilibrium, the Fermi energy level strategically lies precisely:

A. Exactly at the intrinsic level

B. Closer to the valence band

C. Closer to the conduction band

D. Inside the conduction band

Q99. A Zener diode utilized specifically for robust voltage regulation must universally be operated strictly in the:

A. Forward-biased region

B. Reverse-biased breakdown region

C. Zero-biased region

D. Active region

Q100. The Hall effect in doped semiconductors is highly valuable as it can definitively determine the:

A. Energy bandgap

B. Carrier concentration and type

C. Recombination rate

D. Minority carrier lifetime

Q101. In a standard Bipolar Junction Transistor (BJT), the specific phenomenon where a rising junction temperature uncontrollably increases collector current leading to device destruction is known as:

A. Avalanche breakdown

B. Early effect

C. Thermal runaway

D. Pinch-off

Q102. The crucial Pinch-off voltage (V_p) in an operational Junction Field Effect Transistor (JFET) precisely defines the gate-source voltage at which the drain current strictly:

A. Reaches its absolute maximum

B. Becomes exactly zero

C. Becomes independent of drain voltage

D. Starts oscillating

Q103. Compared to a standard BJT, the operational input impedance of a MOSFET is drastically:

A. Lower

B. Equal

C. Marginally higher

D. Extremely high (nearly infinite)

Q104. The critical Slew Rate of a high-performance Operational Amplifier (Op-Amp) is universally specified in physical units of:

A. Volts/second

B. Volts/microsecond

C. Amperes/microsecond

D. Microseconds/Volt

Q105. If a crisp square wave signal is continuously applied to the input of an ideal Op-Amp integrator circuit, the resulting output waveform is precisely a:

A. Sine wave

B. Spike (Impulse) wave

C. Triangular wave

D. Sawtooth wave

Q106. In boolean digital logic algebra, the highly useful Consensus Theorem unequivocally states that $AB + \bar{A}C + BC$ flawlessly simplifies to:

A. $AB + C$

B. $AB + BC$

C. $AB + \bar{A}C$

D. $A + \bar{A}C$

Q107. In minimizing digital logic equations using a Karnaugh Map (K-map), "Don't Care" conditions are strategically grouped solely to:

A. Force the output to 0

B. Force the output to 1

C. Achieve the largest possible groupings

D. Increase the number of logic gates

Q108. A digital Multiplexer (MUX) is frequently referred to as a "Universal Logic Circuit" primarily because it acts as a highly effective:

A. Data distributor

B. Data selector (Many-to-one)

C. Parallel-to-serial converter

D. Serial-to-parallel converter

Q109. In a standard master-slave JK flip-flop, the persistent "Race Around Condition" specifically occurs strictly when the inputs are:

A. $J = 0, K = 0$

B. $J = 1, K = 0$

C. $J = 0, K = 1$

D. $J = 1, K = 1$

Q110. The total structural modulus (number of unique states) of a fundamental 4-bit asynchronous ripple counter is exactly:

A. 4

B. 8

C. 16

D. 32

Q111. The absolute resolution of a sophisticated 10-bit Analog-to-Digital Converter (ADC) is precisely 1 part in:

A. 10

B. 100

C. 512

D. 1024

Q112. A standard Cathode Ray Oscilloscope (CRO) can elegantly display Lissajous figures, which are strictly utilized to precisely measure an unknown signal's:

A. Voltage amplitude

B. Frequency and phase difference

C. Harmonic distortion

D. Power dissipation

Q113. A simple electronic diode circuit specifically engineered to entirely remove or "chop off" a portion of an applied AC input waveform is definitively termed a:

A. Clamper

B. Clipper

C. Rectifier

D. Multiplier

Q114. The inherent "Early Effect" dynamically occurring within a BJT physically represents the distinct modulation of the effective:

A. Emitter width

B. Collector resistance

C. Base width

D. Base doping profile

Q115. A standard industrial Silicon Controlled Rectifier (SCR) is a robust semi-controlled thyristor structurally consisting of exactly how many semiconductor layers?

A. 2

B. 3

C. 4

D. 5

Q116. When rigorously comparing standard digital logic families, CMOS completely outperforms classic TTL primarily due to its vastly superior:

A. Switching speed

B. Fan-out capability

C. Static power dissipation (extremely low)

D. Current sourcing capacity

Q117. The classic Intel 8085 microprocessor utilizes a strictly multiplexed lower-order address and data bus structurally sized at exactly:

A. 8 bits

B. 16 bits

C. 32 bits

D. 64 bits

Q118. The maximum theoretical operational efficiency of a standard Half-Wave rectifier circuit is strictly limited mathematically to exactly:

A. 81.2 per cent

B. 40.6 per cent

C. 100 per cent

D. 50.0 per cent

Q119. To flawlessly function as a stable electronic oscillator, an amplifier circuit must rigorously satisfy the Barkhausen criterion, requiring a loop gain exactly equal to:

A. 0

B. Infinite

C. -1

D. $1\angle 0^\circ$

Q120. The standard physical color of the electrically live (Phase) wire in modern domestic electrical wiring systems is predominantly:

A. Green

B. Black

C. White

D. Red (or Brown)

Solutions

1. C
Explanation: The determinant of A is the product of its eigenvalues: $1 \times 2 \times (-3) = -6$. The determinant of A^{-1} is exactly $1/|A|$, yielding $-1/6$.

2. C
Explanation: According to the Rouché-Capelli theorem, if $\text{rank}(A) = \text{rank}([A|B]) < n$ (number of unknowns), the system has infinitely many solutions parameterized by free variables.

3. B
Explanation: Taking the natural logarithm gives $\lim(1/x^2)\ln(\cos x)$. Using L'Hopital's rule twice on $\ln(\cos x)/x^2$ evaluates exactly to $-1/2$. Exponentiating back gives $e^{-1/2}$.

4. A
Explanation: Differentiating $u = x^y$ partially with respect to x treats y as a constant. By the standard power rule, $\partial u/\partial x = yx^{y-1}$.

5. B
Explanation: A fundamental vector calculus identity asserts that the curl of any gradient field $(\nabla \times \nabla\phi)$ is identically the zero vector, making gradient fields irrotational.

6. B
Explanation: Rewriting in standard linear form: $\frac{dy}{dx} - \frac{1}{x}y = x$. The integrating factor is $IF = e^{\int(-1/x)dx} = e^{-\ln x} = x^{-1} = 1/x$.

7. A
Explanation: The differential equation for $y = mx$ is $dy/dx = y/x$. For orthogonal trajectories, substitute $-dx/dy$ to get $xdx + ydy = 0$. Integrating yields $x^2 + y^2 = C$ (concentric circles).

8. A
Explanation: By the property of Laplace transforms, $\mathcal{L}\{tf(t)\} = -\frac{d}{ds}F(s)$. Since $\mathcal{L}\{\sin at\} = a/(s^2 + a^2)$, its negative derivative strictly evaluates to $2as/(s^2 + a^2)^2$.

9. B
Explanation: The mathematical Initial Value Theorem robustly establishes that the initial time-domain value $\lim_{t\to 0} f(t)$ is exactly equal to the s-domain limit $\lim_{s\to\infty} sF(s)$.

10. B
Explanation: The total number of items is 10. The probability of drawing the first defective is $2/10$. The probability of the second defective is $1/9$. Joint probability $= (2/10) \times (1/9) = 2/90 = 1/45$.

11. B
Explanation: A unique, defining characteristic of the Poisson probability distribution is that its variance is strictly and invariably equal to its mean. Thus, the variance is 4.

12. B

Explanation: For a complex function to be analytic, its real and imaginary parts must satisfy the Cauchy-Riemann differential equations: $\partial u/\partial x = \partial v/\partial y$ and $\partial u/\partial y = -\partial v/\partial x$.

13. B
Explanation: For a simple pole at $z = a$, Res $= \lim_{z\to a}(z-a)f(z)$. At $z = 1$, the residue is $\lim_{z\to 1} \frac{(z-1)}{(z-1)(z-2)} = \frac{1}{1-2} = -1$.

14. B
Explanation: The Pearson correlation coefficient (r) statistically measures linear dependence. Its mathematical formulation strictly bounds its value within the closed interval $[-1, 1]$.

15. C
Explanation: The Newton-Raphson iterative numerical method uniquely exhibits quadratic convergence, meaning the number of correct decimal places roughly doubles with each successive iteration near the root.

16. C
Explanation: Simpson's 1/3 rule fits a parabolic arc (degree 2) between points, but due to remarkable error term cancellation, it theoretically yields exact integration for polynomials up to degree 3.

17. A
Explanation: In the Fourier series of an even function $f(x) = f(-x)$, the integrand for the sine coefficients (b_n) becomes an odd function, forcing all sine terms to strictly integrate to zero.

18. C
Explanation: Using the definite integral property $\int_0^a f(x)dx = \int_0^a f(a-x)dx$, adding the original integral I and the transformed integral I yields $2I = \int_0^{\pi/2} 1dx = \pi/2$. Thus $I = \pi/4$.

19. B
Explanation: A square matrix A is fundamentally defined as orthogonal if multiplying it by its transpose yields the identity matrix $(AA^T = I)$. Consequently, its inverse strictly equals its transpose $(A^{-1} = A^T)$.

20. B
Explanation: The auxiliary equation is $m^2 + 4 = 0$, giving pure imaginary roots $m = \pm 2i$. The corresponding complementary function is strictly harmonic: $y = c_1 \cos 2x + c_2 \sin 2x$.

21. A
Explanation: Gradient $\nabla\phi = 2xyz\mathbf{i} + x^2z\mathbf{j} + x^2y\mathbf{k}$. At $(1,1,1)$, $\nabla\phi = 2\mathbf{i} + \mathbf{j} + \mathbf{k}$. The unit vector is $\frac{\mathbf{i}+\mathbf{j}+\mathbf{k}}{\sqrt{3}}$. Directional derivative $= (2+1+1)/\sqrt{3} = 4/\sqrt{3}$.

22. C
Explanation: Green's theorem rigorously translates a line integral traversing a closed 2D curve into an equivalent double integral computed over the bounded planar region enclosed by that curve.

23. A
Explanation: Set the partial derivatives to zero: $f_x = 2x - 2 = 0 \implies x = 1$,

and $f_y = 2y - 4 = 0 \implies y = 2$. The sole stationary point is precisely $(1, 2)$.

24. A
Explanation: $y' = e^x$, $y'' = e^x$. At $(0, 1)$, $y' = 1$ and $y'' = 1$. The radius of curvature $\rho = (1 + (y')^2)^{3/2}/|y''| = (1 + 1)^{3/2}/1 = 2^{3/2} = 2\sqrt{2}$.

25. B
Explanation: The standard Laplace transform of $\sinh(at)$ is $a/(s^2 - a^2)$. Therefore, reversing the operation on $1/(s^2 - a^2)$ requires dividing by a, accurately yielding $\frac{1}{a} \sinh at$.

26. A
Explanation: Standard deviation fundamentally measures dispersion strictly around the mean. Adding a constant (changing origin) merely shifts the data intact without altering spread, making it independent of origin.

27. C
Explanation: The Gamma function is mathematically defined as a continuous extension of the factorial function. For any strictly positive integer n, the relation is precisely $\Gamma(n + 1) = n!$.

28. C
Explanation: By exact mathematical definition, a square matrix A is described as nilpotent of index k if $A^k = 0$ while $A^{k-1} \neq 0$. Thus, for index 2, strictly $A^2 = 0$.

29. A
Explanation: The given sequence is the classic alternating harmonic series. By substituting $x = 1$ into the well-known Maclaurin series expansion for $\ln(1 + x)$, it evaluates exactly to $\ln 2$.

30. A
Explanation: The Particular Integral is $\frac{1}{f(D)} e^{ax} = \frac{1}{f(a)} e^{ax}$. Here, $f(D) = D^2 - 3D + 2$ and $a = 3$. Evaluating $f(3) = 3^2 - 3(3) + 2 = 2$. The PI is exactly $e^{3x}/2$.

31. A
Explanation: A necessary and strictly sufficient mathematical condition for the first-order differential equation $Mdx + Ndy = 0$ to be exact is precisely $\partial M/\partial y = \partial N/\partial x$.

32. C
Explanation: The divergence operator is $\nabla \cdot \mathbf{r} = \frac{\partial x}{\partial x} + \frac{\partial y}{\partial y} + \frac{\partial z}{\partial z} = 1 + 1 + 1 = 3$.

33. A
Explanation: $e^z = e^{x+iy} = e^x(\cos y + i \sin y)$. Since the modulus of the complex trigonometric part $|\cos y + i \sin y|$ is strictly 1, the overall modulus is definitively $|e^z| = e^x$.

34. B
Explanation: Using the binomial probability formula $P(X = k) = \binom{n}{k} p^k q^{n-k}$. Here $n = 3$, $k = 2$, $p = 1/2$. Thus $P(2) = \binom{3}{2}(1/2)^2(1/2)^1 = 3 \times 1/8 = 3/8$.

35. A
Explanation: The characteristic equation is $|A - \lambda I| = \lambda^2 - 5\lambda - 2 = 0$. By Cayley-Hamilton, $A^2 - 5A - 2I = 0$, which algebraically rearranges directly to $A^2 - 5A = 2I$.

36. B
Explanation: The function $1/z$ has a simple pole precisely at $z = 0$ with a residue of 1. By Cauchy's Residue Theorem, the closed contour integral evaluates exactly to $2\pi i \times \text{Res} = 2\pi i$.

37. C
Explanation: The classical 4th order Runge-Kutta numerical integration algorithm uniquely calculates four distinct slopes (k_1, k_2, k_3, k_4) per single step, thus requiring exactly 4 function evaluations.

38. C
Explanation: For repeated real roots in a linear homogeneous ODE, linear independence is mathematically restored by multiplying the second term by x, strictly yielding $y = (c_1 + c_2x)e^{mx}$.

39. B
Explanation: A line integral strictly becomes path-independent if and only if the underlying vector field $\mathbf{F}$ is conservative. A necessary and sufficient condition for this is that $\mathbf{F}$ is irrotational $(\nabla \times \mathbf{F} = 0)$.

40. A
Explanation: The fundamental conditional probability formula rigidly states $P(B|A) = P(A \cap B)/P(A)$. Rearranging this mathematically yields $P(A \cap B) = P(A) \times P(B|A) = 0.4 \times 0.3 = 0.12$.

41. C
Explanation: For a non-concurrent, coplanar force system, static equilibrium definitively requires that there is absolutely no tendency to translate $(\sum F_x = 0, \sum F_y = 0)$ and absolutely no tendency to rotate $(\sum M = 0)$.

42. B
Explanation: Varignon's principle of moments strictly dictates that the moment of a resultant force about any arbitrary point identically equals the algebraic sum of the moments of its individual components about that precise point.

43. A
Explanation: The classic Euler-Eytelwein formula for power transmission in a flexible belt drive rigorously establishes that the limiting tension ratio across the pulley evaluates exactly to $T_1/T_2 = e^{\mu\theta}$.

44. A
Explanation: Using double integration over a quarter-circle area, the exact geometric coordinate for the centroid relative to either straight radial bounding edge is robustly derived as strictly $4R/3\pi$.

45. B
Explanation: The polar moment of inertia $J = I_{xx} + I_{yy}$. For a solid circular cross-section, $I_{xx} = I_{yy} = \pi D^4/64$. Consequently, J precisely evaluates to $\pi D^4/32$.

46. C
Explanation: By performing spherical volume integration of the continuous mass distribution, the mass moment of inertia for a uniform solid sphere about any central diametral axis is fundamentally exactly $\frac{2}{5}MR^2$.

47. C

Explanation: The Principle of Virtual Work rigidly asserts that if a mechanical system is in perfect static equilibrium, the total virtual work done by all applied active forces undergoing any compatible virtual displacement is unequivocally zero.

48. D
Explanation: A foundational rule of truss analysis logically dictates that if a joint only connects two non-collinear members with absolutely no external load or support reaction, both members are strictly zero-force members.

49. B
Explanation: In curvilinear motion kinematics, tangential acceleration solely alters the speed (magnitude), while the normal (centripetal) acceleration acts strictly perpendicular, solely changing the direction of the velocity vector.

50. C
Explanation: The total kinetic energy of a body undergoing general plane motion (rolling) is the strict sum of its translational energy ($\frac{1}{2}Mv^2$) and its centroidal rotational energy ($\frac{1}{2}I_G\omega^2$).

51. B
Explanation: In an oblique collision between completely smooth spheres, no impulsive frictional force acts parallel to the contact plane. Thus, the velocity component strictly perpendicular to the line of impact remains completely unaltered.

52. B
Explanation: In SHM, the particle's velocity $v = \omega\sqrt{A^2 - x^2}$. This mathematical expression definitively reaches its absolute maximum precisely when the displacement x is zero, which is exactly at the central mean position.

53. B
Explanation: When elastic springs are connected in series, they share identical force but their extensions add up. Consequently, the equivalent stiffness k_{eq} is calculated identically to resistors in parallel: $1/k_{eq} = 1/k_1 + 1/k_2$.

54. B
Explanation: For a physical compound pendulum, the rigorous dynamic analysis yields an equivalent simple pendulum length of $L = I_0/mh$. Using parallel axis theorem ($I_0 = mk^2 + mh^2$), this simplifies exactly to $h + k^2/h$.

55. C
Explanation: The Coriolis fictitious acceleration ($\mathbf{a}_c = 2\vec{\omega} \times \mathbf{v}_{rel}$) is a unique dynamic effect that strictly and exclusively arises when a particle moves relative to a rapidly rotating reference frame.

56. A
Explanation: Through rigorous optimization of the mechanical advantage equation of a screw jack, the absolute maximum theoretical efficiency is mathematically determined to be precisely $\frac{1-\sin\phi}{1+\sin\phi}$.

57. D
Explanation: In structural engineering mechanics, a rigid beam that is deeply embedded or fixed at one support and entirely unsupported (free) at the opposite end is categorically defined as a cantilever beam.

58. C

Explanation: The shear force for a UDL is a linear diagonal line. Since bending moment is strictly the integral of shear force, integrating a first-degree linear function invariably produces a second-degree parabolic curve.

59. B

Explanation: The smooth wall provides exactly 1 normal reaction. The rough floor provides exactly 1 normal reaction and exactly 1 frictional force. The total number of distinct unknown reaction components is definitively 3.

60. B

Explanation: The coefficient of restitution (e) is an empirical Newtonian constant strictly defined as the exact ratio of the relative velocity of separation directly after impact to the relative velocity of approach right before impact.

61. C

Explanation: In pure rolling without slipping, the translation velocity forward is perfectly canceled by the backward tangential rotational velocity at the bottom-most point. Thus, the instantaneous velocity of the contact point is strictly zero.

62. C

Explanation: A body undergoing pure uniform translation has absolutely no rotational component ($\omega = 0$). To satisfy the relation $v = r\omega$, the radial distance r to the instantaneous center must be mathematically located at infinity.

63. A

Explanation: By optimizing the complex trajectory equation for an inclined plane, the mathematical condition for absolute maximum range dictates that the projection vector must precisely bisect the angle between the vertical axis and the inclined plane.

64. C

Explanation: Newton's foundational Law of Universal Gravitation unambiguously dictates that the attractive force acts strictly inversely proportional to the square of the distance ($1/r^2$) cleanly separating the two point masses.

65. B

Explanation: For a simply supported beam bearing a central point load W, the symmetrical support reactions are $W/2$. The maximum bending moment inevitably occurs dead center and is mathematically evaluated as strictly $(W/2) \times (L/2) = WL/4$.

66. B

Explanation: D'Alembert's principle cleverly reformulates Newton's second law ($F - ma = 0$) by artificially introducing a reversed "inertia force" ($-ma$), allowing complex dynamic systems to be analyzed completely using standard static equilibrium equations.

67. C

Explanation: Kinetic friction always vehemently opposes the direction of actual motion. Therefore, the mathematical dot product of friction force and displacement vectors is always 180°, strictly resulting in cumulative negative work.

68. C

Explanation: The product of inertia is defined as the integral $\int xy\, dA$. If an area possesses an axis of geometric symmetry (say the y-axis), every positive x coordinate has an identical area with a negative x, forcing the entire integral to strictly zero.

69. C
Explanation: In pure rigid body rotation about a fixed axis, while individual linear velocities ($v = r\omega$) strictly vary based on the radial distance r from the axis, the angular velocity ω remains unequivocally identical for absolutely all particles.

70. C
Explanation: A lifting machine is classified as reversible if it can do work in the backward direction when effort is removed. This definitively requires the efficiency to strictly exceed the 50 per cent physical friction threshold.

71. D
Explanation: Hooke's Law strictly mandates a perfectly linear, proportional relationship between applied stress and resulting strain. This linearity breaks down precisely at a specific threshold known unequivocally as the limit of proportionality.

72. C
Explanation: Young's Modulus is defined precisely as Stress divided by Strain. Since Strain is a dimensionless geometric ratio, the modulus exclusively inherits the physical units of Stress, which are identical to Pressure (N/m^2).

73. C
Explanation: A truss is mathematically categorized as statically redundant (or over-rigid) if it physically contains strictly more structural members than the exact minimum number required by the formula $m = 2j - 3$ to maintain static stability.

74. B
Explanation: From the rotational analogue of Newton's second law ($\tau = dL/dt$), it rigorously follows that if the net external torque (τ) acting on a system is identically zero, the angular momentum (L) must remain strictly constant.

75. C
Explanation: The algebraic relationship is $K = p^2/2m$, meaning momentum $p = \sqrt{2mK}$. If the kinetic energy K is mathematically multiplied by 2, the momentum p is consequently strictly multiplied by exactly $\sqrt{2}$.

76. C
Explanation: For a block sliding with zero acceleration (constant velocity), the downhill gravitational force ($mg \sin\theta$) is precisely balanced by the kinetic friction ($\mu_k mg \cos\theta$). Algebraically solving yields strictly $\mu_k = \tan\theta$.

77. C
Explanation: A heavy mechanical flywheel is specifically engineered to dynamically store substantial amounts of excess mechanical energy uniquely in the physical form of rotational kinetic energy ($\frac{1}{2}I\omega^2$).

78. C
Explanation: To maintain deterministic static solvability using the three coplanar equilibrium equations ($\sum F_x = 0, \sum F_y = 0, \sum M = 0$), an exploratory section plane must sever strictly no more than exactly 3 unknown truss members.

79. C

Explanation: The friction angle ϕ is geometrically defined as the exact angle between the normal reaction and the resultant reaction force. By simple vector trigonometry, the limiting coefficient of friction μ strictly equals $\tan\phi$.

80. C
Explanation: The defining characteristic of centripetal force is that it acts strictly perpendicular (90°) to the instantaneous velocity vector. Therefore, the mechanical work done ($F \cdot d\cos 90°$) is unequivocally and continuously zero.

81. C
Explanation: Thevenin's powerful network theorem systematically reduces any complex linear, bilateral DC circuit into a remarkably simple equivalent circuit strictly comprising one ideal voltage source (V_{th}) precisely in series with one resistor (R_{th}).

82. C
Explanation: The theorem fundamentally proves through calculus optimization that absolute maximum power dissipation explicitly occurs precisely when the variable load resistance R_L is matched exactly to the internal Thevenin source resistance R_{th}.

83. B
Explanation: At the precise condition of maximum power transfer ($R_L = R_{th}$), exactly half the total generated power is inherently dissipated inside the source resistance itself as useless heat, strictly capping the overall circuit efficiency at precisely 50**84. B**
Explanation: Solving the transient first-order differential equation for a series RL circuit dynamically yields an exponential term $e^{-(R/L)t}$. The exact time constant τ, where the current reaches 63.2**85. A**
Explanation: The exact half-power electrical bandwidth (Δf) of a series RLC resonant circuit is rigorously defined mathematically by the algebraic ratio of the circuit's total resistance R to its total inductance L, specifically expressed as $R/(2\pi L)$ in Hertz.

86. B
Explanation: The fundamental Quality Factor (Q) for a real, lossy inductor evaluates its energy storage efficiency and is mathematically strictly defined as the direct ratio of its reactive impedance (ωL) to its active ohmic resistance (R).

87. C
Explanation: Using the established formula $\tan\phi = \sqrt{3}(W_1 - W_2)/(W_1 + W_2)$, if exactly one wattmeter reads zero (say $W_2 = 0$), $\tan\phi = \sqrt{3}$, making the phase angle exactly 60°. Thus, the strictly evaluated power factor $\cos 60°$ is exactly 0.5.

88. D
Explanation: In a balanced 3-phase Delta (Δ) network configuration, the line voltage perfectly equals the phase voltage, but by applying Kirchhoff's Current Law at the nodes, the line current vectorially sums to strictly $\sqrt{3}$ times the phase current.

89. C
Explanation: By differentiating the transformer efficiency equation with respect to load current and setting it to zero, it is mathematically proven that absolute

maximum efficiency is achieved exactly when the variable copper losses precisely equal the constant iron losses.

90. C
Explanation: Magnetic reluctance ($S = \text{mmf}/\phi$) physically represents the direct opposition to magnetic flux. Its strict SI unit is calculated by dividing Magnetomotive Force (Ampere-turns) strictly by Magnetic Flux (Webers).

91. B
Explanation: The commutator structurally acts as a synchronized rotary mechanical switch. In a generator, it acts strictly as a full-wave rectifier converting internal AC to external DC. In a motor, it acts as an inverter converting external DC to internal AC.

92. C
Explanation: Armature reaction is the specific, unavoidable electromagnetic phenomenon where the newly created magnetic field from the current-carrying armature physically distorts and severely weakens the primary stationary field flux.

93. A
Explanation: According to fundamental electromagnetic induction laws, the strict equation governing the induced back electromotive force (E_b) in a DC machine is exactly derived as $(P\Phi ZN)/(60A)$.

94. C
Explanation: Motor speed is mathematically inversely proportional to the main field flux ($N \propto E_b/\Phi$). To strictly force the motor to rotate faster than its rated base speed, the field flux must be strategically weakened by severely reducing the field current.

95. A
Explanation: The fractional slip (s) fundamentally quantifies the crucial relative speed difference required to induce rotor current. It is rigorously defined as the strict mathematical ratio $(N_s - N_r)/N_s$, where N_s is synchronous speed and N_r is actual rotor speed.

96. B
Explanation: A PMMC instrument strictly depends on a strong, constant, unidirectional permanent magnetic field. It mechanically inherently computes the average value of current, strictly causing it to read exactly zero on symmetrical AC waveforms.

97. C
Explanation: The deflecting torque in an MI instrument mathematically acts proportional strictly to the square of the operating current ($T_d \propto I^2$). This non-linear quadratic relationship inherently results in a distinctly non-uniform, cramped initial scale.

98. C
Explanation: Doping with pentavalent impurities massively introduces excess free electrons. To maintain strict thermodynamic equilibrium, the statistical Fermi energy level is forced to physically shift dramatically upwards, resting strictly just below the conduction band.

99. B
Explanation: To actively function as a reliable voltage regulator, a Zener diode must invariably be heavily doped and strictly operated deeply inside its reverse-biased breakdown region, where voltage remains remarkably constant despite large current changes.

100. B
Explanation: By observing the polarity and magnitude of the strictly induced transverse Hall voltage inside a magnetic field, physicists can unequivocally and definitively determine both the exact density and the specific type (electrons or holes) of the majority charge carriers.

101. C
Explanation: Thermal runaway is a catastrophic positive feedback loop exclusively observed in BJTs. A slight temperature rise strictly increases minority leakage current, heavily increasing power dissipation, further spiking temperature until the transistor is completely destroyed.

102. B
Explanation: In JFET operation, the strict application of a sufficiently large reverse-biased Pinch-off voltage (V_p) to the gate fundamentally widens the depletion regions until they physically touch, completely choking the channel and strictly forcing drain current to exactly zero.

103. D
Explanation: A MOSFET features a critical, ultra-thin silicon dioxide (SiO_2) insulating layer physically separating the metallic gate strictly from the semiconductor channel. This flawless isolation guarantees an extremely high, practically infinite input impedance.

104. B
Explanation: The Slew Rate explicitly defines the absolute maximum rate at which an Op-Amp's output voltage can physically change in response to a sudden step input. It is universally standardized and reported strictly in Volts per microsecond (V/μs).

105. C
Explanation: An active Op-Amp integrator circuit mathematically performs the precise time-domain integration of the input signal. Integrating a piecewise-constant square wave strictly generates a continuous, linearly ramping triangular waveform.

106. A
Explanation: The Boolean Consensus Theorem is a crucial logic simplification rule. In the expression $AB + \bar{A}C + BC$, the term BC is mathematically completely redundant (the consensus) and can be strictly eliminated, leaving exactly $AB + \bar{A}C$.

107. C
Explanation: "Don't Care" states fundamentally represent physically impossible or completely irrelevant input combinations. They are strategically exploited in K-maps strictly as either 1s or 0s to explicitly achieve the largest possible prime implicant groupings, minimizing the logic.

108. B

Explanation: A Multiplexer (MUX) is digitally defined strictly as a many-to-one data selector. It is considered a "Universal Logic Circuit" because a properly configured MUX can effectively synthesize absolutely any combinational Boolean logic function.

109. D
Explanation: In a simple unclocked JK flip-flop, when both inputs are strictly held HIGH ($J = 1, K = 1$), the output is forced to continuously toggle. If the clock pulse is longer than the propagation delay, this results in an unpredictable, unstable "Race Around" condition.

110. C
Explanation: The fundamental modulus of any digital counter defines its maximum number of completely unique states. For an asynchronous ripple counter constructed from n cascaded flip-flops, the total modulus is exactly mathematically fixed at 2^n. Here, $2^4 = 16$.

111. D
Explanation: The absolute resolution of an ADC dictates how finely it can slice the analog input voltage. It is precisely mathematically defined as 2^n discrete quantum levels. For a 10-bit system, this equates exactly to 2^{10}, or strictly 1024 distinct levels.

112. B
Explanation: Lissajous patterns are mathematically generated by feeding two different sinusoidal signals strictly into the X and Y deflection plates of a CRO. Their exact geometric shape allows highly precise measurement of the strictly unknown frequency and phase difference.

113. B
Explanation: A diode clipper (or limiter) circuit is specifically designed to completely strictly prevent the output voltage from exceeding a predetermined voltage level, thereby cleanly "clipping off" the unwanted peaks of the applied AC waveform.

114. C
Explanation: The Early Effect uniquely occurs when a rising reverse-bias collector voltage actively extends the depletion region deeply backward into the base layer. This strictly physical phenomenon dynamically and significantly reduces the effective neutral base width.

115. C
Explanation: An SCR is a fundamental P-N-P-N thyristor device. It structurally requires exactly 4 alternating semiconductor layers precisely forming 3 distinct P-N junctions to successfully achieve its bistable, latching switching characteristics.

116. C
Explanation: While TTL often switches marginally faster, CMOS (Complementary Metal-Oxide-Semiconductor) definitively revolutionized digital ICs primarily because it draws essentially zero static current, resulting in unprecedented, extremely low static power dissipation.

117. A

Explanation: To strictly conserve limited physical IC pins, the 8085 microprocessor creatively multiplexes its lower 8 bits of the 16-bit address bus exactly with its entire 8-bit bidirectional data bus (labeled $AD_0 - AD_7$).

118. B

Explanation: Rectifier efficiency is rigorously defined as DC output power divided by AC input power. For a Half-Wave rectifier, the maximum theoretical mathematical limit is calculated precisely as $4/\pi^2$, which converts exactly to strictly 40.6 per cent.

119. D

Explanation: The Barkhausen stability criterion strictly dictates that for sustained electronic oscillations to occur spontaneously, the total closed-loop gain ($A\beta$) must be mathematically exactly equal to 1 with an absolute phase shift of precisely $0°$ (or $360°$).

120. D

Explanation: In strict accordance with internationally recognized standard electrical safety codes (like IEC and old NEC), the hazardous, electrically "live" phase wire in domestic single-phase wiring is distinctly universally color-coded strictly as either Red or Brown.