GATE Electrical Engineering

Sample Paper – 4

Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Electrical Engineering** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Unless stated otherwise take $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m and $c = 3 \times 10^8$ m/s.

Electric Circuits

Q1. A one-port source network is reduced to its Thevenin equivalent with open-circuit voltage $V_{th} = 20$ V and Thevenin resistance $R_{th} = 10\ \Omega$. For maximum power transfer, the value of the load resistance to be connected across the terminals is: **[1 mark]**

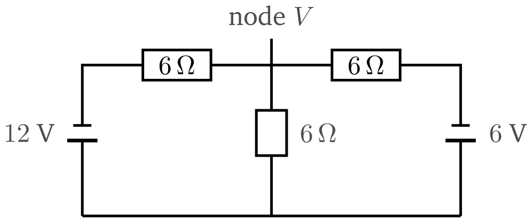
(A) $20\ \Omega$

(B) $5\ \Omega$

(C) $10\ \Omega$

(D) $40\ \Omega$

Q2. In the circuit shown, a 12 V source (through a $6\ \Omega$ resistor) and a 6 V source (through a $6\ \Omega$ resistor) feed a common node that has a $6\ \Omega$ load to the reference. Using superposition, the node voltage V is: **[1 mark]**



(A) 4 V

(B) 6 V

(C) 9 V

(D) 3 V

Q3. A network is reduced to its Thevenin equivalent with $V_{th} = 30$ V and $R_{th} = 15\ \Omega$. When a load resistance is chosen for maximum power transfer, the maximum power delivered to the load, $P_{\max} = \dfrac{V_{th}^2}{4R_{th}}$, is: **[1 mark]**

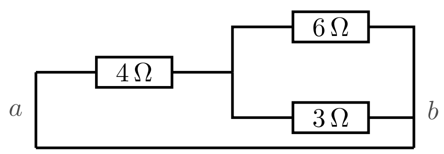
(A) 15 W

(B) 30 W

(C) 7.5 W

(D) 60 W

Q4. For the resistive network shown, all sources have been deactivated. The Thevenin (equivalent) resistance seen between terminals a and b, formed by $4\ \Omega$ in series with the parallel combination of $6\ \Omega$ and $3\ \Omega$, is: **[1 mark]**



(A) $4\ \Omega$

(B) $2\ \Omega$

(C) $6\ \Omega$

(D) $9\ \Omega$

Q5. A source-free series RL circuit has $L = 0.5$ H and $R = 10\ \Omega$. The time constant of the natural (transient) response, $\tau = L/R$, is: **[1 mark]**

(A) 50 ms

(B) 5 ms

(C) 20 ms

(D) 100 ms

Q6. When a load is matched to a source for maximum power transfer ($R_L = R_{th}$), the fraction of the total power (drawn from the source) that reaches the load, i.e. the power-transfer efficiency, is: **[1 mark]**

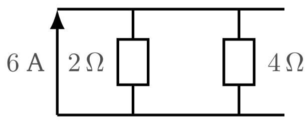
(A) 100%

(B) 50%

(C) 75%

(D) 25%

Q7. An ideal 6 A current source feeds two resistors of $2\ \Omega$ and $4\ \Omega$ connected in parallel, as shown. By the current-divider rule the current flowing through the $2\ \Omega$ resistor is: **[1 mark]**



(A) 4 A

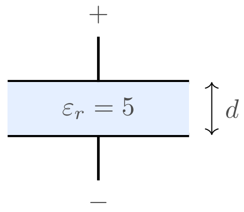
(B) 2 A

(C) 6 A

(D) 3 A

Electromagnetic Fields

Q8. A parallel-plate capacitor of plate area $A = 0.01$ m^2 and separation $d = 0.5$ mm is completely filled with a dielectric of relative permittivity $\varepsilon_r = 5$, as shown. Using $C = \dfrac{\varepsilon_0 \varepsilon_r A}{d}$, the capacitance is nearest to: **[1 mark]**



(A) 885 pF

(B) 177 pF

(C) 88.5 pF

(D) 1770 pF

Q9. At a point in free space the electric field intensity is $E = 1 \times 10^6$ V/m. The electrostatic energy density stored in the field, $u = \frac{1}{2}\varepsilon_0 E^2$, is nearest to: **[1 mark]**

(A) 8.85 J/m^3

(B) 2.21 J/m^3

(C) 17.7 J/m^3

(D) 4.43 J/m^3

Q10. A capacitor is charged so that it stores 8 J of electrostatic energy, and it is then disconnected from the source (so its charge Q stays fixed). A dielectric slab of relative permittivity $\varepsilon_r = 4$ is now inserted, completely filling the gap. The new stored energy, from $W = \dfrac{Q^2}{2C}$ with $C \to 4C$, is: **[1 mark]**

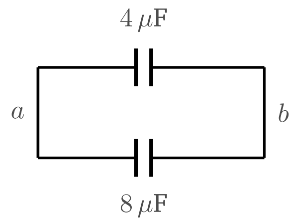
(A) 32 J

(B) 8 J

(C) 4 J

(D) 2 J

Q11. Two capacitors of $4\ \mu$F and $8\ \mu$F are connected in parallel between terminals a and b, as shown. The equivalent capacitance of the combination is: **[1 mark]**



(A) $2.67\ \mu$F

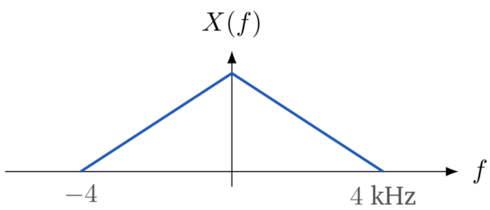
(B) $4\ \mu$F

(C) $12\ \mu$F

(D) $32\ \mu$F

Signals and Systems

Q12. A continuous-time signal is band-limited so that its spectrum $X(f)$ is zero for $|f| > 4$ kHz, as sketched. According to the sampling theorem, the minimum (Nyquist) sampling rate needed to avoid aliasing is: **[1 mark]**



(A) 4 kHz

(B) 8 kHz

(C) 2 kHz

(D) 16 kHz

Q13. Let $x(t)$ have Fourier transform $X(\omega)$. By the time-shifting property, the Fourier transform of the delayed signal $x(t - t_0)$ is: **[1 mark]**

(A) $X(\omega - \omega_0)$

(B) $X(\omega)\, e^{+j\omega t_0}$

(C) $X(\omega)\, e^{-j\omega t_0}$

(D) $X(-\omega)$

Q14. A pure sinusoid of frequency 5 kHz is sampled at a rate of 8 kHz, which is below its Nyquist rate. The (aliased) frequency at which it appears in the sampled signal, $f_a = |f - f_s|$, is: **[1 mark]**

(A) 3 kHz

(B) 5 kHz

(C) 8 kHz

(D) 13 kHz

Q15. Using the standard analysis convention, the Fourier transform of the unit impulse $\delta(t)$ is: **[1 mark]**

(A) $\delta(\omega)$

(B) $2\pi\, \delta(\omega)$

(C) $\dfrac{1}{j\omega}$

(D) 1

Q16. A periodic signal is $x(t) = 3 + 2\cos(\omega_0 t) + \sin(2\omega_0 t)$. Its average (d.c.) value over one full period, which is the a_0 Fourier-series coefficient, is: **[1 mark]**

(A) 2

(B) 3

(C) 5

(D) 0

Electrical Machines

Q17. A 6-pole, three-phase synchronous generator (alternator) is driven at a speed of 1000 rpm. The frequency of the generated e.m.f., $f = \frac{PN}{120}$, is:
[1 mark]

(A) 50 Hz

(B) 60 Hz

(C) 100 Hz

(D) 25 Hz

Q18. A three-phase, 8-pole synchronous motor is supplied from a 50 Hz source. Its synchronous (running) speed, $N_s = \frac{120f}{P}$, is: **[1 mark]**

(A) 1000 rpm

(B) 1500 rpm

(C) 750 rpm

(D) 3000 rpm

Q19. A synchronous generator has an open-circuit (no-load) e.m.f. of $E = 250$ V and, when loaded, a terminal voltage of $V = 220$ V. Its percentage voltage regulation, $\frac{E - V}{V} \times 100\%$, is nearest to: **[1 mark]**

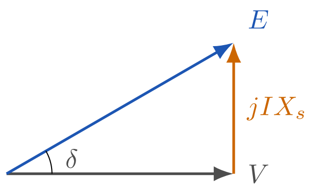
(A) 12%

(B) 13.6%

(C) 30%

(D) 88%

Q20. A cylindrical-rotor synchronous generator has excitation e.m.f. $E = 1.2$ pu, terminal voltage $V = 1.0$ pu, synchronous reactance $X_s = 0.6$ pu and load (power) angle $\delta = 30^\circ$, as illustrated by the phasor diagram. The real power delivered, $P = \frac{EV}{X_s} \sin\delta$, is: **[1 mark]**



(A) 1.0 pu

(B) 0.5 pu

(C) 2.0 pu

(D) 0.6 pu

Q21. A three-phase induction motor has a synchronous speed of 1500 rpm and runs at a per-unit slip of $s = 0.04$. Its actual rotor speed, $N = N_s(1 - s)$, is: **[2 marks]**

(A) 1500 rpm

(B) 1440 rpm

(C) 60 rpm

(D) 1460 rpm

Q22. A synchronous generator delivers an output power of 100 kW while its total losses (core plus copper plus friction) amount to 5 kW. Its efficiency, $\eta = \dfrac{P_{out}}{P_{out} + P_{loss}}$, is nearest to: **[2 marks]**

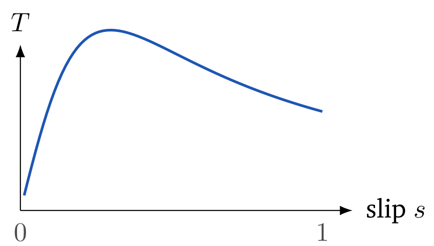
(A) 90%

(B) 98%

(C) 94%

(D) 95.2%

Q23. A three-phase induction motor is supplied from a 50 Hz source and operates at a per-unit slip of $s = 0.05$, on the stable part of the torque–slip curve shown. The frequency of the rotor (slip) currents, $f_r = sf$, is: **[2 marks]**



(A) 50 Hz

(B) 0.5 Hz

(C) 2.5 Hz

(D) 5 Hz

Power Systems

Q24. A short transmission line with total series impedance Z is represented by its $ABCD$ (transmission) parameters. For a short line these are $A = 1$, $B = Z$, $C = 0$, $D = 1$. The value of the A parameter is therefore: **[2 marks]**

(A) 1

(B) 0

(C) Z

(D) Y

Q25. A short transmission line has a total series impedance $Z = (10 + j40)\ \Omega$ and negligible shunt admittance. In its $ABCD$ representation ($A = D = 1$, $C = 0$), the value of the B parameter is: **[2 marks]**

(A) 1

(B) 0

(C) $(40 + j10)\ \Omega$

(D) $(10 + j40)\ \Omega$

Q26. The $ABCD$ (transmission) parameters of any passive, reciprocal two-port network representing a transmission line obey a fixed determinant condition. The value of $AD - BC$ for such a line is: **[2 marks]**

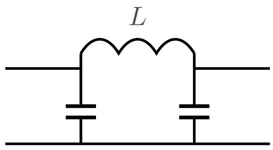
(A) 0

(B) Z

(C) Y

(D) 1

Q27. A lossless transmission line, modelled by the π-section shown, has a series inductance $L = 1.6$ mH/km and a shunt capacitance $C = 0.01$ μF/km. Its surge (characteristic) impedance $Z_c = \sqrt{L/C}$ is: **[2 marks]**



$C/2$ each end

(A) $400\ \Omega$

(B) $200\ \Omega$

(C) $300\ \Omega$

(D) $160\ \Omega$

Q28. Two buses of a lossless line are held at $V_1 = V_2 = 1.0$ pu with a line reactance $X = 0.25$ pu, and the load (power) angle is $\delta = 30°$. The real power transmitted, $P = \dfrac{V_1 V_2}{X} \sin \delta$, is: **[2 marks]**

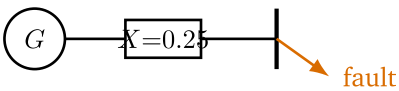
(A) 1 pu

(B) 2 pu

(C) 4 pu

(D) 0.5 pu

Q29. A generator with reactance $X = 0.25$ pu (on a 100 MVA base) and pre-fault e.m.f. $E = 1.0$ pu feeds the bus shown. For a balanced three-phase fault at the bus the per-unit fault current, $I_f = \dfrac{E}{X}$, is: **[2 marks]**



(A) 0.25 pu

(B) 4 pu

(C) 2 pu

(D) 1 pu

Q30. A per-unit study chooses a base of 200 MVA and 20 kV. The base impedance, $Z_{base} = \dfrac{(kV_{base})^2}{MVA_{base}}$, is: **[2 marks]**

(A) $0.5\ \Omega$

(B) $10\ \Omega$

(C) $2\ \Omega$

(D) $20\ \Omega$

Control Systems

Q31. A linear system is described in state-space form with system matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$. The poles (eigenvalues), i.e. the roots of $\det(sI - A) = s^2 + 3s + 2 = 0$, are: **[2 marks]**

(A) $-1,\ -3$

(B) $0,\ -3$

(C) $-1,\ -2$

(D) $-2,\ -3$

Q32. A second-order system has $A = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix}$ and $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$. Its controllability matrix is $Q_c = [\,B \quad AB\,] = \begin{bmatrix} 0 & 1 \\ 1 & -2 \end{bmatrix}$, with $\det Q_c = -1 \neq 0$. The system is therefore: **[2 marks]**

(A) completely controllable

(B) uncontrollable

(C) unstable

(D) marginally stable

Q33. A standard second-order system has the characteristic equation $s^2 + 4s + 16 = 0$. Comparing with $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$, the damping ratio ζ is: **[2 marks]**

(A) 1

(B) 0.25

(C) 0.5

(D) 0.4

Q34. The state matrix A of a linear time-invariant system has eigenvalues at $s = -2$ and $s = +1$. Judging stability from the location of these eigenvalues (poles) in the s-plane, the system is: **[2 marks]**

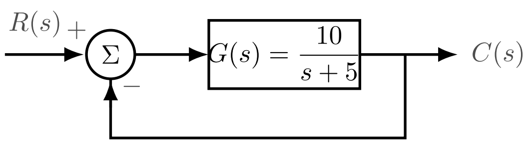
(A) stable

(B) marginally stable

(C) critically damped

(D) unstable

Q35. For the unity-feedback control system shown, the forward-path transfer function is $G(s) = \dfrac{10}{s+5}$. The d.c. gain of the closed-loop transfer function $\dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)}$ (its value at $s = 0$) is nearest to: **[2 marks]**



(A) 10

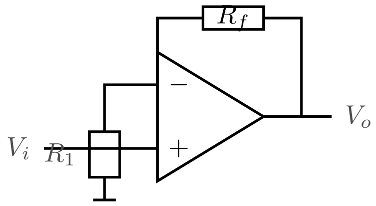
(B) 2

(C) 1

(D) 0.667

Analog, Digital and Measurements

Q36. For the ideal-op-amp non-inverting amplifier shown, $R_1 = 10$ kΩ and $R_f = 20$ kΩ. Its closed-loop voltage gain $\dfrac{V_o}{V_i} = 1 + \dfrac{R_f}{R_1}$ is: **[2 marks]**



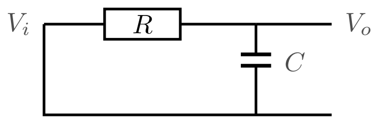
(A) 2

(B) 20

(C) 3

(D) 0.5

Q37. A first-order RC low-pass filter has $R = 1$ kΩ and $C = 1$ μF, as shown. Its -3 dB cut-off frequency, $f_c = \dfrac{1}{2\pi RC}$, is nearest to: **[2 marks]**



(A) 1000 Hz

(B) 6.28 Hz

(C) 100 Hz

(D) 159 Hz

Q38. An 8-bit analog-to-digital converter (ADC) has a full-scale input range of 5.12 V. Its resolution (the voltage change corresponding to one LSB), $\Delta = \dfrac{V_{FS}}{2^n}$, is: **[2 marks]**

(A) 20 mV

(B) 5 mV

(C) 256 mV

(D) 40 mV

Q39. An n-bit analog-to-digital converter produces 2^n distinct output codes (quantization levels). The number of quantization levels of a 4-bit ADC is: **[2 marks]**

(A) 4

(B) 8

(C) 16

(D) 32

Q40. Applying De Morgan's theorem, the Boolean expression $\overline{A+B}$ simplifies to: **[2 marks]**

(A) $\bar{A}+\bar{B}$

(B) $A \cdot B$

(C) $\bar{A} \cdot B$

(D) $\bar{A} \cdot \bar{B}$

Q41. A pure sinusoidal voltage is applied to a measurement circuit. The form factor of the waveform, defined as $\frac{V_{rms}}{V_{avg}}$ where V_{avg} is the average of the full-wave rectified value $\left(=\frac{2V_m}{\pi}\right)$ and $V_{rms}=\frac{V_m}{\sqrt{2}}$, is nearest to: **[2 marks]**

(A) 1.0

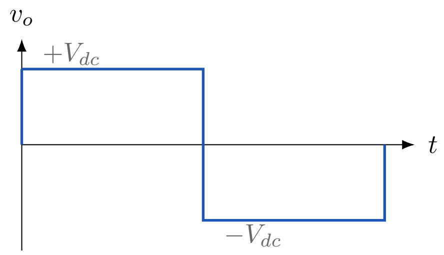
(B) 1.11

(C) 1.57

(D) 0.707

Power Electronics

Q42. A single-phase full-bridge (square-wave) voltage-source inverter operates from a d.c. input of $V_{dc}=200$ V, producing the square-wave output shown that swings between $+V_{dc}$ and $-V_{dc}$. The r.m.s. value of this output voltage is: **[2 marks]**



(A) 200 V

(B) 141 V

(C) 100 V

(D) 283 V

Q43. A single-phase half-bridge (square-wave) inverter operates from a d.c. input of $V_{dc} = 200$ V, so its output swings between $+V_{dc}/2$ and $-V_{dc}/2$. The r.m.s. value of this output voltage is: **[2 marks]**

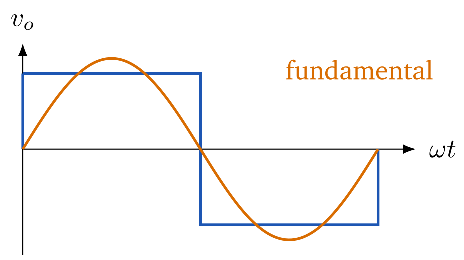
(A) 200 V

(B) 100 V

(C) 141 V

(D) 50 V

Q44. A single-phase full-bridge square-wave inverter has an output that swings between $+V_{dc}$ and $-V_{dc}$ with $V_{dc} = 100$ V. From Fourier analysis the r.m.s. value of the fundamental component, $V_{1,rms} = \frac{4}{\pi} \cdot \frac{V_{dc}}{\sqrt{2}} \approx 0.9\,V_{dc}$, is: **[2 marks]**



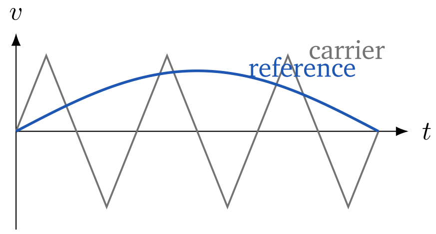
(A) 100 V

(B) 90 V

(C) 45 V

(D) 127 V

Q45. In a single-phase sinusoidal-PWM (SPWM) inverter, a sinusoidal reference (modulating) signal of peak 8 V is compared with a triangular carrier of peak 10 V, as sketched. The amplitude modulation index, $m_a = \dfrac{\hat{V}_{control}}{\hat{V}_{tri}}$, is: **[2 marks]**



(A) 1.25

(B) 10

(C) 0.2

(D) 0.8

Q46. A single-phase square-wave inverter produces a fundamental output at 50 Hz. Since the square wave contains only odd harmonics, the lowest-order harmonic present is the third; its frequency, $f_3 = 3f_1$, is: **[2 marks]**

(A) 50 Hz

(B) 150 Hz

(C) 100 Hz

(D) 250 Hz

Detailed Solutions

Q1.

Solution

Concept – maximum power transfer theorem: A resistive load draws maximum power from a source network when the load resistance is made equal to the Thevenin resistance of that network, $R_L = R_{th}$.

Step 1 – read the Thevenin data: $V_{th} = 20$ V, $R_{th} = 10\ \Omega$.

Step 2 – apply the matching condition: The maximum-power condition is independent of V_{th} and depends only on R_{th}.

Step 3 – set the load equal to the Thevenin resistance: $R_L = R_{th} = 10\ \Omega$

Step 4 – interpret: With $R_L = 10\ \Omega$ the source and load impedances are matched, giving the largest possible load power.

Final Answer: $R_L = 10\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – superposition theorem: The response at the node is the algebraic sum of the responses produced by each independent source acting alone, with the other voltage sources short-circuited.

Step 1 – keep the 12 V source, short the 6 V source: The node then sees its own $6\ \Omega$ load in parallel with the shorted branch's $6\ \Omega$.

Step 2 – combine that parallel pair: $6 \parallel 6 = \dfrac{6 \times 6}{6+6} = 3\ \Omega$

Step 3 – form the divider for the 12 V source through its series $6\ \Omega$: $V' = 12 \times \dfrac{3}{6+3} = 12 \times \dfrac{3}{9} = 4$ V

Step 4 – keep the 6 V source, short the 12 V source: By identical symmetry the node again sees $6 \parallel 6 = 3\ \Omega$ facing the series $6\ \Omega$.

Step 5 – form the divider for the 6 V source: $V'' = 6 \times \dfrac{3}{6+3} = 6 \times \dfrac{3}{9} = 2$ V

Step 6 – add the two contributions: $V = V' + V'' = 4 + 2 = 6$ V

Final Answer: $V = 6\text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept – power delivered at maximum power transfer: When $R_L = R_{th}$, the power delivered to the load is $P_{\max} = \dfrac{V_{th}^2}{4R_{th}}$.

Step 1 – list the data: $V_{th} = 30$ V, $R_{th} = 15\ \Omega$.

Step 2 – square the Thevenin voltage: $V_{th}^2 = 30^2 = 900$

Step 3 – form the denominator: $4R_{th} = 4 \times 15 = 60$

Step 4 – divide: $P_{\max} = \dfrac{900}{60}$

$P_{\max} = 15$ W

Final Answer: $P_{\max} = 15 \text{ W} \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q3**

Q4.

Solution

Concept – Thevenin resistance by reduction: With all independent sources deactivated, series and parallel combinations are reduced step by step to a single equivalent resistance across the terminals.

Step 1 – combine the two parallel resistors: $6 \parallel 3 = \dfrac{6 \times 3}{6+3} = \dfrac{18}{9} = 2\ \Omega$

Step 2 – add the series $4\ \Omega$ in front of that parallel block: $R_{th} = 4 + 2$

Step 3 – evaluate: $R_{th} = 6\ \Omega$

Step 4 – sanity check: The $2\ \Omega$ parallel block plus the $4\ \Omega$ series element must exceed $4\ \Omega$, and $6 > 4$, so the result is consistent.

Final Answer: $R_{th} = 6\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q4**

Q5.

Solution

Concept – time constant of an RL circuit: For a first-order RL circuit the time constant is $\tau = \dfrac{L}{R}$.

Step 1 – list the data: $L = 0.5$ H, $R = 10\ \Omega$.

Step 2 – substitute: $\tau = \dfrac{0.5}{10}$

Step 3 – evaluate: $\tau = 0.05$ s

Step 4 – convert to milliseconds: $\tau = 50$ ms

Final Answer: $\tau = 50 \text{ ms} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q5

Q6.

Solution

Concept – efficiency at maximum power transfer: At the matched condition the load and the source (Thevenin) resistances are equal, so the total series current dissipates equal power in each.

Step 1 – write the two dissipations: Load power $= I^2 R_L$ and internal loss $= I^2 R_{th}$, with the same current I.

Step 2 – use the matching condition $R_L = R_{th}$: Both dissipations are therefore equal.

Step 3 – form the efficiency: $\eta = \dfrac{I^2 R_L}{I^2 R_L + I^2 R_{th}} = \dfrac{R_L}{R_L + R_{th}}$

Step 4 – substitute $R_L = R_{th}$: $\eta = \dfrac{R_{th}}{2R_{th}} = \dfrac{1}{2}$

Step 5 – express as a percentage: $\eta = 50\%$

Why the other options are wrong:

- A, 100%: would need zero source resistance, which contradicts matching.
- C and D: neither 75% nor 25% corresponds to equal load and source resistances.

Final Answer: $\eta = 50\% \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept – current-divider rule: For two resistors in parallel fed by a current source, the current in one branch is the source current times the *opposite* resistor over the sum, $I_1 = I_s \dfrac{R_2}{R_1 + R_2}$.

Step 1 – identify the branches: $R_1 = 2\ \Omega$ (the branch of interest), $R_2 = 4\ \Omega$, $I_s = 6$ A.

Step 2 – form the denominator: $R_1 + R_2 = 2 + 4 = 6\ \Omega$

Step 3 – apply the divider using the opposite resistance: $I_{2\Omega} = 6 \times \dfrac{4}{6}$

Step 4 – evaluate: $I_{2\Omega} = 4$ A

Step 5 – sanity check: The smaller resistor carries the larger share, so its current (4 A) exceeds half of 6 A; consistent.

Final Answer: $I_{2\Omega} = 4 \text{ A} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – parallel-plate capacitor with a dielectric: $C = \dfrac{\varepsilon_0 \varepsilon_r A}{d}$, where ε_r is the relative permittivity of the filling dielectric.

Step 1 – list the data in base units: $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m, $\varepsilon_r = 5$, $A = 0.01$ m^2, $d = 0.5$ mm $= 0.5 \times 10^{-3}$ m.

Step 2 – form the numerator $\varepsilon_0 \varepsilon_r A$: $\varepsilon_0 \varepsilon_r A = (8.854 \times 10^{-12}) \times 5 \times 0.01$

$\varepsilon_0 \varepsilon_r A = 4.427 \times 10^{-13}$

Step 3 – divide by the separation: $C = \dfrac{4.427 \times 10^{-13}}{0.5 \times 10^{-3}}$

Step 4 – combine the numbers and powers of ten: $C = 8.854 \times 10^{-10}$ F

Step 5 – convert to picofarads: $C = 885.4$ pF ≈ 885 pF

Final Answer: $C \approx 885 \text{ pF} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – electrostatic energy density: The energy stored per unit volume of an electric field in free space is $u = \frac{1}{2}\varepsilon_0 E^2$.

Step 1 – list the data: $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m, $E = 1 \times 10^6$ V/m.

Step 2 – square the field: $E^2 = (1 \times 10^6)^2 = 1 \times 10^{12}$ V^2/m^2

Step 3 – substitute into the energy-density formula: $u = \frac{1}{2} \times (8.854 \times 10^{-12}) \times (1 \times 10^{12})$

Step 4 – combine the powers of ten: $(8.854 \times 10^{-12}) \times (1 \times 10^{12}) = 8.854$

Step 5 – take one-half: $u = \frac{1}{2} \times 8.854 = 4.427$ J/m^3 ≈ 4.43 J/m^3

Final Answer: $u \approx 4.43$ J/m^3 $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

Q10.

Solution

Concept – energy of an isolated (charge-fixed) capacitor with a dielectric: For a capacitor whose charge Q is held constant, $W = \frac{Q^2}{2C}$. Inserting a dielectric of relative permittivity ε_r multiplies the capacitance by ε_r, so the energy falls by the factor ε_r.

Step 1 – note the initial energy: $W_1 = 8$ J, with charge Q fixed after disconnection.

Step 2 – write how capacitance changes: The dielectric $\varepsilon_r = 4$ raises the capacitance to $C' = 4C$.

Step 3 – write how the energy changes at fixed Q: $W_2 = \frac{Q^2}{2C'} = \frac{Q^2}{2(4C)} = \frac{1}{4} \cdot \frac{Q^2}{2C} = \frac{W_1}{4}$

Step 4 – substitute the number: $W_2 = \frac{8}{4}$

Step 5 – evaluate: $W_2 = 2$ J

Why the other options are wrong:

- A, 32 J: multiplies rather than divides by ε_r (that is the constant-voltage case, wrong here).
- C, 4 J: uses a factor of 2 instead of 4.

Final Answer: $W_2 = 2$ J $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept – capacitors in parallel: Capacitances in parallel add directly, $C_{eq} = C_1 + C_2$.

Step 1 – list the data: $C_1 = 4\ \mu$F, $C_2 = 8\ \mu$F.

Step 2 – add the two values: $C_{eq} = 4 + 8$

Step 3 – evaluate: $C_{eq} = 12\ \mu$F

Step 4 – sanity check: A parallel combination is always larger than either capacitor, and $12 > 8$, so the result is consistent.

Final Answer: $C_{eq} = 12\ \mu\text{F} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept – Nyquist sampling theorem: A band-limited signal with highest frequency f_m must be sampled at a rate of at least $f_s = 2f_m$ to allow exact reconstruction without aliasing.

Step 1 – read the maximum frequency: $f_m = 4$ kHz (the spectrum is zero beyond this).

Step 2 – apply the Nyquist criterion: $f_s = 2f_m = 2 \times 4$

Step 3 – evaluate: $f_s = 8$ kHz

Step 4 – interpret: Sampling any slower than 8 kHz would fold the high-frequency content back into the baseband (aliasing).

Final Answer: $f_s = 8\ \text{kHz} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept – time-shifting property of the Fourier transform: A delay in time corresponds to multiplication by a linear-phase term in frequency, $x(t - t_0) \longleftrightarrow X(\omega)\, e^{-j\omega t_0}$.

Step 1 – start from the definition of the transform of the shifted signal: $\mathcal{F}\{x(t - t_0)\} = \int_{-\infty}^{\infty} x(t - t_0)\, e^{-j\omega t}\, dt$

Step 2 – substitute $\tau = t - t_0$ (so $t = \tau + t_0$, $dt = d\tau$): $= \int_{-\infty}^{\infty} x(\tau)\, e^{-j\omega(\tau + t_0)}\, d\tau$

Step 3 – pull the constant phase factor out of the integral: $= e^{-j\omega t_0} \int_{-\infty}^{\infty} x(\tau)\, e^{-j\omega\tau}\, d\tau$

Step 4 – recognise the remaining integral as $X(\omega)$: $= X(\omega)\, e^{-j\omega t_0}$

Step 5 – interpret: A pure time delay changes only the phase (not the magnitude) of the spectrum.

Why the other options are wrong:

- A, $X(\omega-\omega_0)$: that is the frequency-shift (modulation) property.
- B, $e^{+j\omega t_0}$: has the wrong sign, corresponding to a time *advance*.
- D, $X(-\omega)$: that is the time-reversal property.

Final Answer: $X(\omega)\,e^{-j\omega t_0} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q13

Q14.

Solution

Concept – aliasing due to under-sampling: When a sinusoid of frequency f is sampled at $f_s < 2f$, it appears at the folded frequency $f_a = |f - f_s|$ (for this range).

Step 1 – list the data: $f = 5$ kHz, $f_s = 8$ kHz.

Step 2 – check that aliasing occurs: The Nyquist rate would be $2 \times 5 = 10$ kHz, and $8 < 10$, so the signal is under-sampled.

Step 3 – compute the alias frequency: $f_a = |5 - 8|$

Step 4 – evaluate: $f_a = 3$ kHz

Step 5 – interpret: The 5 kHz tone masquerades as a 3 kHz tone in the sampled data.

Final Answer: $f_a = 3\text{ kHz} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q14

Q15.

Solution

Concept – Fourier transform of the unit impulse: Using the sifting property, the impulse has a flat (constant) spectrum equal to unity for all ω.

Step 1 – write the defining integral: $\mathcal{F}\{\delta(t)\} = \int_{-\infty}^{\infty} \delta(t)\, e^{-j\omega t}\, dt$

Step 2 – apply the sifting property (the impulse picks the value at $t = 0$): $= e^{-j\omega \cdot 0}$

Step 3 – evaluate the exponential at $t = 0$: $= e^0 = 1$

Step 4 – interpret: The impulse contains every frequency in equal measure, so its transform is the constant 1.

Why the other options are wrong:

- A and B: $\delta(\omega)$ and $2\pi\delta(\omega)$ are the transforms of a constant (d.c.) signal, the reverse pair.
- C, $1/j\omega$: is (part of) the transform of the unit step, not the impulse.

Final Answer: $\mathcal{F}\{\delta(t)\} = 1 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – d.c. (average) value of a Fourier series: The average value of a periodic signal over one period equals the constant term a_0; every pure sinusoid averages to zero over a whole number of cycles.

Step 1 – identify the terms of $x(t)$: Constant part $= 3$; oscillatory parts $= 2\cos(\omega_0 t)$ and $\sin(2\omega_0 t)$.

Step 2 – average each sinusoid over one fundamental period: $\langle 2\cos(\omega_0 t)\rangle = 0$ and $\langle \sin(2\omega_0 t)\rangle = 0$.

Step 3 – average the constant term: $\langle 3\rangle = 3$

Step 4 – add the averages: $\bar{x} = 3 + 0 + 0$

Step 5 – state the result: $\bar{x} = 3$

Final Answer: average value $= 3 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept – frequency of a synchronous generator: The generated frequency is linked to poles P and speed N (rpm) by $f = \dfrac{PN}{120}$.

Step 1 – list the data: $P = 6$, $N = 1000$ rpm.

Step 2 – form the product PN: $PN = 6 \times 1000 = 6000$

Step 3 – divide by 120: $f = \dfrac{6000}{120}$

Step 4 – evaluate: $f = 50$ Hz

Final Answer: $f = 50$ Hz $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – synchronous speed: A synchronous machine runs exactly at $N_s = \dfrac{120f}{P}$.

Step 1 – list the data: $f = 50$ Hz, $P = 8$.

Step 2 – form the numerator $120f$**:** $120 \times 50 = 6000$

Step 3 – divide by the number of poles: $N_s = \dfrac{6000}{8}$

Step 4 – evaluate: $N_s = 750$ rpm

Final Answer: $N_s = 750$ rpm $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q18

Q19.

Solution

Concept – voltage regulation of a synchronous generator: Percentage regulation compares the no-load e.m.f. with the full-load terminal voltage, Reg% $= \dfrac{E - V}{V} \times 100$.

Step 1 – list the data: $E = 250$ V, $V = 220$ V.

Step 2 – find the voltage drop $E - V$**:** $E - V = 250 - 220 = 30$ V

Step 3 – divide by the terminal voltage: $\dfrac{30}{220} = 0.1364$

Step 4 – convert to a percentage: Reg% $= 0.1364 \times 100 = 13.64\% \approx 13.6\%$

Why the other options are wrong:

- C, 30%: takes the raw 30 V drop as a percentage, forgetting to divide by V.
- D, 88%: is V/E, an unrelated ratio.

Final Answer: Reg $\approx 13.6\% \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept – power–angle relation of a cylindrical-rotor generator: The real power delivered is $P = \frac{EV}{X_s}\sin\delta$.

Step 1 – list the data: $E = 1.2$ pu, $V = 1.0$ pu, $X_s = 0.6$ pu, $\delta = 30°$.

Step 2 – evaluate $\sin\delta$**:** $\sin 30° = 0.5$

Step 3 – form the numerator $EV\sin\delta$**:** $1.2 \times 1.0 \times 0.5 = 0.6$

Step 4 – divide by the synchronous reactance: $P = \frac{0.6}{0.6}$

Step 5 – evaluate: $P = 1.0$ pu

Final Answer: $P = 1.0 \text{ pu} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – slip and rotor speed of an induction motor: The rotor runs slower than the synchronous field by the slip, $N = N_s(1-s)$.

Step 1 – list the data: $N_s = 1500$ rpm, $s = 0.04$.

Step 2 – form $(1-s)$**:** $1 - 0.04 = 0.96$

Step 3 – multiply by the synchronous speed: $N = 1500 \times 0.96$

Step 4 – evaluate: $N = 1440$ rpm

Step 5 – sanity check: The running speed must be just below N_s, and $1440 < 1500$; consistent.

Final Answer: $N = 1440 \text{ rpm} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – efficiency of a machine: Efficiency is output over input, and input equals output plus losses, $\eta = \frac{P_{out}}{P_{out} + P_{loss}}$.

Step 1 – list the data: $P_{out} = 100$ kW, $P_{loss} = 5$ kW.

Step 2 – form the input power: $P_{in} = 100 + 5 = 105$ kW

Step 3 – form the efficiency ratio: $\eta = \dfrac{100}{105}$

Step 4 – evaluate: $\eta = 0.952$

Step 5 – convert to a percentage: $\eta = 95.2\%$

Final Answer: $\eta = 95.2\% \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept – rotor (slip) frequency: The frequency of the currents induced in the rotor is the supply frequency scaled by the slip, $f_r = sf$.

Step 1 – list the data: $s = 0.05$, $f = 50$ Hz.

Step 2 – multiply: $f_r = 0.05 \times 50$

Step 3 – evaluate: $f_r = 2.5$ Hz

Step 4 – sanity check: At small slip the rotor frequency is only a few hertz, far below the 50 Hz stator frequency; consistent.

Final Answer: $f_r = 2.5$ Hz $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept – $ABCD$ parameters of a short line: A short line is modelled by a single series impedance Z with no shunt branch, giving $A = 1$, $B = Z$, $C = 0$, $D = 1$.

Step 1 – recall the two-port relations: $V_S = AV_R + BI_R$ and $I_S = CV_R + DI_R$.

Step 2 – apply the short-line assumptions (no shunt admittance): The sending-end and receiving-end currents are equal, so $C = 0$ and $D = 1$.

Step 3 – relate the voltages through the series drop: $V_S = V_R + ZI_R$, which matches $A = 1$ and $B = Z$.

Step 4 – read off the A parameter: $A = 1$

Final Answer: $A = 1 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q24

Q25.

Solution

Concept – the B parameter of a short line: For a short line B equals the total series impedance Z (it has units of ohms).

Step 1 – read the series impedance: $Z = (10 + j40)\ \Omega$.

Step 2 – identify the B parameter: From $V_S = AV_R + BI_R$ with $A = 1$, the coefficient of I_R is the series impedance.

Step 3 – write the value: $B = Z = (10 + j40)\ \Omega$

Why the other options are wrong:

- A and B: 1 and 0 are the (dimensionless) A/D and C values, not B.
- C, $(40 + j10)\ \Omega$: swaps the real and imaginary parts of Z.

Final Answer: $B = (10 + j40)\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q25**

Q26.

Solution

Concept – determinant property of $ABCD$ parameters: For any passive, reciprocal (bilateral) two-port, the transmission parameters satisfy $AD - BC = 1$.

Step 1 – state the reciprocity condition: A transmission line is a passive reciprocal network.

Step 2 – apply the property: $AD - BC = 1$

Step 3 – verify with the short-line values ($A = D = 1$, $B = Z$, $C = 0$): $AD - BC = (1)(1) - (Z)(0) = 1 - 0 = 1$

Step 4 – state the result: The determinant is 1 regardless of the line length.

Final Answer: $AD - BC = 1 \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q26**

Q27.

Solution

Concept – surge (characteristic) impedance: For a lossless line $Z_c = \sqrt{L/C}$, using per-kilometre values of L and C.

Step 1 – list the data in base units: $L = 1.6$ mH/km $= 1.6 \times 10^{-3}$ H/km, $C = 0.01\ \mu$F/km $= 1 \times 10^{-8}$ F/km.

Step 2 – form the ratio L/C: $\dfrac{L}{C} = \dfrac{1.6 \times 10^{-3}}{1 \times 10^{-8}}$

Step 3 – combine the powers of ten: $\dfrac{L}{C} = 1.6 \times 10^5$

Step 4 – take the square root: $Z_c = \sqrt{1.6 \times 10^5} = \sqrt{160000}$

Step 5 – evaluate: $Z_c = 400\ \Omega$

Final Answer: $Z_c = 400\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept – power transfer across a reactance: The real power sent over a lossless line is $P = \dfrac{V_1 V_2}{X}\sin\delta$.

Step 1 – list the data: $V_1 = V_2 = 1.0$ pu, $X = 0.25$ pu, $\delta = 30°$.

Step 2 – evaluate $\sin\delta$: $\sin 30° = 0.5$

Step 3 – form the numerator $V_1 V_2 \sin\delta$: $1.0 \times 1.0 \times 0.5 = 0.5$

Step 4 – divide by the reactance: $P = \dfrac{0.5}{0.25}$

Step 5 – evaluate: $P = 2$ pu

Final Answer: $P = 2$ pu $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q28

Q29.

Solution

Concept – three-phase (symmetrical) fault current: For a bolted three-phase fault fed through a reactance X from source e.m.f. E, the per-unit fault current is $I_f = \dfrac{E}{X}$.

Step 1 – list the data: $E = 1.0$ pu, $X = 0.25$ pu.

Step 2 – form the ratio: $I_f = \frac{1.0}{0.25}$

Step 3 – evaluate: $I_f = 4$ pu

Step 4 – interpret: A per-unit fault current of 4 means four times the base current flows into the fault.

Final Answer: $I_f = 4 \text{ pu} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – base impedance in per-unit analysis: $Z_{base} = \frac{(kV_{base})^2}{MVA_{base}}$.

Step 1 – list the data: $kV_{base} = 20$ kV, $MVA_{base} = 200$ MVA.

Step 2 – square the base voltage: $(20)^2 = 400$

Step 3 – divide by the base MVA: $Z_{base} = \frac{400}{200}$

Step 4 – evaluate: $Z_{base} = 2\ \Omega$

Final Answer: $Z_{base} = 2\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q30

Q31.

Solution

Concept – poles from the state matrix: The poles (natural modes) of a state-space system are the eigenvalues of A, i.e. the roots of $\det(sI - A) = 0$.

Step 1 – form $sI - A$: $sI - A = \begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix}$

Step 2 – take the determinant: $\det(sI - A) = s(s+3) - (-1)(2)$

Step 3 – expand: $= s^2 + 3s + 2$

Step 4 – factor the characteristic polynomial: $s^2 + 3s + 2 = (s+1)(s+2)$

Step 5 – read the roots: $s = -1$ and $s = -2$

Final Answer: poles at $-1,\ -2 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – controllability test: A system of order n is completely controllable if its controllability matrix $Q_c = [\,B \;\; AB \;\; \cdots \;\; A^{n-1}B\,]$ has full rank n (equivalently, a non-zero determinant for a square Q_c).

Step 1 – compute AB: $AB = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$

Step 2 – assemble the controllability matrix: $Q_c = [\,B \;\; AB\,] = \begin{bmatrix} 0 & 1 \\ 1 & -2 \end{bmatrix}$

Step 3 – evaluate its determinant: $\det Q_c = (0)(-2) - (1)(1) = -1$

Step 4 – test the rank: $\det Q_c = -1 \neq 0$, so Q_c has full rank 2.

Step 5 – conclude: The system is completely controllable.

Final Answer: completely controllable $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – damping ratio of a second-order system: Comparing $s^2 + 2\zeta\omega_n s + \omega_n^2$ with the given polynomial gives ω_n and then ζ.

Step 1 – match the constant term to ω_n^2: $\omega_n^2 = 16 \Rightarrow \omega_n = 4$ rad/s

Step 2 – match the middle term to $2\zeta\omega_n$: $2\zeta\omega_n = 4$

Step 3 – substitute $\omega_n = 4$: $2\zeta(4) = 4 \Rightarrow 8\zeta = 4$

Step 4 – solve for ζ: $\zeta = \dfrac{4}{8} = 0.5$

Step 5 – interpret: $\zeta = 0.5$ describes an under-damped response $(0 < \zeta < 1)$.

Final Answer: $\zeta = 0.5 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – stability from eigenvalue location: A linear time-invariant system is stable only if every eigenvalue of A lies in the left half of the s-plane (negative real part). A single eigenvalue with positive real part makes it unstable.

Step 1 – list the eigenvalues: $s_1 = -2$ (left half-plane) and $s_2 = +1$ (right half-plane).

Step 2 – test each against the stability requirement: $s_1 = -2$ is fine, but $s_2 = +1$ has a positive real part.

Step 3 – apply the stability rule: Even one right-half-plane pole produces an unbounded growing mode (e^{+t}).

Step 4 – conclude: The system is unstable.

Final Answer: unstable $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q34

Q35.

Solution

Concept – d.c. gain of a closed-loop system: The closed-loop transfer function is $\dfrac{G(s)}{1+G(s)}$; its d.c. gain is that expression evaluated at $s = 0$.

Step 1 – evaluate $G(0)$: $G(0) = \dfrac{10}{0+5} = \dfrac{10}{5} = 2$

Step 2 – form the closed-loop d.c. gain: $\left.\dfrac{C}{R}\right|_{s=0} = \dfrac{G(0)}{1+G(0)} = \dfrac{2}{1+2}$

Step 3 – add the denominator: $1 + 2 = 3$

Step 4 – divide: $\dfrac{2}{3} = 0.667$

Step 5 – interpret: Feedback pulls the d.c. gain below unity toward 0.667.

Final Answer: d.c. gain $= 0.667 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q35

Q36.

Solution

Concept – non-inverting amplifier gain: For an ideal op-amp in the non-inverting configuration the closed-loop gain is $A_v = 1 + \dfrac{R_f}{R_1}$.

Step 1 – list the data: $R_1 = 10\ \text{k}\Omega$, $R_f = 20\ \text{k}\Omega$.

Step 2 – form the resistor ratio: $\dfrac{R_f}{R_1} = \dfrac{20}{10} = 2$

Step 3 – add the unity term: $A_v = 1 + 2$

Step 4 – evaluate: $A_v = 3$

Step 5 – sanity check: A non-inverting gain is always at least 1, and $3 > 1$; consistent.

Why the other options are wrong:

- A, 2: uses only R_f/R_1 and forgets the $+1$ (that would be an inverting-magnitude value).
- D, 0.5: inverts the ratio.

Final Answer: $A_v = 3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q36

Q37.

Solution

Concept – cut-off frequency of an RC low-pass filter: The -3 dB corner frequency is $f_c = \dfrac{1}{2\pi RC}$.

Step 1 – list the data in base units: $R = 1\text{ k}\Omega = 1 \times 10^3\ \Omega$, $C = 1\ \mu\text{F} = 1 \times 10^{-6}$ F.

Step 2 – form the product RC: $RC = (1 \times 10^3) \times (1 \times 10^{-6}) = 1 \times 10^{-3}$ s

Step 3 – form $2\pi RC$: $2\pi RC = 2\pi \times 10^{-3} = 6.283 \times 10^{-3}$

Step 4 – take the reciprocal: $f_c = \dfrac{1}{6.283 \times 10^{-3}}$

Step 5 – evaluate: $f_c = 159.2\text{ Hz} \approx 159\text{ Hz}$

Why the other options are wrong:

- A, 1000 Hz: uses $1/RC$ but forgets the 2π.
- B, 6.28 Hz: is $2\pi RC$ expressed wrongly as a frequency.

Final Answer: $f_c \approx 159\text{ Hz} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – ADC resolution: The smallest resolvable voltage (one LSB) is the full-scale range divided by the number of steps, $\Delta = \dfrac{V_{FS}}{2^n}$.

Step 1 – list the data: $V_{FS} = 5.12$ V, $n = 8$ bits.

Step 2 – find the number of steps: $2^n = 2^8 = 256$

Step 3 – divide the full scale by the number of steps: $\Delta = \dfrac{5.12}{256}$

Step 4 – evaluate: $\Delta = 0.02$ V

Step 5 – convert to millivolts: $\Delta = 20$ mV

Final Answer: $\Delta = 20$ mV $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q38

Q39.

Solution

Concept – quantization levels of an ADC: An n-bit converter resolves the input into 2^n distinct levels.

Step 1 – note the number of bits: $n = 4$.

Step 2 – raise two to that power: $2^4 = 2 \times 2 \times 2 \times 2$

Step 3 – evaluate: $2^4 = 16$

Step 4 – state the result: The 4-bit ADC has 16 quantization levels.

Final Answer: 16 levels $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept – De Morgan's theorem: The complement of a sum equals the product of the complements, $\overline{A+B} = \bar{A} \cdot \bar{B}$.

Step 1 – identify the operation: The bar covers the whole OR expression $A + B$.

Step 2 – apply De Morgan (OR becomes AND, complement each variable): $\overline{A+B} = \bar{A} \cdot \bar{B}$

Step 3 – verify with a test row ($A = 0, B = 0$): LHS $= \overline{0+0} = \bar{0} = 1$; RHS $= \bar{0} \cdot \bar{0} = 1 \cdot 1 = 1$. They agree.

Step 4 – state the simplified form: $Y = \bar{A} \cdot \bar{B}$

Why the other options are wrong:

- A, $\bar{A} + \bar{B}$: is $\overline{A \cdot B}$, the dual (mixes up the operator).

Final Answer: $\bar{A} \cdot \bar{B} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – form factor of a sinusoid: Form factor $= \dfrac{V_{rms}}{V_{avg}}$, where for a sinusoid $V_{rms} = \dfrac{V_m}{\sqrt{2}}$ and the (full-wave) average is $V_{avg} = \dfrac{2V_m}{\pi}$.

Step 1 – write the RMS value: $V_{rms} = \dfrac{V_m}{\sqrt{2}} = 0.707\,V_m$

Step 2 – write the average value: $V_{avg} = \dfrac{2V_m}{\pi} = 0.637\,V_m$

Step 3 – form the ratio (the V_m cancels): $\mathrm{FF} = \dfrac{0.707\,V_m}{0.637\,V_m} = \dfrac{0.707}{0.637}$

Step 4 – evaluate: $\mathrm{FF} = 1.11$

Step 5 – cross-check with the closed form: $\dfrac{\pi}{2\sqrt{2}} = \dfrac{3.1416}{2.828} = 1.11$; consistent.

Why the other options are wrong:

- C, 1.57: is the peak factor V_m/V_{avg}, not the form factor.
- D, 0.707: is V_{rms}/V_m, a different ratio.

Final Answer: form factor $= 1.11 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q41

Q42.

Solution

Concept – RMS of a full-bridge square-wave inverter output: The output equals $+V_{dc}$ for one half period and $-V_{dc}$ for the other, so its magnitude is always V_{dc}; hence the RMS value equals V_{dc}.

Step 1 – write the RMS integral for a square wave: $V_{rms} = \sqrt{\dfrac{1}{T}\displaystyle\int_0^T v_o^2\,dt}$

Step 2 – note that $v_o^2 = V_{dc}^2$ throughout the period: Both half-cycles give $(\pm V_{dc})^2 = V_{dc}^2$.

Step 3 – carry out the average of a constant: $\dfrac{1}{T}\displaystyle\int_0^T V_{dc}^2\,dt = V_{dc}^2$

Step 4 – take the square root: $V_{rms} = \sqrt{V_{dc}^2} = V_{dc}$

Step 5 – substitute the value: $V_{rms} = 200\ \mathrm{V}$

Final Answer: $V_{rms} = 200\ \mathrm{V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – RMS of a half-bridge square-wave inverter output: A half-bridge output swings between $+V_{dc}/2$ and $-V_{dc}/2$; its magnitude is always $V_{dc}/2$, so the RMS value is $V_{dc}/2$.

Step 1 – write the peak magnitude: $|v_o| = \dfrac{V_{dc}}{2} = \dfrac{200}{2} = 100\text{ V}$

Step 2 – note the square-wave RMS equals its magnitude: Since $v_o^2 = (V_{dc}/2)^2$ over the whole period,

Step 3 – evaluate the RMS: $V_{rms} = \dfrac{V_{dc}}{2} = 100\text{ V}$

Step 4 – compare with the full-bridge case: The half-bridge delivers half the RMS voltage of a full bridge on the same V_{dc}.

Final Answer: $V_{rms} = 100\text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q43

Q44.

Solution

Concept – fundamental component of a square wave: The Fourier series of a $\pm V_{dc}$ square wave has a fundamental of peak $\dfrac{4V_{dc}}{\pi}$, whose RMS is $\dfrac{4V_{dc}}{\pi\sqrt{2}} \approx 0.9\,V_{dc}$.

Step 1 – write the fundamental peak: $\hat{V}_1 = \dfrac{4V_{dc}}{\pi} = \dfrac{4 \times 100}{3.1416} = 127.3\text{ V}$

Step 2 – convert the peak to RMS: $V_{1,rms} = \dfrac{\hat{V}_1}{\sqrt{2}} = \dfrac{127.3}{1.414}$

Step 3 – evaluate: $V_{1,rms} = 90\text{ V}$

Step 4 – cross-check with the $0.9\,V_{dc}$ shortcut: $0.9 \times 100 = 90$ V; consistent.

Why the other options are wrong:

- A, 100 V: is the total RMS (all harmonics), not the fundamental alone.
- D, 127 V: is the fundamental *peak*, before converting to RMS.

Final Answer: $V_{1,rms} = 90\text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q44

Q45.

Solution

Concept – amplitude modulation index in SPWM: The amplitude modulation index is the ratio of the reference (control) peak to the carrier (triangle) peak, $m_a = \dfrac{\hat{V}_{control}}{\hat{V}_{tri}}$.

Step 1 – list the data: $\hat{V}_{control} = 8$ V, $\hat{V}_{tri} = 10$ V.

Step 2 – form the ratio: $m_a = \dfrac{8}{10}$

Step 3 – evaluate: $m_a = 0.8$

Step 4 – interpret: $m_a = 0.8 < 1$, so the inverter operates in the linear (under-modulated) region.

Why the other options are wrong:

- A, 1.25: inverts the ratio (carrier over control).
- B, 10: uses only the carrier peak.

Final Answer: $m_a = 0.8 \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q45**

Q46.

Solution

Concept – harmonics of a square wave: An ideal square wave has half-wave symmetry, so it contains only odd harmonics $(1, 3, 5, \ldots)$; the lowest above the fundamental is the third, at $f_3 = 3f_1$.

Step 1 – note the fundamental frequency: $f_1 = 50$ Hz.

Step 2 – identify the lowest harmonic present: Even harmonics are absent, so the lowest is the third.

Step 3 – compute its frequency: $f_3 = 3 \times 50$

Step 4 – evaluate: $f_3 = 150$ Hz

Why the other options are wrong:

- A, 50 Hz: is the fundamental itself, not a harmonic.
- C, 100 Hz: is the second harmonic, which a symmetric square wave does not contain.

Final Answer: $f_3 = 150 \text{ Hz} \Rightarrow \boxed{\text{B}}$

$\boxed{\text{Answer: (B)}}$ Go Back to Q46

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	A	4	C	5	A
6	B	7	A	8	A	9	D	10	D
11	C	12	B	13	C	14	A	15	D
16	B	17	A	18	C	19	B	20	A
21	B	22	D	23	C	24	A	25	D
26	D	27	A	28	B	29	B	30	C
31	C	32	A	33	C	34	D	35	D
36	C	37	D	38	A	39	C	40	D
41	B	42	A	43	B	44	B	45	D
46	B								