GATE Electrical Engineering

Sample Paper – 5

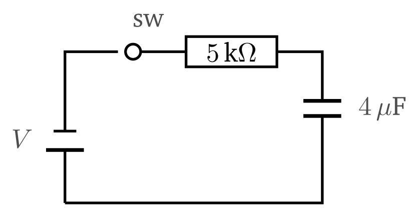
Duration: 128 Minutes **Maximum Marks: 72**

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 series RC circuit is connected to a d.c. source through a switch closed at $t = 0$, as shown, with $R = 5$ kΩ and $C = 4$ μF. The time constant of the charging transient is: **[1 mark]**



(A) 10 ms

(B) 40 ms

(C) 20 ms

(D) 2 ms

Q2. A capacitor charged to an initial voltage $V_0 = 100$ V at $t = 0$ is allowed to discharge through a resistor in a source-free RC circuit. After one full time constant ($t = \tau$) the capacitor voltage, $v(\tau) = V_0 e^{-1}$, is nearest to: **[1 mark]**

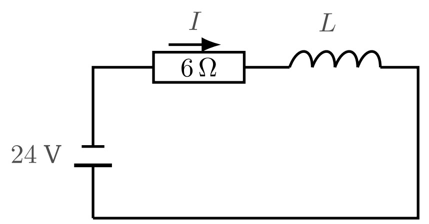
(A) 36.8 V

(B) 63.2 V

(C) 100 V

(D) 0 V

Q3. In the circuit shown, a 24 V d.c. source feeds a 6 Ω resistor in series with an inductor L. After the circuit has reached d.c. steady state (the inductor behaving as a short circuit), the current I drawn from the source is: **[1 mark]**



(A) 6 A

(B) 2 A

(C) 4 A

(D) 8 A

Q4. Two resistors of 10 Ω and 40 Ω are connected in parallel between two nodes. The equivalent resistance of the combination is: **[1 mark]**

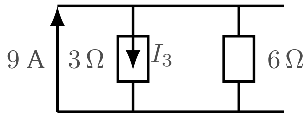
(A) 50 Ω

(B) 8 Ω

(C) 30 Ω

(D) 4 Ω

Q5. An ideal 9 A current source feeds two parallel resistors of 3 Ω and 6 Ω, as shown. Using the current-divider rule, the current I_3 through the 3 Ω resistor is: **[1 mark]**



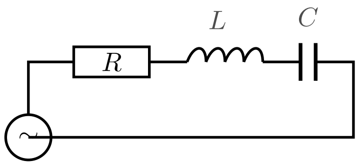
(A) 6 A

(B) 3 A

(C) 9 A

(D) 4.5 A

Q6. The series RLC circuit shown has $L = 1$ mH and $C = 10\ \mu$F. The undamped resonant (natural) angular frequency, $\omega_0 = \frac{1}{\sqrt{LC}}$, is: **[1 mark]**



(A) 10000 rad/s

(B) 1000 rad/s

(C) 100000 rad/s

(D) 5000 rad/s

Q7. A one-port network is reduced to a Thevenin equivalent with open-circuit voltage $V_{th} = 20$ V and Thevenin resistance $R_{th} = 4\ \Omega$. When a load is set for maximum power transfer, the power delivered to the load, $P_{\max} = \frac{V_{th}^2}{4R_{th}}$, is: **[1 mark]**

(A) 100 W

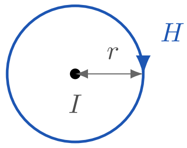
(B) 50 W

(C) 10 W

(D) 25 W

Electromagnetic Fields

Q8. By Ampere's circuital law the magnetic field intensity around a long straight conductor carrying current I is $H = \dfrac{I}{2\pi r}$. For $I = 10$ A at a radial distance $r = 0.05$ m, as shown, H is nearest to: **[1 mark]**



(A) 15.9 A/m

(B) 31.8 A/m

(C) 63.7 A/m

(D) 10 A/m

Q9. A magnetic core is wound with $N = 200$ turns carrying a current $I = 2$ A, and the mean magnetic path length is $l = 0.4$ m. The magnetic field intensity in the core, $H = \dfrac{NI}{l}$, is: **[1 mark]**

(A) 1000 A/m

(B) 400 A/m

(C) 2000 A/m

(D) 500 A/m

Q10. An inductor of $L = 2$ H carries a steady current of $I = 3$ A. The magnetic energy stored in the inductor, $W = \frac{1}{2}LI^2$, is: **[1 mark]**

(A) 9 J

(B) 18 J

(C) 3 J

(D) 6 J

Q11. Two capacitors of $4\ \mu$F and $8\ \mu$F are connected in parallel between two nodes. The equivalent capacitance of the parallel combination is: **[1 mark]**

(A) $2.67\ \mu$F

(B) $32\ \mu$F

(C) $4\ \mu$F

(D) $12\ \mu$F

Signals and Systems

Q12. Two finite-length discrete-time sequences of lengths 6 and 3 samples are linearly convolved. The length (number of samples) of the resulting output sequence is: **[1 mark]**

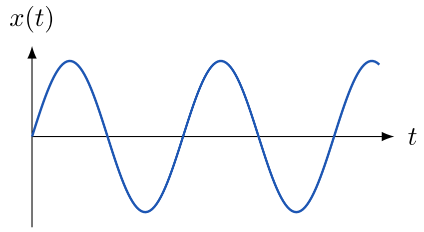
(A) 8

(B) 18

(C) 6

(D) 9

Q13. A continuous-time signal is $x(t) = \sin(50\pi t)$, one cycle of which is sketched below. Its fundamental period T is: **[1 mark]**



(A) 20 ms

(B) 40 ms

(C) 10 ms

(D) 80 ms

Q14. An input $x(t)$ is applied to an LTI system whose impulse response is the shifted impulse $h(t) = \delta(t-5)$. Using the sifting property of convolution, the output $y(t) = x(t) * \delta(t-5)$ is: **[1 mark]**

(A) $x(t+5)$

(B) $x(t-5)$

(C) $x(t)$

(D) $x(5t)$

Q15. The d.c. (average) value over one period of the periodic signal $x(t) = 8 + 6\cos(\omega_0 t) + 2\sin(2\omega_0 t)$ is: **[1 mark]**

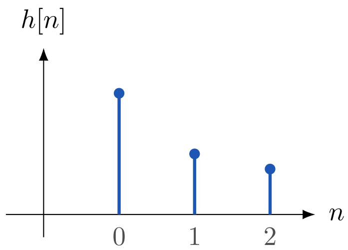
(A) 8

(B) 6

(C) 16

(D) 0

Q16. A discrete-time sequence $x[n]$ with $\sum_n x[n] = 4$ is convolved with an LTI system whose impulse response $h[n]$ (shown) has $\sum_n h[n] = 3$. Using the convolution-sum property, the total sum $\sum_n y[n]$ of the output is: **[1 mark]**



(A) 7

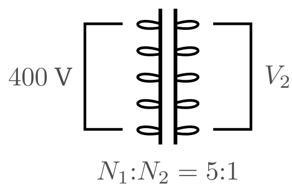
(B) 1

(C) 4

(D) 12

Electrical Machines

Q17. An ideal single-phase transformer has a turns ratio $N_1/N_2 = 5$ and is supplied at 400 V on the primary, as shown. The secondary (open-circuit) voltage is: **[1 mark]**



(A) 2000 V

(B) 40 V

(C) 80 V

(D) 100 V

Q18. A d.c. shunt motor is supplied at $V = 250$ V and draws an armature current $I_a = 40$ A. The armature-circuit resistance is $R_a = 0.25\ \Omega$. The back e.m.f. $E_b = V - I_aR_a$ is: **[1 mark]**

(A) 250 V

(B) 260 V

(C) 10 V

(D) 240 V

Q19. A d.c. shunt motor runs at 1000 rpm with a back e.m.f. of 200 V. If the field flux is held constant and the back e.m.f. is raised to 240 V (speed control by armature voltage), the new speed, from $N \propto E_b$, is: **[1 mark]**

(A) 1000 rpm

(B) 1200 rpm

(C) 800 rpm

(D) 960 rpm

Q20. A 10 kVA single-phase transformer has a rated secondary voltage of 200 V. The rated (full-load) secondary current is: **[1 mark]**

(A) 5 A

(B) 10 A

(C) 50 A

(D) 20 A

Q21. A d.c. motor develops a back e.m.f. of $E_b = 220$ V while carrying an armature current of $I_a = 30$ A. The gross mechanical power developed in the armature, $P = E_b I_a$, is: **[2 marks]**

(A) 5 kW

(B) 8 kW

(C) 6.6 kW

(D) 10 kW

Q22. A single-phase transformer delivers an output of 9.5 kW. Its core (iron) loss is 300 W and its copper loss at this load is 200 W. The efficiency $\eta = \dfrac{P_{out}}{P_{out} + P_{loss}}$ is nearest to: **[2 marks]**

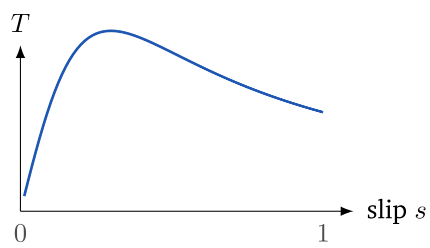
(A) 95%

(B) 90%

(C) 97.4%

(D) 98%

Q23. A 6-pole, 50 Hz three-phase induction motor runs at a rotor speed of 960 rpm; its torque–slip characteristic is sketched below. The per-unit slip $s = \dfrac{N_s - N}{N_s}$ is: **[2 marks]**



(A) 2%

(B) 4%

(C) 6%

(D) 8%

Power Systems

Q24. In per-unit analysis a base of 50 MVA and 10 kV is chosen. The base impedance $Z_{base} = \dfrac{(kV_{base})^2}{MVA_{base}}$ is: **[2 marks]**

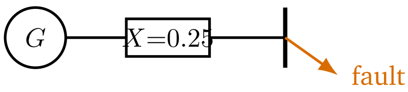
(A) $0.2\ \Omega$

(B) $0.5\ \Omega$

(C) $5\ \Omega$

(D) $2\ \Omega$

Q25. A generator is connected to a bus of base 100 MVA through a reactance of $X = 0.25$ pu, as shown by the single-line diagram. For a three-phase symmetrical fault at the bus the fault level $\text{MVA}_{fault} = \dfrac{\text{MVA}_{base}}{X_{pu}}$ is: **[2 marks]**



(A) 100 MVA

(B) 25 MVA

(C) 400 MVA

(D) 200 MVA

Q26. A generator reactance is specified as 0.15 pu on a base of 100 MVA. Converting it to a new base of 200 MVA at the same voltage, using $X_{new} = X_{old} \times \dfrac{MVA_{new}}{MVA_{old}}$, gives: **[2 marks]**

(A) 0.3 pu

(B) 0.075 pu

(C) 0.15 pu

(D) 0.6 pu

Q27. A power transformer has a no-load secondary voltage of 240 V, which falls to 220 V at full load. Its percentage voltage regulation, $VR = \dfrac{V_{nl} - V_{fl}}{V_{fl}} \times 100\%$, is nearest to: **[2 marks]**

(A) 5%

(B) 8.3%

(C) 4.5%

(D) 9.09%

Q28. In a two-bus load-flow study the bus voltages are $V_1 = 1.0$ pu and $V_2 = 0.98$ pu with a power angle $\delta = 30^\circ$ between them, and the connecting lossless line has reactance $X = 0.5$ pu. The real power transferred, $P = \dfrac{V_1 V_2 \sin\delta}{X}$, is: **[2 marks]**

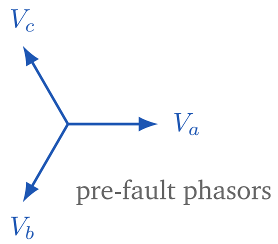
(A) 1.96 pu

(B) 0.98 pu

(C) 0.49 pu

(D) 0.5 pu

Q29. A single-line-to-ground fault occurs on an unloaded generator whose sequence reactances are $Z_1 = Z_2 = Z_0 = 0.15$ pu, with a pre-fault e.m.f. $E = 1.0$ pu. The fault current $I_f = \dfrac{3E}{Z_1 + Z_2 + Z_0}$ is: **[2 marks]**



(A) 10 pu

(B) 3.33 pu

(C) 20 pu

(D) 6.67 pu

Q30. A three-phase system uses a base of 100 MVA at a line voltage of 220 kV. The base current $I_{base} = \dfrac{\text{MVA}_{base}}{\sqrt{3}\,\text{kV}_{base}}$ is nearest to: **[2 marks]**

(A) 437 A

(B) 262 A

(C) 758 A

(D) 100 A

Control Systems

Q31. A standard second-order system has the characteristic equation $s^2 + 8s + 16 = 0$. Comparing with $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$, the damping ratio ζ is: **[2 marks]**

(A) 0.5

(B) 2

(C) 0.25

(D) 1

Q32. The characteristic equation of a closed-loop system is $s^3 + s^2 + 2s + 8 = 0$. Using the Routh–Hurwitz criterion, the number of closed-loop poles lying in the right half of the s-plane is: **[2 marks]**

(A) 0

(B) 1

(C) 3

(D) 2

Q33. A unity-feedback system has open-loop transfer function $G(s) = \dfrac{20}{(s+2)(s+5)}$ (a type-0 system). For a unit-step input the steady-state error, $e_{ss} = \dfrac{1}{1+K_p}$ with $K_p = \lim_{s\to 0} G(s)$, is: **[2 marks]**

(A) 0.333

(B) 0.5

(C) 0

(D) 1

Q34. A unity-feedback system has open-loop transfer function $G(s) = \dfrac{100}{s(s+10)}$ (a type-1 system). For a unit-ramp input the steady-state error, $e_{ss} = \dfrac{1}{K_v}$ with $K_v = \lim_{s\to 0} sG(s)$, is: **[2 marks]**

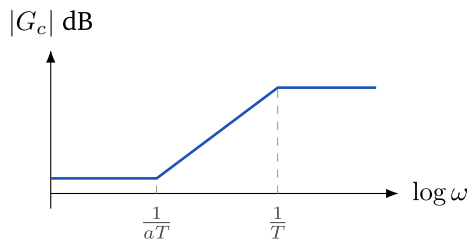
(A) 0.1

(B) 0

(C) 0.5

(D) 1

Q35. A phase-lead compensator has the transfer function $G_c(s) = \dfrac{1+aTs}{1+Ts}$ with $a = 3$, whose Bode magnitude asymptotes are sketched below. The maximum phase lead it can contribute, $\phi_m = \sin^{-1}\left(\dfrac{a-1}{a+1}\right)$, is: **[2 marks]**



(A) $45°$

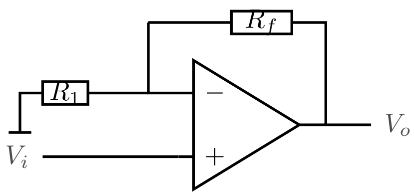
(B) $30°$

(C) $60°$

(D) $90°$

Analog, Digital and Measurements

Q36. For the ideal-op-amp non-inverting amplifier shown, $R_1 = 10\ \text{k}\Omega$ (to ground) and $R_f = 40\ \text{k}\Omega$ (feedback). The closed-loop voltage gain $\dfrac{V_o}{V_i} = 1 + \dfrac{R_f}{R_1}$ is: **[2 marks]**



(A) 4

(B) 0.2

(C) 6

(D) 5

Q37. The unsigned binary number $(11010)_2$ has the decimal (base-10) value: [2 marks]

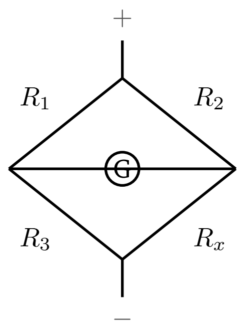
(A) 11

(B) 26

(C) 22

(D) 13

Q38. The Wheatstone bridge shown is balanced with $R_1 = 200\ \Omega$, $R_2 = 400\ \Omega$ and $R_3 = 600\ \Omega$. The unknown resistance, from the balance condition $R_x = \dfrac{R_2 R_3}{R_1}$, is: [2 marks]



(A) 1200 Ω

(B) 600 Ω

(C) 150 Ω

(D) 800 Ω

Q39. The hexadecimal number $(2F)_{16}$ has the decimal (base-10) value: [2 marks]

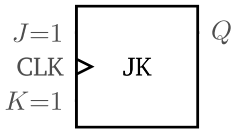
(A) 16

(B) 32

(C) 47

(D) 26

Q40. A JK flip-flop is wired with $J = K = 1$ so that it toggles on every active clock edge, as shown. If the clock frequency is 10 kHz, the frequency of the output Q (a divide-by-two action) is: **[2 marks]**



(A) 10 kHz

(B) 20 kHz

(C) 5 kHz

(D) 2.5 kHz

Q41. For a full-wave rectified (or pure) sinusoidal waveform the form factor is defined as $FF = \dfrac{V_{rms}}{V_{avg}}$. For a sinusoid of peak V_m, with $V_{rms} = 0.707\,V_m$ and full-wave average $V_{avg} = 0.637\,V_m$, the form factor is nearest to: **[2 marks]**

(A) 1.00

(B) 1.11

(C) 1.414

(D) 0.707

Power Electronics

Q42. A single-phase half-wave diode rectifier feeds a resistive load from a supply of peak voltage $V_m = 157$ V. The average (d.c.) output voltage $V_{dc} = \dfrac{V_m}{\pi}$ is nearest to: **[2 marks]**

(A) 100 V

(B) 78.5 V

(C) 50 V

(D) 157 V

Q43. A single-phase full-wave (bridge) diode rectifier feeds a resistive load from a supply of peak voltage $V_m = 110$ V. The average (d.c.) output voltage $V_{dc} = \dfrac{2V_m}{\pi}$ is nearest to: **[2 marks]**

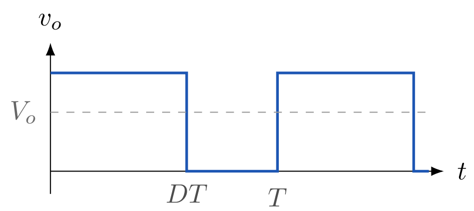
(A) 110 V

(B) 55 V

(C) 70 V

(D) 35 V

Q44. A step-down (buck) d.c. chopper operates from a supply $V_s = 150$ V at a duty ratio $D = 0.6$, producing the output-voltage waveform shown. The average output voltage $V_o = D\,V_s$ is: **[2 marks]**



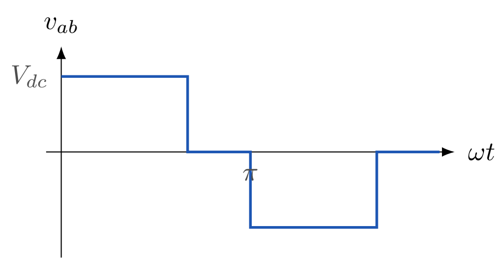
(A) 150 V

(B) 250 V

(C) 60 V

(D) 90 V

Q45. A three-phase voltage-source inverter operating in $180°$-conduction mode is fed from a d.c. link of $V_{dc} = 600$ V, producing the six-step line-voltage waveform sketched below. The r.m.s. value of the line voltage, $V_{L,rms} = \sqrt{\frac{2}{3}}\,V_{dc}$, is nearest to: **[2 marks]**



(A) 600 V

(B) 490 V

(C) 245 V

(D) 424 V

Q46. A three-phase voltage-source inverter running in $180°$-conduction (six-step) mode produces a quasi-square line-voltage waveform. Because the three phase legs are $120°$ apart, all triplen (third and its multiples) harmonics cancel in the line voltage, so the lowest-order harmonics actually present are the: **[2 marks]**

(A) 2nd and 3rd

(B) 3rd and 9th

(C) 5th and 7th

(D) all even harmonics

Detailed Solutions

Q1.

Solution

Concept – time constant of an RC circuit: For a first-order RC circuit the charging or discharging transient decays with time constant $\tau = RC$.

Step 1 – convert the values to base units: $R = 5\ \text{k}\Omega = 5 \times 10^3\ \Omega$

$C = 4\ \mu\text{F} = 4 \times 10^{-6}\ \text{F}$

Step 2 – form the product RC: $\tau = (5 \times 10^3) \times (4 \times 10^{-6})$

Step 3 – multiply the mantissas and add the exponents: $\tau = (5 \times 4) \times 10^{3-6}$

$\tau = 20 \times 10^{-3}\ \text{s}$

Step 4 – express in milliseconds: $\tau = 20\ \text{ms}$

Final Answer: $\tau = 20\ \text{ms} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – discharge of a capacitor: In a source-free RC circuit the capacitor voltage decays exponentially as $v(t) = V_0\, e^{-t/\tau}$.

Step 1 – set the elapsed time to one time constant: At $t = \tau$ the exponent is $-t/\tau = -1$.

Step 2 – write the voltage at that instant: $v(\tau) = V_0\, e^{-1}$

Step 3 – substitute $V_0 = 100$ V: $v(\tau) = 100 \times e^{-1}$

Step 4 – use $e^{-1} = 0.3679$: $v(\tau) = 100 \times 0.3679$

Step 5 – evaluate: $v(\tau) = 36.8\ \text{V}$

Why the other options are wrong:

- B, 63.2 V: that is $V_0(1 - e^{-1})$, the value for a *charging* capacitor, not a discharging one.
- C, 100 V: that is the initial value at $t = 0$, before any decay.
- D, 0 V: the fully discharged value, reached only as $t \to \infty$.

Final Answer: $v(\tau) = 36.8\ \text{V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q2

Q3.

Solution

Concept – inductor in d.c. steady state: Once all transients die out, a constant current flows and the inductor voltage $L\,di/dt$ becomes zero, so the inductor behaves as a plain short circuit.

Step 1 – replace the inductor by a short: The circuit reduces to the 24 V source in series with the $6\ \Omega$ resistor only.

Step 2 – apply Ohm's law around the loop: $I = \dfrac{V}{R}$

Step 3 – substitute the values: $I = \dfrac{24}{6}$

Step 4 – evaluate: $I = 4$ A

Final Answer: $I = 4\text{ A} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept – two resistors in parallel: The equivalent of two parallel resistors is their product over their sum, $R_{eq} = \dfrac{R_1R_2}{R_1 + R_2}$.

Step 1 – list the data: $R_1 = 10\ \Omega$, $R_2 = 40\ \Omega$.

Step 2 – form the product: $R_1R_2 = 10 \times 40 = 400$

Step 3 – form the sum: $R_1 + R_2 = 10 + 40 = 50$

Step 4 – divide: $R_{eq} = \dfrac{400}{50}$

$R_{eq} = 8\ \Omega$

Step 5 – sanity check: A parallel combination is always smaller than the smaller branch ($10\ \Omega$), and $8 < 10$, so the result is consistent.

Final Answer: $R_{eq} = 8\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q4

Q5.

Solution

Concept – current-divider rule: When a current I_s enters two parallel resistors, the current in one branch is proportional to the *opposite* resistance: $I_3 = I_s \times \dfrac{R_6}{R_3 + R_6}$.

Step 1 – list the data: $I_s = 9$ A, $R_3 = 3\ \Omega$, $R_6 = 6\ \Omega$.

Step 2 – form the sum of the two resistances: $R_3 + R_6 = 3 + 6 = 9\ \Omega$

Step 3 – write the divider ratio for the $3\ \Omega$ branch (uses the other resistance $6\ \Omega$): $\dfrac{R_6}{R_3 + R_6} = \dfrac{6}{9}$

Step 4 – multiply by the source current: $I_3 = 9 \times \dfrac{6}{9}$

Step 5 – evaluate: $I_3 = 6$ A

Final Answer: $I_3 = 6\text{ A} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q5

Q6.

Solution

Concept – resonance of a series RLC circuit: The undamped natural (resonant) angular frequency is $\omega_0 = \dfrac{1}{\sqrt{LC}}$, independent of R.

Step 1 – convert to base units: $L = 1\text{ mH} = 1 \times 10^{-3}$ H

$C = 10\ \mu\text{F} = 10 \times 10^{-6}\text{ F} = 1 \times 10^{-5}$ F

Step 2 – form the product LC: $LC = (1 \times 10^{-3}) \times (1 \times 10^{-5})$

$LC = 1 \times 10^{-8}$

Step 3 – take the square root: $\sqrt{LC} = \sqrt{1 \times 10^{-8}} = 1 \times 10^{-4}$

Step 4 – take the reciprocal: $\omega_0 = \dfrac{1}{1 \times 10^{-4}}$

$\omega_0 = 1 \times 10^4\text{ rad/s} = 10000\text{ rad/s}$

Final Answer: $\omega_0 = 10000\text{ rad/s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q6

Q7.

Solution

Concept – maximum power transfer theorem: Maximum power reaches the load when $R_L = R_{th}$, and then $P_{\max} = \dfrac{V_{th}^2}{4R_{th}}$.

Step 1 – list the data: $V_{th} = 20$ V, $R_{th} = 4\ \Omega$.

Step 2 – square the Thevenin voltage: $V_{th}^2 = 20^2 = 400$

Step 3 – form the denominator: $4R_{th} = 4 \times 4 = 16$

Step 4 – divide: $P_{\max} = \dfrac{400}{16}$

$P_{\max} = 25$ W

Final Answer: $P_{\max} = 25 \text{ W} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – Ampere's circuital law for a long straight wire: The magnetic field intensity at radius r from a long straight conductor is $H = \dfrac{I}{2\pi r}$.

Step 1 – list the data: $I = 10$ A, $r = 0.05$ m.

Step 2 – form the denominator $2\pi r$: $2\pi r = 2 \times 3.1416 \times 0.05$

$2\pi r = 0.3142$

Step 3 – divide the current by this: $H = \dfrac{10}{0.3142}$

Step 4 – evaluate: $H = 31.8$ A/m

Final Answer: $H = 31.8 \text{ A/m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – magnetic field intensity in a wound core: The m.m.f. is NI and it drives the field over the mean path length l, so $H = \dfrac{NI}{l}$.

Step 1 – list the data: $N = 200$ turns, $I = 2$ A, $l = 0.4$ m.

Step 2 – form the magnetomotive force: $NI = 200 \times 2 = 400$ ampere-turns

Step 3 – divide by the mean path length: $H = \dfrac{400}{0.4}$

Step 4 – evaluate: $H = 1000$ A/m

Final Answer: $H = 1000$ A/m $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept – energy stored in an inductor: The magnetic energy held by an inductor carrying current I is $W = \frac{1}{2}LI^2$.

Step 1 – list the data: $L = 2$ H, $I = 3$ A.

Step 2 – square the current: $I^2 = 3^2 = 9$

Step 3 – substitute into the energy formula: $W = \frac{1}{2} \times 2 \times 9$

Step 4 – multiply $\frac{1}{2} \times 2$ first: $W = 1 \times 9$

Step 5 – evaluate: $W = 9$ J

Final Answer: $W = 9$ J $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept – capacitors in parallel: Capacitors in parallel add directly, $C_{eq} = C_1 + C_2$ (unlike resistors).

Step 1 – list the data: $C_1 = 4$ μF, $C_2 = 8$ μF.

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

Step 3 – evaluate: $C_{eq} = 12$ μF

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

Final Answer: $C_{eq} = 12$ μF $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept – length of a linear convolution: If two finite sequences have lengths L_1 and L_2, their linear convolution has length $L_1 + L_2 - 1$.

Step 1 – list the lengths: $L_1 = 6$, $L_2 = 3$.

Step 2 – add the two lengths: $L_1 + L_2 = 6 + 3 = 9$

Step 3 – subtract one: $L = 9 - 1$

Step 4 – evaluate: $L = 8$ samples

Final Answer: $L = 8 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – period of a sinusoid: For $x(t) = \sin(\omega_0 t)$ the fundamental period is $T = \dfrac{2\pi}{\omega_0}$.

Step 1 – read off the angular frequency: $\omega_0 = 50\pi$ rad/s.

Step 2 – substitute into the period formula: $T = \dfrac{2\pi}{50\pi}$

Step 3 – cancel π: $T = \dfrac{2}{50}$

Step 4 – evaluate: $T = 0.04$ s

Step 5 – convert to milliseconds: $T = 40$ ms

Final Answer: $T = 40$ ms $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – convolution with a shifted impulse: Convolving any signal with $\delta(t - t_0)$ shifts it in time: $x(t) * \delta(t - t_0) = x(t - t_0)$.

Step 1 – identify the shift: Here $h(t) = \delta(t - 5)$, so $t_0 = 5$.

Step 2 – apply the sifting (shifting) property: $y(t) = x(t) * \delta(t - 5)$

Step 3 – write the result: $y(t) = x(t - 5)$

Step 4 – interpret: The output is the input delayed by 5 seconds (a pure time delay, no change in shape).

Why the other options are wrong:

- A, $x(t+5)$: this is a time *advance*, which would need $\delta(t+5)$.
- C, $x(t)$: convolution with $\delta(t)$ (no shift), not $\delta(t-5)$.
- D, $x(5t)$: time scaling, unrelated to an impulse shift.

Final Answer: $y(t) = x(t-5) \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept – d.c. (average) value of a Fourier series: The average over one period equals the constant (a_0) term; every pure sine or cosine term averages to zero.

Step 1 – identify the terms: $x(t) = 8 + 6\cos(\omega_0 t) + 2\sin(2\omega_0 t)$.

Step 2 – average the cosine term: The mean of $6\cos(\omega_0 t)$ over one period is 0.

Step 3 – average the sine term: The mean of $2\sin(2\omega_0 t)$ over one period is 0.

Step 4 – keep the constant term: Only the 8 survives.

$\bar{x} = 8$

Final Answer: $\bar{x} = 8 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept – convolution-sum (area) property: For $y[n] = x[n]*h[n]$, the sum of the output equals the product of the input sums: $\sum_n y[n] = \left(\sum_n x[n]\right)\left(\sum_n h[n]\right)$.

Step 1 – list the two given sums: $\sum_n x[n] = 4$, $\sum_n h[n] = 3$.

Step 2 – apply the property (multiply the sums): $\sum_n y[n] = 4 \times 3$

Step 3 – evaluate: $\sum_n y[n] = 12$

Step 4 – interpret: This is why the d.c. gain of a cascade is the product of the individual d.c. gains.

Final Answer: $\sum_n y[n] = 12 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – voltage ratio of an ideal transformer: The secondary voltage follows the turns ratio, $\frac{V_1}{V_2} = \frac{N_1}{N_2}$, so $V_2 = V_1 \times \frac{N_2}{N_1}$.

Step 1 – list the data: $V_1 = 400$ V, $\frac{N_1}{N_2} = 5$.

Step 2 – write the secondary voltage: $V_2 = \frac{V_1}{N_1/N_2}$

Step 3 – substitute: $V_2 = \frac{400}{5}$

Step 4 – evaluate: $V_2 = 80$ V

Step 5 – check: A turns ratio greater than one is a step-down transformer, so $V_2 < V_1$, consistent with $80 < 400$.

Final Answer: $V_2 = 80 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q17

Q18.

Solution

Concept – back e.m.f. of a d.c. motor: The armature circuit obeys $V = E_b + I_a R_a$, so $E_b = V - I_a R_a$.

Step 1 – list the data: $V = 250$ V, $I_a = 40$ A, $R_a = 0.25\ \Omega$.

Step 2 – form the armature-resistance drop: $I_a R_a = 40 \times 0.25$

$I_a R_a = 10$ V

Step 3 – subtract from the supply voltage: $E_b = 250 - 10$

Step 4 – evaluate: $E_b = 240$ V

Final Answer: $E_b = 240 \text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q18

Q19.

Solution

Concept – armature-voltage speed control of a d.c. motor: With the field flux constant, the back e.m.f. is proportional to speed, $E_b = k\phi N \Rightarrow N \propto E_b$. Hence $\dfrac{N_2}{N_1} = \dfrac{E_{b2}}{E_{b1}}$.

Step 1 – list the data: $N_1 = 1000$ rpm, $E_{b1} = 200$ V, $E_{b2} = 240$ V.

Step 2 – form the ratio of back e.m.f.s: $\dfrac{E_{b2}}{E_{b1}} = \dfrac{240}{200} = 1.2$

Step 3 – multiply the old speed by this ratio: $N_2 = 1000 \times 1.2$

Step 4 – evaluate: $N_2 = 1200$ rpm

Step 5 – interpret: Raising the armature voltage (and hence E_b) with fixed flux is exactly how a shunt motor is sped up below and up to base speed.

Final Answer: $N_2 = 1200 \text{ rpm} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept – full-load current of a transformer: The rated current on a winding is the volt-ampere rating divided by that winding's rated voltage, $I = \dfrac{S}{V}$.

Step 1 – list the data in base units: $S = 10$ kVA $= 10000$ VA, $V = 200$ V.

Step 2 – divide the rating by the voltage: $I = \dfrac{10000}{200}$

Step 3 – evaluate: $I = 50$ A

Final Answer: $I = 50 \text{ A} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q20

Q21.

Solution

Concept – gross mechanical power of a d.c. motor: The power converted from electrical to mechanical form in the armature is $P = E_b I_a$.

Step 1 – list the data: $E_b = 220$ V, $I_a = 30$ A.

Step 2 – multiply: $P = 220 \times 30$

Step 3 – evaluate: $P = 6600$ W

Step 4 – convert to kilowatts: $P = 6.6$ kW

Final Answer: $P = 6.6$ kW $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q21

Q22.

Solution

Concept – transformer efficiency: Efficiency is the output power divided by the input power, and input equals output plus all losses: $\eta = \dfrac{P_{out}}{P_{out} + P_{iron} + P_{cu}}$.

Step 1 – list the data: $P_{out} = 9.5$ kW $= 9500$ W, $P_{iron} = 300$ W, $P_{cu} = 200$ W.

Step 2 – add the losses: $P_{loss} = 300 + 200 = 500$ W

Step 3 – form the input power: $P_{in} = 9500 + 500 = 10000$ W

Step 4 – divide output by input: $\eta = \dfrac{9500}{10000}$

Step 5 – evaluate and convert to percent: $\eta = 0.95 = 95\%$

Final Answer: $\eta = 95\% \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept – slip of an induction motor: The synchronous speed is $N_s = \dfrac{120f}{P}$ and the per-unit slip is $s = \dfrac{N_s - N}{N_s}$.

Step 1 – compute the synchronous speed: $N_s = \dfrac{120 \times 50}{6}$

$N_s = \dfrac{6000}{6} = 1000$ rpm

Step 2 – form the difference $N_s - N$: $N_s - N = 1000 - 960 = 40$ rpm

Step 3 – divide by the synchronous speed: $s = \dfrac{40}{1000}$

Step 4 – evaluate: $s = 0.04$

Step 5 – convert to percent: $s = 4\%$

Final Answer: $s = 4\% \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – base impedance in per-unit analysis: For a chosen voltage and volt-ampere base, $Z_{base} = \dfrac{(kV_{base})^2}{MVA_{base}}$ (three-phase, line-to-line kV).

Step 1 – list the data: $kV_{base} = 10$ kV, $MVA_{base} = 50$ MVA.

Step 2 – square the base voltage: $(kV_{base})^2 = 10^2 = 100$

Step 3 – divide by the base MVA: $Z_{base} = \dfrac{100}{50}$

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

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

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – short-circuit (fault) MVA: For a three-phase fault fed through a per-unit reactance, the fault level is $\text{MVA}_{fault} = \dfrac{\text{MVA}_{base}}{X_{pu}}$.

Step 1 – list the data: $\text{MVA}_{base} = 100$ MVA, $X_{pu} = 0.25$.

Step 2 – divide the base MVA by the reactance: $\text{MVA}_{fault} = \dfrac{100}{0.25}$

Step 3 – evaluate: $\text{MVA}_{fault} = 400$ MVA

Step 4 – interpret: A smaller series reactance would give an even larger fault level, so a fault MVA well above the base MVA is expected here.

Final Answer: $\text{MVA}_{fault} = 400 \text{ MVA} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q25

Q26.

Solution

Concept – change of MVA base (same voltage): A per-unit reactance scales directly with the MVA base when the voltage base is unchanged: $X_{new} = X_{old} \times \dfrac{MVA_{new}}{MVA_{old}}$.

Step 1 – list the data: $X_{old} = 0.15$ pu, $MVA_{old} = 100$, $MVA_{new} = 200$.

Step 2 – form the MVA ratio: $\dfrac{MVA_{new}}{MVA_{old}} = \dfrac{200}{100} = 2$

Step 3 – multiply the old reactance by this ratio: $X_{new} = 0.15 \times 2$

Step 4 – evaluate: $X_{new} = 0.3$ pu

Final Answer: $X_{new} = 0.3$ pu $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q26

Q27.

Solution

Concept – percentage voltage regulation: Voltage regulation compares the drop from no-load to full-load against the full-load voltage: $VR = \dfrac{V_{nl} - V_{fl}}{V_{fl}} \times 100\%$.

Step 1 – list the data: $V_{nl} = 240$ V, $V_{fl} = 220$ V.

Step 2 – form the voltage drop: $V_{nl} - V_{fl} = 240 - 220 = 20$ V

Step 3 – divide by the full-load voltage: $VR = \dfrac{20}{220}$

Step 4 – evaluate the fraction: $VR = 0.0909$

Step 5 – convert to percent: $VR = 9.09\%$

Final Answer: $VR = 9.09\% \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q27

Q28.

Solution

Concept – real power flow over a lossless line: The power transferred between two buses across a reactance is $P = \dfrac{V_1 V_2 \sin\delta}{X}$, where δ is the angle between the two bus voltages.

Step 1 – list the data: $V_1 = 1.0$ pu, $V_2 = 0.98$ pu, $\delta = 30°$, $X = 0.5$ pu.

Step 2 – evaluate the sine of the angle: $\sin 30° = 0.5$

Step 3 – form the numerator $V_1 V_2 \sin\delta$: $1.0 \times 0.98 \times 0.5 = 0.49$

Step 4 – divide by the reactance: $P = \dfrac{0.49}{0.5}$

Step 5 – evaluate: $P = 0.98$ pu

Final Answer: $P = 0.98$ pu $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q28

Q29.

Solution

Concept – single-line-to-ground fault current: For an LG fault the three sequence networks are in series, giving $I_f = \dfrac{3E}{Z_1 + Z_2 + Z_0}$.

Step 1 – list the data: $Z_1 = Z_2 = Z_0 = 0.15$ pu, $E = 1.0$ pu.

Step 2 – add the three sequence reactances: $Z_1 + Z_2 + Z_0 = 0.15 + 0.15 + 0.15 = 0.45$ pu

Step 3 – form the numerator $3E$: $3E = 3 \times 1.0 = 3$

Step 4 – divide: $I_f = \dfrac{3}{0.45}$

Step 5 – evaluate: $I_f = 6.67$ pu

Final Answer: $I_f = 6.67$ pu $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q29**

Q30.

Solution

Concept – base current of a three-phase system: The base current is $I_{base} = \dfrac{\text{MVA}_{base} \times 10^6}{\sqrt{3} \times \text{kV}_{base} \times 10^3}$ (line quantities).

Step 1 – list the data: $\text{MVA}_{base} = 100$, $\text{kV}_{base} = 220$.

Step 2 – form the denominator $\sqrt{3}\,\text{kV}_{base}$: $\sqrt{3} \times 220 = 1.732 \times 220 = 381.05$

Step 3 – write the current in consistent units (MVA over kV gives kA, then $\times 1000$ for A): $I_{base} = \dfrac{100 \times 10^6}{381.05 \times 10^3}$

Step 4 – simplify the powers of ten: $I_{base} = \dfrac{100000}{381.05}$

Step 5 – evaluate: $I_{base} = 262$ A

Final Answer: $I_{base} = 262$ A $\Rightarrow \boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q30**

Q31.

Solution

Concept – damping ratio of a second-order system: Matching $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$ term by term gives ω_n from the constant and then ζ from the middle coefficient.

Step 1 – read off the constant term: $\omega_n^2 = 16 \Rightarrow \omega_n = 4$ rad/s.

Step 2 – read off the middle coefficient: $2\zeta\omega_n = 8$

Step 3 – substitute $\omega_n = 4$**:** $2\zeta \times 4 = 8$

Step 4 – solve for ζ**:** $8\zeta = 8 \Rightarrow \zeta = 1$

Step 5 – interpret: $\zeta = 1$ means the system is critically damped (a repeated real pole at $s = -4$).

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

Answer: (D) Go Back to Q31

Q32.

Solution

Concept – Routh–Hurwitz stability test: Build the Routh array; the number of sign changes in the first column equals the number of right-half-plane (unstable) poles.

Step 1 – write the first two rows from $s^3 + s^2 + 2s + 8$**:** s^3 row: 1 2

s^2 row: 1 8

Step 2 – compute the s^1 **row entry:** $b_1 = \dfrac{(1)(2) - (1)(8)}{1} = \dfrac{2-8}{1} = -6$

Step 3 – compute the s^0 **row entry:** The last row carries down the constant, 8.

Step 4 – list the first column and mark the signs: $1\ (+),\ 1\ (+),\ -6\ (-),\ 8\ (+)$

Step 5 – count the sign changes: $+ \to +$ (none), $+ \to -$ (one change), $- \to +$ (a second change) $\Rightarrow$ 2 sign changes.

Step 6 – conclude: There are 2 poles in the right half plane, so the system is unstable.

Final Answer: number of RHP poles $= 2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept – steady-state error to a step (type-0 system): The position error constant is $K_p = \lim_{s\to 0} G(s)$ and the step error is $e_{ss} = \dfrac{1}{1+K_p}$.

Step 1 – evaluate K_p **by letting** $s \to 0$**:** $K_p = \dfrac{20}{(0+2)(0+5)}$

Step 2 – simplify the denominator: $(2)(5) = 10$

Step 3 – compute K_p: $K_p = \dfrac{20}{10} = 2$

Step 4 – substitute into the error formula: $e_{ss} = \dfrac{1}{1+2}$

Step 5 – evaluate: $e_{ss} = \dfrac{1}{3} = 0.333$

Final Answer: $e_{ss} = 0.333 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q33

Q34.

Solution

Concept – steady-state error to a ramp (type-1 system): The velocity error constant is $K_v = \lim_{s\to 0} sG(s)$ and the ramp error is $e_{ss} = \dfrac{1}{K_v}$.

Step 1 – form $sG(s)$: $sG(s) = \dfrac{100\,s}{s(s+10)} = \dfrac{100}{s+10}$

Step 2 – let $s \to 0$ to get K_v: $K_v = \dfrac{100}{0+10}$

Step 3 – evaluate K_v: $K_v = \dfrac{100}{10} = 10$

Step 4 – take the reciprocal for the error: $e_{ss} = \dfrac{1}{10}$

Step 5 – evaluate: $e_{ss} = 0.1$

Final Answer: $e_{ss} = 0.1 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – maximum phase lead of a lead compensator: For $G_c(s) = \dfrac{1+aTs}{1+Ts}$ with $a > 1$, the peak phase lead is $\phi_m = \sin^{-1}\left(\dfrac{a-1}{a+1}\right)$.

Step 1 – list the data: $a = 3$.

Step 2 – form the numerator $a-1$: $a - 1 = 3 - 1 = 2$

Step 3 – form the denominator $a+1$: $a + 1 = 3 + 1 = 4$

Step 4 – take the ratio: $\dfrac{a-1}{a+1} = \dfrac{2}{4} = 0.5$

Step 5 – take the inverse sine: $\phi_m = \sin^{-1}(0.5) = 30^\circ$

Final Answer: $\phi_m = 30^\circ \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q35

Q36.

Solution

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

Step 1 – list the data: $R_1 = 10\ \mathrm{k\Omega}$, $R_f = 40\ \mathrm{k\Omega}$.

Step 2 – form the feedback ratio: $\frac{R_f}{R_1} = \frac{40}{10} = 4$

Step 3 – add one: $\frac{V_o}{V_i} = 1 + 4$

Step 4 – evaluate: $\frac{V_o}{V_i} = 5$

Step 5 – note: Unlike the inverting amplifier (gain R_f/R_1), the non-inverting gain always exceeds unity and is positive.

Final Answer: gain $= 5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – binary-to-decimal conversion: Multiply each bit by its positional weight 2^k and add.

Step 1 – label the bits of $(11010)_2$ **with weights:** $1{\cdot}2^4 \quad 1{\cdot}2^3 \quad 0{\cdot}2^2 \quad 1{\cdot}2^1 \quad 0{\cdot}2^0$

Step 2 – evaluate each nonzero weight: $2^4 = 16$, $2^3 = 8$, $2^1 = 2$

Step 3 – add the contributing weights: $16 + 8 + 0 + 2 + 0$

Step 4 – evaluate: $= 26$

Final Answer: $(11010)_2 = 26 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – balanced Wheatstone bridge: At balance the galvanometer current is zero and the products of opposite arms are equal, giving $R_x = \dfrac{R_2 R_3}{R_1}$.

Step 1 – list the data: $R_1 = 200\ \Omega$, $R_2 = 400\ \Omega$, $R_3 = 600\ \Omega$.

Step 2 – form the product R_2R_3: $R_2R_3 = 400 \times 600 = 240000$

Step 3 – divide by R_1: $R_x = \dfrac{240000}{200}$

Step 4 – evaluate: $R_x = 1200\ \Omega$

Final Answer: $R_x = 1200\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q38

Q39.

Solution

Concept – hexadecimal-to-decimal conversion: Each hex digit carries a weight 16^k; the digit F equals 15.

Step 1 – split $(2\text{F})_{16}$ into weighted digits: $2\cdot 16^1 + \text{F}\cdot 16^0$

Step 2 – evaluate the 16^1 term: $2 \times 16 = 32$

Step 3 – evaluate the 16^0 term (F $= 15$): $15 \times 1 = 15$

Step 4 – add: $32 + 15 = 47$

Final Answer: $(2\text{F})_{16} = 47 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept – JK flip-flop in toggle mode: With $J = K = 1$ the flip-flop complements its output on every active clock edge, so Q changes once per clock period. A full output cycle therefore spans two clock periods, halving the frequency.

Step 1 – note the toggle action: Q needs one edge to go high and the next edge to go low, i.e. two input cycles per output cycle.

Step 2 – write the divide-by-two relation: $f_Q = \dfrac{f_{clk}}{2}$

Step 3 – substitute the clock frequency: $f_Q = \dfrac{10\text{ kHz}}{2}$

Step 4 – evaluate: $f_Q = 5$ kHz

Why the other options are wrong:

- A, 10 kHz: that would mean no division at all.
- B, 20 kHz: a toggle divides, it cannot multiply the frequency.
- D, 2.5 kHz: that is divide-by-four, needing two cascaded flip-flops.

Final Answer: $f_Q = 5$ kHz $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q40

Q41.

Solution

Concept – form factor of a sinusoid: The form factor is the ratio of the r.m.s. value to the average value, $FF = \dfrac{V_{rms}}{V_{avg}}$.

Step 1 – list the data: $V_{rms} = 0.707\,V_m$, $V_{avg} = 0.637\,V_m$.

Step 2 – form the ratio (the V_m cancels): $FF = \dfrac{0.707\,V_m}{0.637\,V_m} = \dfrac{0.707}{0.637}$

Step 3 – evaluate the division: $FF = 1.11$

Step 4 – interpret: The standard form factor of a sine wave is 1.11; it links average-reading and true-r.m.s. meter scales.

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

Answer: (B) Go Back to Q41

Q42.

Solution

Concept – average output of a half-wave rectifier: For a resistive load the mean (d.c.) output of a single-phase half-wave rectifier is $V_{dc} = \dfrac{V_m}{\pi}$.

Step 1 – list the data: $V_m = 157$ V, $\pi = 3.1416$.

Step 2 – substitute into the formula: $V_{dc} = \dfrac{157}{3.1416}$

Step 3 – evaluate: $V_{dc} = 50$ V

Why the other options are wrong:

- B, 78.5 V: that is $V_m/2$, not V_m/π.
- D, 157 V: that is the peak value, not the average.

Final Answer: $V_{dc} = 50 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q42

Q43.

Solution

Concept – average output of a full-wave rectifier: For a resistive load the mean output of a single-phase full-wave (bridge) rectifier is $V_{dc} = \frac{2V_m}{\pi}$, twice the half-wave value.

Step 1 – list the data: $V_m = 110$ V, $\pi = 3.1416$.

Step 2 – form the numerator $2V_m$: $2V_m = 2 \times 110 = 220$

Step 3 – divide by π: $V_{dc} = \dfrac{220}{3.1416}$

Step 4 – evaluate: $V_{dc} = 70$ V

Final Answer: $V_{dc} = 70 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – average output of a step-down chopper: For a buck chopper the mean output voltage is the input scaled by the duty ratio, $V_o = D\,V_s$.

Step 1 – list the data: $V_s = 150$ V, $D = 0.6$.

Step 2 – multiply: $V_o = 0.6 \times 150$

Step 3 – evaluate: $V_o = 90$ V

Step 4 – sanity check: A step-down chopper must give $V_o < V_s$, and $90 < 150$, so the result is consistent.

Why the other options are wrong:

- A, 150 V: that assumes $D = 1$ (switch always on).
- B, 250 V: a buck chopper cannot boost the voltage above the source.
- C, 60 V: uses $D = 0.4$, the off-time fraction, by mistake.

Final Answer: $V_o = 90 \text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q44

Q45.

Solution

Concept – r.m.s. line voltage of a 180° VSI: For a three-phase voltage-source inverter in 180°-conduction mode the r.m.s. line-to-line voltage is $V_{L,rms} = \sqrt{\frac{2}{3}}\, V_{dc}$.

Step 1 – list the data: $V_{dc} = 600$ V.

Step 2 – evaluate the constant $\sqrt{2/3}$: $\sqrt{2/3} = \sqrt{0.6667} = 0.8165$

Step 3 – multiply by the d.c.-link voltage: $V_{L,rms} = 0.8165 \times 600$

Step 4 – evaluate: $V_{L,rms} = 490$ V

Step 5 – interpret: The six-step line waveform spends two-thirds of each cycle at $\pm V_{dc}$, which is exactly why the factor is $\sqrt{2/3}$.

Final Answer: $V_{L,rms} = 490$ V $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q45

Q46.

Solution

Concept – harmonics of a 180° three-phase VSI: The quasi-square output has half-wave symmetry, so it contains no even harmonics, and because the three legs are 120° apart, all triplen harmonics (3rd, 9th, 15th, . . .) cancel in the line voltage.

Step 1 – eliminate the even harmonics: Half-wave symmetry removes the 2nd, 4th, 6th, . . .

Step 2 – eliminate the triplen harmonics: The 120° phase displacement removes the 3rd, 9th, . . . in the line voltage.

Step 3 – list the survivors in ascending order: The remaining harmonics are of order $6k \pm 1$: $5, 7, 11, 13, \ldots$

Step 4 – pick the two lowest: The lowest-order harmonics present are the 5th and 7th.

Why the other options are wrong:

- A and D: even harmonics are absent by half-wave symmetry.
- B: the 3rd and 9th are triplen harmonics, which cancel in the line voltage.

Final Answer: lowest harmonics = 5th and 7th $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q46

Answer Key

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