GATE Electrical Engineering

Sample Paper – 8

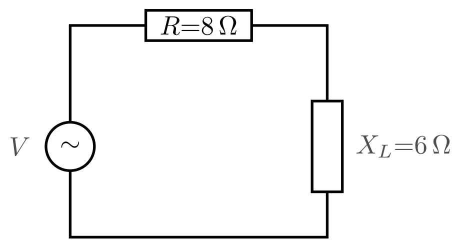
Duration: 128 Minutes **Maximum Marks: 72**

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. In the sinusoidal steady-state circuit shown, a resistance $R = 8\ \Omega$ is in series with an inductive reactance $X_L = 6\ \Omega$. The magnitude of the total impedance $|Z| = \sqrt{R^2 + X_L^2}$ is: **[1 mark]**



(A) $14\ \Omega$

(B) $10\ \Omega$

(C) $2\ \Omega$

(D) $100\ \Omega$

Q2. A single-phase load draws a current of 10 A (rms) at a voltage of 200 V (rms) with a power factor of 0.8 lagging. The reactive power $Q = VI \sin \phi$ absorbed by the load is: **[1 mark]**

(A) 1600 VAR

(B) 2000 VAR

(C) 1200 VAR

(D) 800 VAR

Q3. A sinusoidal current $i(t) = 10 \sin(\omega t)$ A flows through a pure resistance of $5\ \Omega$. The average power dissipated, $P = I_{rms}^2 R$, is: **[1 mark]**

(A) 250 W

(B) 500 W

(C) 125 W

(D) 50 W

Q4. A capacitor of $C = 100\ \mu$F is driven at an angular frequency $\omega = 1000$ rad/s. Its capacitive reactance $X_C = \dfrac{1}{\omega C}$ is: **[1 mark]**

(A) $10\ \Omega$

(B) $100\ \Omega$

(C) $0.1\ \Omega$

(D) $1\ \Omega$

Q5. An inductor of $L = 50$ mH is connected to a 50 Hz a.c. supply. Its inductive reactance $X_L = 2\pi f L$ is nearest to: **[1 mark]**

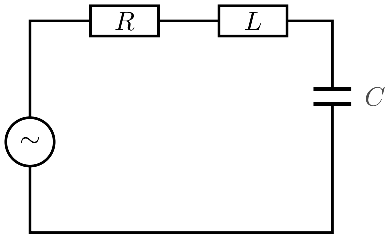
(A) $5\ \Omega$

(B) $50\ \Omega$

(C) $3.14\ \Omega$

(D) $15.7\ \Omega$

Q6. The series RLC circuit shown has $L = 1$ H and $C = 1\ \mu$F. The angular resonant frequency $\omega_0 = \dfrac{1}{\sqrt{LC}}$ is: **[1 mark]**



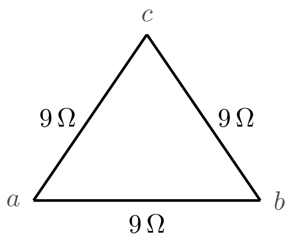
(A) 100 rad/s

(B) 1000 rad/s

(C) 10000 rad/s

(D) 10^6 rad/s

Q7. Three equal resistors of $9\ \Omega$ each are connected in a delta (Δ) network, as shown. When converted to an equivalent star (Y) network, each star resistance $R_Y = \dfrac{R_\Delta}{3}$ is: **[1 mark]**



(A) $27\ \Omega$

(B) $9\ \Omega$

(C) $3\ \Omega$

(D) $1\ \Omega$

Electromagnetic Fields

Q8. A parallel-plate capacitor with a dielectric of relative permittivity $\varepsilon_r = 4$ has plate area $A = 0.02$ m^2 and separation $d = 2$ mm, as shown. Using $C = \dfrac{\varepsilon_0 \varepsilon_r A}{d}$, the capacitance is nearest to: **[1 mark]**

(A) 88.5 pF

(B) 354 pF

(C) 35.4 pF

(D) 708 pF

Q9. An inductor of $L = 0.5$ H carries a steady current of $I = 4$ A. The energy stored in its magnetic field, $W = \frac{1}{2}LI^2$, is: **[1 mark]**

(A) 2 J

(B) 8 J

(C) 4 J

(D) 1 J

Q10. Two equal point charges of $Q = 2$ μC each are held 6 m apart in free space. By Coulomb's law $F = \dfrac{1}{4\pi\varepsilon_0} \dfrac{Q^2}{r^2}$ (take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$), the force between them is: **[1 mark]**

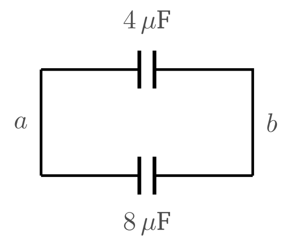
(A) 1 mN

(B) 2 mN

(C) 4 mN

(D) 0.5 mN

Q11. Two capacitors of 4 μF and 8 μF are connected in parallel, as shown. The equivalent capacitance of the combination is: **[1 mark]**



(A) $2.67\ \mu$F

(B) $4\ \mu$F

(C) $32\ \mu$F

(D) $12\ \mu$F

Signals and Systems

Q12. The Laplace transform of the causal signal $x(t) = e^{-3t}u(t)$ is: **[1 mark]**

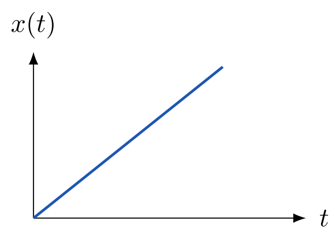
(A) $\dfrac{1}{s+3}$

(B) $\dfrac{1}{s-3}$

(C) $\dfrac{3}{s}$

(D) $\dfrac{s}{s+3}$

Q13. The unit-ramp signal $x(t) = t\,u(t)$ is sketched below. Its Laplace transform $X(s)$ is: **[1 mark]**



(A) $\dfrac{1}{s}$

(B) s

(C) $\dfrac{1}{s+1}$

(D) $\dfrac{1}{s^2}$

Q14. A stable LTI system has transfer function such that the Laplace transform of its step response is $X(s) = \dfrac{10}{s(s+5)}$. By the final-value theorem, the steady-state value $x(\infty) = \lim_{s\to 0} sX(s)$ is: **[1 mark]**

(A) 10

(B) 2

(C) 0

(D) ∞

Q15. A first-order LTI system has transfer function $H(s) = \dfrac{5}{s+2}$. The time constant of its impulse response is: **[1 mark]**

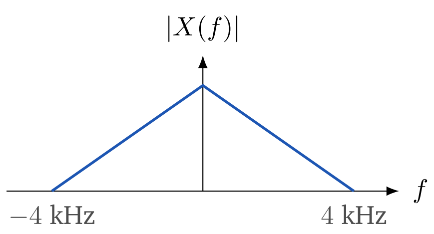
(A) 0.5 s

(B) 2 s

(C) 5 s

(D) 0.2 s

Q16. A band-limited signal has the magnitude spectrum shown, with a highest frequency component of 4 kHz. To avoid aliasing, the minimum (Nyquist) sampling rate $f_s = 2f_{\max}$ is: **[1 mark]**



(A) 2 kHz

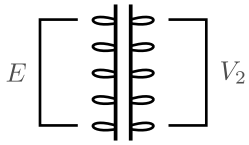
(B) 4 kHz

(C) 16 kHz

(D) 8 kHz

Electrical Machines

Q17. The single-phase transformer shown has $N = 200$ primary turns and operates at $f = 50$ Hz with a peak mutual flux $\Phi_m = 0.02$ Wb. By the e.m.f. equation $E = 4.44\, f\, N\, \Phi_m$, the primary induced e.m.f. is: **[1 mark]**



$N = 200,\ f = 50$ Hz

(A) 888 V

(B) 444 V

(C) 222 V

(D) 1776 V

Q18. A 6-pole single-phase induction motor is supplied from a 50 Hz source. Its synchronous speed $N_s = \dfrac{120f}{P}$ is: **[1 mark]**

(A) 500 rpm

(B) 1000 rpm

(C) 3000 rpm

(D) 1500 rpm

Q19. A d.c. shunt motor is supplied at $V = 240$ V and draws an armature current $I_a = 15$ A through an armature resistance $R_a = 0.4\ \Omega$. The back e.m.f. $E_b = V - I_a R_a$ is: **[1 mark]**

(A) 246 V

(B) 240 V

(C) 6 V

(D) 234 V

Q20. A 10 kVA single-phase transformer has a rated secondary voltage of 400 V. The rated (full-load) secondary current is: **[1 mark]**

(A) 4 A

(B) 40 A

(C) 10 A

(D) 25 A

Q21. A single-phase induction motor runs with a forward (per-unit) slip of $s = 0.04$. Under the double-revolving-field theory, the slip of the rotor with respect to the backward-rotating field is $s_b = 2 - s$, which equals: **[2 marks]**

(A) 0.04

(B) 1.96

(C) 0.96

(D) 2.04

Q22. A single-phase transformer delivers an output of 9.6 kW. At this load its iron loss is 200 W and its copper loss is 200 W. The efficiency $\eta = \dfrac{P_{out}}{P_{out} + P_{loss}}$ is nearest to: **[2 marks]**

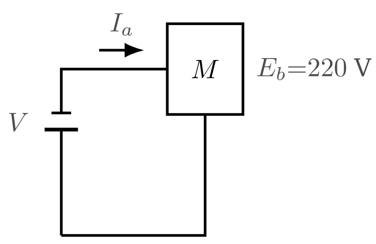
(A) 96%

(B) 90%

(C) 98%

(D) 92%

Q23. 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, as shown. The gross mechanical power developed in the armature, $P = E_b I_a$, is: **[2 marks]**



(A) 5 kW

(B) 4.4 kW

(C) 6.6 kW

(D) 7.5 kW

Power Systems

Q24. In per-unit analysis a base of 200 MVA and 20 kV is chosen. The base impedance $Z_{base} = \dfrac{(kV_{base})^2}{MVA_{base}}$ is: **[2 marks]**

(A) $2\ \Omega$

(B) $0.2\ \Omega$

(C) $20\ \Omega$

(D) $200\ \Omega$

Q25. In the economic operation of a power system, a generating unit has an incremental transmission loss $\dfrac{\partial P_L}{\partial P_i} = 0.1$. Its penalty factor $L_i = \dfrac{1}{1 - \partial P_L/\partial P_i}$ is nearest to: **[2 marks]**

(A) 0.9

(B) 1.111

(C) 1.0

(D) 0.111

Q26. Neglecting transmission losses, a thermal unit has incremental fuel cost $\dfrac{dC}{dP} = 0.04P + 12$ Rs/MWh (with P in MW). For an economic dispatch at a system incremental cost of $\lambda = 20$ Rs/MWh, the optimal output P of this unit is: **[2 marks]**

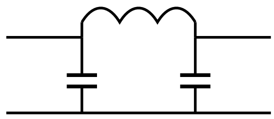
(A) 100 MW

(B) 150 MW

(C) 200 MW

(D) 250 MW

Q27. A lossless transmission line is modelled by the π-section shown with series inductance $L = 1$ mH/km and shunt capacitance $C = 0.016\ \mu$F/km. Its surge (characteristic) impedance $Z_c = \sqrt{L/C}$ is: **[2 marks]**



(A) $400\ \Omega$

(B) $250\ \Omega$

(C) $500\ \Omega$

(D) $125\ \Omega$

Q28. Two buses of a lossless line are held at $V_1 = V_2 = 1.0$ pu and the line reactance is $X = 0.4$ pu. The theoretical maximum power transferable, $P_{max} = \dfrac{V_1 V_2}{X}$ (at $\delta = 90°$), is: **[2 marks]**

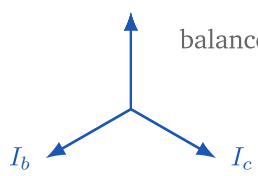
(A) 4 pu

(B) 1 pu

(C) 2.5 pu

(D) 0.5 pu

Q29. A balanced three-phase (symmetrical) fault occurs at the terminals of an unloaded generator with a positive-sequence reactance $X_1 = 0.125$ pu and pre-fault e.m.f. $E = 1.0$ pu. The symmetrical fault current $I_f = \dfrac{E}{X_1}$ (whose balanced phasor set is sketched) is: **[2 marks]**



(A) 10 pu

(B) 8 pu

(C) 5 pu

(D) 12.5 pu

Q30. A three-phase system has a base of 50 MVA and a line voltage of 33 kV. The base current $I_{base} = \dfrac{\text{MVA}_{base}}{\sqrt{3}\,\text{kV}_{base}}$ is nearest to: **[2 marks]**

(A) 758 A

(B) 500 A

(C) 875 A

(D) 1000 A

Control Systems

Q31. 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) 0.5

(B) 1

(C) 0.25

(D) 2

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 in the right half of the s-plane is: **[2 marks]**

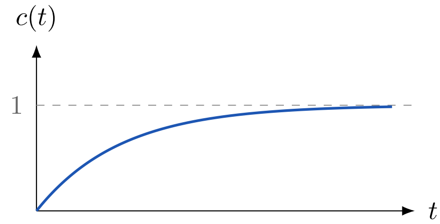
(A) 0

(B) 2

(C) 1

(D) 3

Q33. A unity-feedback second-order system has $\zeta = 0.6$ and undamped natural frequency $\omega_n = 5$ rad/s. For a unit-step input the peak time $t_p = \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}}$ (illustrated below) is nearest to: **[2 marks]**



(A) 0.5 s

(B) 1.57 s

(C) 0.785 s

(D) 0.25 s

Q34. A unity-feedback system has open-loop transfer function $G(s) = \dfrac{20}{(s+2)(s+5)}$. 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]**

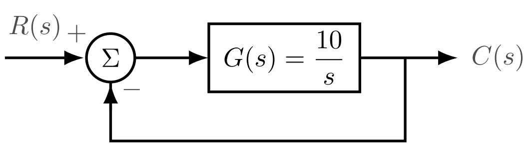
(A) 0

(B) 0.5

(C) 0.1

(D) 0.333

Q35. For the unity-feedback control system shown, the forward path is a pure integrator $G(s) = \dfrac{10}{s}$. The closed-loop transfer function $\dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)}$ is first order; its time constant is: **[2 marks]**



(A) 0.1 s

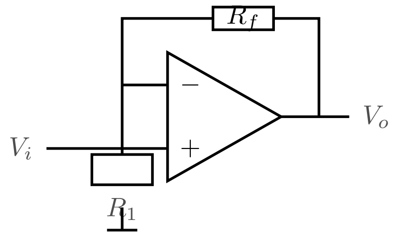
(B) 10 s

(C) 1 s

(D) 0.01 s

Analog, Digital and Measurements

Q36. For the ideal-op-amp non-inverting amplifier shown, $R_f = 90$ kΩ and $R_1 = 10$ kΩ. The closed-loop voltage gain $\dfrac{V_o}{V_i} = 1 + \dfrac{R_f}{R_1}$ is: **[2 marks]**



(A) 9

(B) 5

(C) 100

(D) 10

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

(A) 22

(B) 13

(C) 26

(D) 52

Q38. A single-phase induction-type energy meter has a meter constant of 500 revolutions per kWh. When it supplies a constant load of 2 kW for 3 hours, the number of revolutions made by its disc is: **[2 marks]**

(A) 1000

(B) 1500

(C) 2500

(D) 3000

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

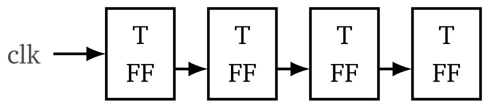
(A) 32

(B) 15

(C) 79

(D) 47

Q40. A 4-bit binary ripple (asynchronous) counter is built from the toggle flip-flops shown. The number of distinct states it passes through before repeating, 2^n with $n = 4$, is: **[2 marks]**



(A) 16

(B) 8

(C) 4

(D) 32

Q41. For a pure sinusoidal voltage, the form factor is defined as the ratio of the r.m.s. value to the average (over a half cycle) value, $k_f = \dfrac{V_m/\sqrt{2}}{2V_m/\pi}$. Its value is nearest to: **[2 marks]**

(A) 1.0

(B) 1.11

(C) 1.414

(D) 0.707

Power Electronics

Q42. A step-down (frequency-reducing) cycloconverter is fed from a 50 Hz single-phase supply and is arranged to synthesise an output whose frequency is one-fifth of the input. The output frequency is: **[2 marks]**

(A) 50 Hz

(B) 25 Hz

(C) 10 Hz

(D) 250 Hz

Q43. A single-phase half-wave diode rectifier feeds a resistive load from a supply of peak voltage $V_m = 200$ V. The average (d.c.) output voltage $V_{dc} = \dfrac{V_m}{\pi}$ is: **[2 marks]**

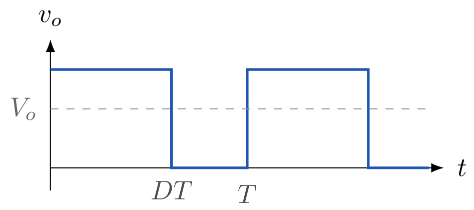
(A) 127.3 V

(B) 100 V

(C) 31.83 V

(D) 63.66 V

Q44. A step-down (buck) d.c. chopper operates from a supply $V_s = 100$ 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]**



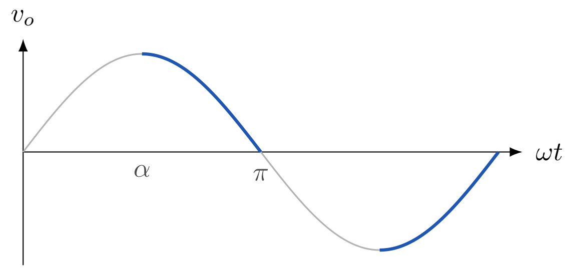
(A) 100 V

(B) 40 V

(C) 60 V

(D) 166 V

Q45. A single-phase full-wave a.c. voltage controller with a purely resistive load is fed from a supply of peak voltage $V_m = 200$ V and fired at a delay angle $\alpha = 90°$, giving the chopped waveform shown. The r.m.s. output voltage is $V_{o,rms} = \dfrac{V_m}{\sqrt{2}}\sqrt{\dfrac{1}{\pi}\left(\pi - \alpha + \dfrac{\sin 2\alpha}{2}\right)}$. Its value is nearest to: **[2 marks]**



(A) 100 V

(B) 141.4 V

(C) 200 V

(D) 173.2 V

Q46. A single-phase fully controlled bridge rectifier feeds a highly inductive load from a supply of peak voltage $V_m = 200$ V at a firing angle $\alpha = 60°$. The average output voltage $V_{dc} = \dfrac{2V_m}{\pi}\cos\alpha$ is: **[2 marks]**

(A) 127.3 V

(B) 63.66 V

(C) 31.83 V

(D) 0 V

Detailed Solutions

Q1.

Solution

Concept – impedance of a series R–L branch: In the sinusoidal steady state a resistance and a reactance in series add as a right-angled phasor sum, so the magnitude is $|Z| = \sqrt{R^2 + X_L^2}$.

Step 1 – list the data: $R = 8\ \Omega$, $X_L = 6\ \Omega$.

Step 2 – square each part: $R^2 = 8^2 = 64$

$X_L^2 = 6^2 = 36$

Step 3 – add the squares: $R^2 + X_L^2 = 64 + 36 = 100$

Step 4 – take the square root: $|Z| = \sqrt{100}$

$|Z| = 10\ \Omega$

Step 5 – sanity check: The magnitude must be larger than either R or X_L but less than their arithmetic sum ($14\ \Omega$), and $8 < 10 < 14$, so the result is consistent.

Final Answer: $|Z| = 10\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q1

Q2.

Solution

Concept – reactive power of a single-phase load: The reactive power is $Q = VI\sin\phi$, where ϕ is the angle whose cosine is the power factor.

Step 1 – find the phase angle from the power factor: $\cos\phi = 0.8 \Rightarrow \phi = 36.87^\circ$

Step 2 – find $\sin\phi$: $\sin\phi = \sqrt{1 - 0.8^2} = \sqrt{1 - 0.64} = \sqrt{0.36} = 0.6$

Step 3 – form the apparent power: $VI = 200 \times 10 = 2000$ VA

Step 4 – multiply by $\sin\phi$: $Q = 2000 \times 0.6$

$Q = 1200$ VAR

Why the other options are wrong:

- A, 1600 VAR: that is the real power $P = VI\cos\phi$, not the reactive power.
- B, 2000 VAR: that is the apparent power VI.
- D, 800 VAR: uses an incorrect $\sin\phi$.

Final Answer: $Q = 1200$ VAR $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q2

Q3.

Solution

Concept – average power in a resistor: Only the r.m.s. value of a sinusoid produces average power, and for a resistor $P = I_{rms}^2 R$.

Step 1 – read the peak current: $I_m = 10$ A (the amplitude of $10 \sin \omega t$).

Step 2 – convert peak to r.m.s.: $I_{rms} = \dfrac{I_m}{\sqrt{2}} = \dfrac{10}{\sqrt{2}}$

Step 3 – square the r.m.s. current: $I_{rms}^2 = \left(\dfrac{10}{\sqrt{2}}\right)^2 = \dfrac{100}{2} = 50\ \text{A}^2$

Step 4 – multiply by the resistance: $P = 50 \times 5$

$P = 250$ W

Why the other options are wrong:

- B, 500 W: uses the peak current squared, $I_m^2 R/\ldots$, forgetting the factor of $\frac{1}{2}$.
- C, 125 W: halves the correct value once too often.
- D, 50 W: stops at I_{rms}^2 without multiplying by R.

Final Answer: $P = 250$ W $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q3

Q4.

Solution

Concept – capacitive reactance: A capacitor opposes a.c. through its reactance $X_C = \dfrac{1}{\omega C}$.

Step 1 – list the data in base units: $C = 100\ \mu\text{F} = 100 \times 10^{-6}$ F, $\omega = 1000$ rad/s.

Step 2 – form the product ωC: $\omega C = 1000 \times (100 \times 10^{-6})$

$\omega C = 1000 \times 10^{-4} = 0.1$

Step 3 – take the reciprocal: $X_C = \dfrac{1}{0.1}$

$X_C = 10\ \Omega$

Final Answer: $X_C = 10\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – inductive reactance: An inductor's opposition to a.c. is $X_L = 2\pi f L$.

Step 1 – list the data in base units: $f = 50$ Hz, $L = 50$ mH $= 0.05$ H.

Step 2 – form the product $2\pi f$: $2\pi f = 2 \times 3.1416 \times 50 = 314.16$ rad/s

Step 3 – multiply by the inductance: $X_L = 314.16 \times 0.05$

Step 4 – evaluate: $X_L = 15.71\ \Omega \approx 15.7\ \Omega$

Final Answer: $X_L \approx 15.7\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q5**

Q6.

Solution

Concept – resonance of a series RLC circuit: At resonance the inductive and capacitive reactances cancel, and the angular resonant frequency is $\omega_0 = \dfrac{1}{\sqrt{LC}}$.

Step 1 – list the data in base units: $L = 1$ H, $C = 1\ \mu$F $= 1 \times 10^{-6}$ F.

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

Step 3 – take the square root: $\sqrt{LC} = \sqrt{1 \times 10^{-6}} = 1 \times 10^{-3}$

Step 4 – take the reciprocal: $\omega_0 = \dfrac{1}{1 \times 10^{-3}}$

$\omega_0 = 1000$ rad/s

Final Answer: $\omega_0 = 1000$ rad/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q6**

Q7.

Solution

Concept – delta-to-star conversion of equal resistors: When all three delta resistances are equal to R_Δ, every star resistance is $R_Y = \dfrac{R_\Delta}{3}$.

Step 1 – list the data: $R_\Delta = 9\ \Omega$ for each of the three delta arms.

Step 2 – apply the equal-resistor rule: $R_Y = \dfrac{9}{3}$

Step 3 – evaluate: $R_Y = 3\ \Omega$

Step 4 – sanity check: The general formula $R_Y = \dfrac{R_{ab}R_{ca}}{R_{ab} + R_{bc} + R_{ca}} = \dfrac{9 \times 9}{9 + 9 + 9} =$

$\frac{81}{27} = 3\ \Omega$ confirms the shortcut.

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

Answer: (C) Go Back to Q7

Q8.

Solution

Concept – capacitance with a dielectric: Filling the gap with a dielectric of relative permittivity ε_r multiplies the vacuum value, so $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$.

Step 1 – list the data in base units: $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m, $\varepsilon_r = 4$, $A = 0.02$ m^2, $d = 2$ mm $= 2 \times 10^{-3}$ m.

Step 2 – form the geometric factor A/d: $\frac{A}{d} = \frac{0.02}{2 \times 10^{-3}} = 10$ m

Step 3 – multiply by ε_r: $\varepsilon_r \frac{A}{d} = 4 \times 10 = 40$

Step 4 – multiply by ε_0: $C = (8.854 \times 10^{-12}) \times 40$

$C = 354.2 \times 10^{-12}$ F

Step 5 – convert to picofarads: $C \approx 354$ pF

Final Answer: $C \approx 354$ pF $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – energy stored in an inductor: A current-carrying inductor stores magnetic energy $W = \frac{1}{2}LI^2$.

Step 1 – list the data: $L = 0.5$ H, $I = 4$ A.

Step 2 – square the current: $I^2 = 4^2 = 16$ A^2

Step 3 – multiply by the inductance: $LI^2 = 0.5 \times 16 = 8$

Step 4 – take one-half: $W = \frac{1}{2} \times 8$

$W = 4$ J

Final Answer: $W = 4$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – Coulomb's law: The force between two point charges is $F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q_1Q_2}{r^2}$.

Step 1 – list the data: $\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$, $Q_1 = Q_2 = 2\ \mu\text{C} = 2 \times 10^{-6}$ C, $r = 6$ m.

Step 2 – form the product of the charges: $Q_1Q_2 = (2 \times 10^{-6}) \times (2 \times 10^{-6}) = 4 \times 10^{-12}$

Step 3 – square the distance: $r^2 = 6^2 = 36\ \text{m}^2$

Step 4 – substitute into Coulomb's law: $F = \dfrac{(9 \times 10^9) \times (4 \times 10^{-12})}{36}$

Step 5 – evaluate the numerator: $(9 \times 10^9) \times (4 \times 10^{-12}) = 36 \times 10^{-3}$

Step 6 – divide by r^2: $F = \dfrac{36 \times 10^{-3}}{36} = 1 \times 10^{-3}\ \text{N} = 1\ \text{mN}$

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

Answer: (A) Go Back to Q10

Q11.

Solution

Concept – capacitors in parallel: Capacitors in parallel share the same voltage, so their capacitances simply add, $C_{eq} = C_1 + C_2$.

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

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

$C_{eq} = 12\ \mu\text{F}$

Step 3 – sanity check: A parallel combination is always larger than the largest individual capacitor ($8\ \mu$F), and $12 > 8$, so the result is consistent.

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

Answer: (D) Go Back to Q11

Q12.

Solution

Concept – Laplace transform of a decaying exponential: The standard pair is $e^{-at}u(t) \longleftrightarrow \dfrac{1}{s+a}$ for $a > 0$.

Step 1 – identify the decay constant: Here $a = 3$, since $x(t) = e^{-3t}u(t)$.

Step 2 – write the transform from the standard pair: $X(s) = \dfrac{1}{s+3}$

Why the other options are wrong:

- B, $\dfrac{1}{s-3}$: corresponds to the growing exponential e^{+3t}.
- C, $\dfrac{3}{s}$: is the transform of the constant $3u(t)$.
- D, $\dfrac{s}{s+3}$: is not a valid transform of a simple exponential.

Final Answer: $X(s) = \dfrac{1}{s+3} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – Laplace transform of the unit ramp: The unit ramp is the integral of the unit step, and each integration divides by s, so $t\,u(t) \longleftrightarrow \dfrac{1}{s^2}$.

Step 1 – start from the unit step: $u(t) \longleftrightarrow \dfrac{1}{s}$

Step 2 – apply the integration property once: Integrating $u(t)$ gives the ramp $t\,u(t)$, and integration in time divides the transform by s.

Step 3 – write the result: $X(s) = \dfrac{1}{s} \times \dfrac{1}{s} = \dfrac{1}{s^2}$

Final Answer: $X(s) = \dfrac{1}{s^2} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q13

Q14.

Solution

Concept – final-value theorem: For a signal whose poles all lie in the left half-plane (except possibly one at the origin), the steady-state value is $x(\infty) = \lim_{s\to 0} sX(s)$.

Step 1 – multiply $X(s)$ by s: $sX(s) = s \cdot \dfrac{10}{s(s+5)} = \dfrac{10}{s+5}$

Step 2 – take the limit as $s \to 0$: $x(\infty) = \dfrac{10}{0+5}$

Step 3 – evaluate: $x(\infty) = \dfrac{10}{5} = 2$

Step 4 – check applicability: The only poles are at $s = 0$ and $s = -5$; the nonorigin pole is in the left half-plane, so the theorem is valid.

Final Answer: $x(\infty) = 2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept – time constant of a first-order system: Writing $H(s) = \dfrac{K}{s+a}$ in the form $\dfrac{K/a}{1+s/a}$ shows the time constant is $\tau = \dfrac{1}{a}$, the reciprocal of the pole magnitude.

Step 1 – locate the pole: $H(s) = \dfrac{5}{s+2}$ has its pole at $s = -2$, so $a = 2$.

Step 2 – take the reciprocal of the pole magnitude: $\tau = \dfrac{1}{a} = \dfrac{1}{2}$

Step 3 – evaluate: $\tau = 0.5$ s

Why the other options are wrong:

- C, 5 s: mistakes the numerator gain for a time constant.
- D, 0.2 s: uses the numerator 5 as the pole.

Final Answer: $\tau = 0.5\ \text{s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept – Nyquist sampling theorem: To reconstruct a band-limited signal without aliasing, the sampling rate must be at least twice the highest frequency present, $f_s \geq 2f_{\text{max}}$.

Step 1 – read the highest frequency: $f_{\text{max}} = 4$ kHz (edge of the spectrum).

Step 2 – apply the Nyquist criterion: $f_s = 2 \times f_{\text{max}} = 2 \times 4$

Step 3 – evaluate: $f_s = 8$ kHz

Why the other options are wrong:

- A, 2 kHz and B, 4 kHz: both are below the highest frequency and would alias.
- C, 16 kHz: valid but not the *minimum* rate.

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

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – transformer e.m.f. equation: The r.m.s. induced e.m.f. per winding is $E = 4.44\,f\,N\,\Phi_m$, where Φ_m is the peak core flux.

Step 1 – list the data: $f = 50$ Hz, $N = 200$, $\Phi_m = 0.02$ Wb.

Step 2 – form the product $f\,N$: $f\,N = 50 \times 200 = 10000$

Step 3 – multiply by the peak flux: $f\,N\,\Phi_m = 10000 \times 0.02 = 200$

Step 4 – multiply by the constant 4.44**:** $E = 4.44 \times 200$

$E = 888$ V

Final Answer: $E = 888$ V $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – synchronous speed: The rotating field of a machine turns at $N_s = \dfrac{120f}{P}$ rpm, with P the number of poles.

Step 1 – list the data: $f = 50$ Hz, $P = 6$.

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

Step 3 – divide by the number of poles: $N_s = \dfrac{6000}{6}$

$N_s = 1000$ rpm

Why the other options are wrong:

- C, 3000 rpm: corresponds to a 2-pole machine.
- D, 1500 rpm: corresponds to a 4-pole machine.

Final Answer: $N_s = 1000$ rpm $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – back e.m.f. of a d.c. motor: In a motor the supply voltage overcomes both the back e.m.f. and the armature-resistance drop, so $E_b = V - I_a R_a$.

Step 1 – list the data: $V = 240$ V, $I_a = 15$ A, $R_a = 0.4\ \Omega$.

Step 2 – compute the armature-resistance drop: $I_a R_a = 15 \times 0.4 = 6$ V

Step 3 – subtract from the supply voltage: $E_b = 240 - 6$

$E_b = 234$ V

Final Answer: $E_b = 234 \text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – rated current from the kVA rating: For a single-phase transformer the rated current on a winding is $I = \dfrac{\text{VA rating}}{\text{winding voltage}}$.

Step 1 – list the data in base units: $S = 10$ kVA $= 10000$ VA, $V_2 = 400$ V.

Step 2 – divide the VA rating by the secondary voltage: $I_2 = \dfrac{10000}{400}$

Step 3 – evaluate: $I_2 = 25$ A

Final Answer: $I_2 = 25 \text{ A} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept – double-revolving-field theory of a single-phase motor: The single-phase field splits into a forward and a backward rotating field. If the rotor slip relative to the forward field is s, then relative to the backward field it is $s_b = 2 - s$.

Step 1 – list the data: Forward slip $s = 0.04$.

Step 2 – apply the backward-slip relation: $s_b = 2 - s = 2 - 0.04$

Step 3 – evaluate: $s_b = 1.96$

Why the other options are wrong:

- A, 0.04: is the forward slip, not the backward slip.
- C, 0.96: mistakenly uses $1 - s$.

- D, 2.04: adds instead of subtracts the forward slip.

Final Answer: $s_b = 1.96 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – transformer efficiency: Efficiency is output power divided by input power, and input is output plus total loss, so $\eta = \dfrac{P_{out}}{P_{out} + P_{loss}}$.

Step 1 – list the data: $P_{out} = 9.6$ kW $= 9600$ W, iron loss $= 200$ W, copper loss $= 200$ W.

Step 2 – add the losses: $P_{loss} = 200 + 200 = 400$ W

Step 3 – form the input power: $P_{in} = 9600 + 400 = 10000$ W

Step 4 – divide: $\eta = \dfrac{9600}{10000}$

Step 5 – express as a percentage: $\eta = 0.96 = 96\%$

Final Answer: $\eta = 96\% \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

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 the back e.m.f. by the armature current: $P = 220 \times 30$

Step 3 – evaluate: $P = 6600$ W

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

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

Answer: (C) Go Back to Q23

Q24.

Solution

Concept – base impedance in the per-unit system: The base impedance follows from the base voltage and base power as $Z_{base} = \frac{(kV_{base})^2}{MVA_{base}}$.

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: $Z_{base} = 2\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q24

Q25.

Solution

Concept – penalty factor in economic dispatch: When transmission losses are included, each unit's incremental cost is weighted by its penalty factor $L_i = \frac{1}{1 - \partial P_L/\partial P_i}$.

Step 1 – list the data: Incremental transmission loss $\frac{\partial P_L}{\partial P_i} = 0.1$.

Step 2 – form the denominator: $1 - 0.1 = 0.9$

Step 3 – take the reciprocal: $L_i = \frac{1}{0.9}$

Step 4 – evaluate: $L_i = 1.111$

Why the other options are wrong:

- A, 0.9: is the denominator, not the penalty factor.
- C, 1.0: would need zero incremental loss.
- D, 0.111: is $L_i - 1$, not L_i.

Final Answer: $L_i = 1.111 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – economic dispatch neglecting losses: With no transmission losses, every operating unit runs at the common system incremental cost, $\dfrac{dC}{dP} = \lambda$.

Step 1 – set the incremental cost equal to λ: $0.04P + 12 = 20$

Step 2 – move the constant to the right: $0.04P = 20 - 12$

$0.04P = 8$

Step 3 – solve for P: $P = \dfrac{8}{0.04}$

Step 4 – evaluate: $P = 200$ MW

Final Answer: $P = 200$ MW $\Rightarrow \boxed{\text{C}}$

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

Q27.

Solution

Concept – surge (characteristic) impedance of a lossless line: The surge impedance is $Z_c = \sqrt{L/C}$, using the per-unit-length series inductance and shunt capacitance.

Step 1 – list the data in base units: $L = 1$ mH/km $= 1 \times 10^{-3}$ H/km, $C = 0.016\ \mu$F/km $= 1.6 \times 10^{-8}$ F/km.

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

Step 3 – evaluate the ratio: $\dfrac{L}{C} = 6.25 \times 10^{4}$

Step 4 – take the square root: $Z_c = \sqrt{6.25 \times 10^{4}}$

$Z_c = 250\ \Omega$

Final Answer: $Z_c = 250\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q27**

Q28.

Solution

Concept – maximum power transfer over a line: The power sent across a loss-less reactance is $P = \dfrac{V_1 V_2}{X}\sin\delta$, which is greatest at $\delta = 90^\circ$, giving $P_{max} = \dfrac{V_1 V_2}{X}$.

Step 1 – list the data: $V_1 = V_2 = 1.0$ pu, $X = 0.4$ pu.

Step 2 – form the numerator: $V_1V_2 = 1.0 \times 1.0 = 1.0$

Step 3 – divide by the reactance: $P_{max} = \dfrac{1.0}{0.4}$

Step 4 – evaluate: $P_{max} = 2.5$ pu

Final Answer: $P_{max} = 2.5$ pu $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q28

Q29.

Solution

Concept – balanced three-phase fault current: For a symmetrical fault at a generator's terminals only the positive-sequence network carries current, so $I_f = \dfrac{E}{X_1}$.

Step 1 – list the data: $E = 1.0$ pu, $X_1 = 0.125$ pu.

Step 2 – divide the e.m.f. by the reactance: $I_f = \dfrac{1.0}{0.125}$

Step 3 – evaluate: $I_f = 8$ pu

Step 4 – interpret the phasor sketch: The three line currents are equal in magnitude and $120°$ apart, confirming a balanced fault where only the positive sequence is excited.

Final Answer: $I_f = 8$ pu $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – base current of a three-phase system: From the three-phase base MVA and line-to-line base kV, $I_{base} = \dfrac{\text{MVA}_{base} \times 10^6}{\sqrt{3}\,\text{kV}_{base} \times 10^3}$.

Step 1 – list the data: $\text{MVA}_{base} = 50$, $\text{kV}_{base} = 33$.

Step 2 – form the denominator $\sqrt{3}\,$kV: $\sqrt{3} \times 33 = 1.732 \times 33 = 57.16$

Step 3 – divide MVA by that (in consistent units): $I_{base} = \dfrac{50 \times 10^6}{57.16 \times 10^3}$

Step 4 – evaluate: $I_{base} = \dfrac{50000}{57.16} \approx 875$ A

Final Answer: $I_{base} \approx 875$ A $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q30

Q31.

Solution

Concept – damping ratio from the characteristic equation: Matching $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$ term by term gives ω_n from the constant term and ζ from the middle term.

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

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

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

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

Step 5 – classify: Since $0 < \zeta < 1$, the system is under-damped, which is consistent with a complex pair of roots.

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

Answer: (A) Go Back to Q31

Q32.

Solution

Concept – Routh–Hurwitz criterion: The number of closed-loop poles in the right half-plane equals the number of sign changes in the first column of the Routh array.

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

$s^3 : \quad 1 \quad 2$

$s^2 : \quad 1 \quad 8$

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

So the s^1 row entry is -6.

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

Step 4 – inspect the first column: $1,\ 1,\ -6,\ 8$

Step 5 – count sign changes: $1 \to 1$ (no change), $1 \to -6$ (one change), $-6 \to 8$ (one change): two sign changes.

Step 6 – conclude: Two sign changes mean two poles in the right half-plane, so the system is unstable.

Final Answer: 2 RHP poles $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

Q33.

Solution

Concept – peak time of an under-damped second-order system: The response first peaks at $t_p = \frac{\pi}{\omega_d}$, where $\omega_d = \omega_n\sqrt{1-\zeta^2}$ is the damped natural frequency.

Step 1 – list the data: $\zeta = 0.6$, $\omega_n = 5$ rad/s.

Step 2 – compute $\sqrt{1-\zeta^2}$: $1 - 0.6^2 = 1 - 0.36 = 0.64$

$\sqrt{0.64} = 0.8$

Step 3 – compute the damped frequency: $\omega_d = 5 \times 0.8 = 4$ rad/s

Step 4 – apply the peak-time formula: $t_p = \frac{\pi}{\omega_d} = \frac{3.1416}{4}$

Step 5 – evaluate: $t_p = 0.785$ s

Final Answer: $t_p = 0.785 \text{ s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – steady-state error to a step (type-0 system): For a unit-step input the steady-state error is $e_{ss} = \frac{1}{1+K_p}$, where the position error constant is $K_p = \lim_{s\to 0} G(s)$.

Step 1 – evaluate the position error constant: $K_p = \lim_{s\to 0} \frac{20}{(s+2)(s+5)} = \frac{20}{(2)(5)} = \frac{20}{10} = 2$

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

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

Why the other options are wrong:

- A, 0: would require an infinite K_p, i.e. at least one open-loop pole at the origin (a type-1 system).
- B, 0.5: uses $K_p = 1$.
- C, 0.1: uses $K_p = 9$.

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

Answer: (D) Go Back to Q34

Q35.

Solution

Concept – closed-loop of an integrator with unity feedback: With $G(s) = \frac{K}{s}$, the closed loop is $\frac{C}{R} = \frac{G}{1+G} = \frac{K}{s+K}$, a first-order system with time constant $\tau = \frac{1}{K}$.

Step 1 – form the closed-loop transfer function: $\frac{C(s)}{R(s)} = \frac{10/s}{1+10/s} = \frac{10}{s+10}$

Step 2 – identify the pole: The single pole is at $s = -10$, so $K = 10$.

Step 3 – take the reciprocal of the pole magnitude: $\tau = \frac{1}{10}$

Step 4 – evaluate: $\tau = 0.1$ s

Final Answer: $\tau = 0.1$ s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q35

Q36.

Solution

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

Step 1 – list the data: $R_f = 90$ kΩ, $R_1 = 10$ kΩ.

Step 2 – form the resistor ratio: $\frac{R_f}{R_1} = \frac{90}{10} = 9$

Step 3 – add one: $\frac{V_o}{V_i} = 1 + 9$

Step 4 – evaluate: $\frac{V_o}{V_i} = 10$

Why the other options are wrong:

- A, 9: is R_f/R_1, the inverting-configuration magnitude, missing the "1+".
- C, 100: multiplies the ratio by 10 in error.

Final Answer: $\frac{V_o}{V_i} = 10 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – binary to decimal conversion: Each bit contributes its face value times the corresponding power of two, summed over all positions.

Step 1 – write the place values for $(11010)_2$: Bits (from MSB): $1\,1\,0\,1\,0$ with weights $2^4, 2^3, 2^2, 2^1, 2^0$.

Step 2 – multiply each bit by its weight: $1 \times 16 = 16$

$1 \times 8 = 8$

$0 \times 4 = 0$

$1 \times 2 = 2$

$0 \times 1 = 0$

Step 3 – add the contributions: $16 + 8 + 0 + 2 + 0 = 26$

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

Answer: (C) Go Back to Q37

Q38.

Solution

Concept – energy-meter disc revolutions: The disc turns in proportion to energy consumed, so revolutions = (meter constant) $\times$ (energy in kWh), and energy = power $\times$ time.

Step 1 – compute the energy consumed: $E = P \times t = 2\text{ kW} \times 3\text{ h} = 6\text{ kWh}$

Step 2 – list the meter constant: $K = 500$ revolutions per kWh.

Step 3 – multiply energy by the meter constant: $N = 6 \times 500$

Step 4 – evaluate: $N = 3000$ revolutions

Final Answer: $N = 3000$ revolutions $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q38

Q39.

Solution

Concept – hexadecimal to decimal conversion: Each hex digit is weighted by a power of 16, with A–F standing for 10–15.

Step 1 – identify the digits of $(2\text{F})_{16}$: Most significant digit = 2 (weight 16^1); least significant digit = F = 15 (weight 16^0).

Step 2 – multiply each digit by its weight: $2 \times 16 = 32$

$15 \times 1 = 15$

Step 3 – add: $32 + 15 = 47$

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

Answer: (D) Go Back to Q39

Q40.

Solution

Concept – modulus of a binary ripple counter: An n-stage binary counter cycles through 2^n distinct states (counts 0 to $2^n - 1$) before repeating.

Step 1 – count the flip-flops: $n = 4$ toggle flip-flops in the chain.

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

Step 3 – evaluate: $2^4 = 16$

Step 4 – interpret: The counter is a modulo-16 counter, stepping through 0000 up to 1111 and then rolling over.

Final Answer: 16 states $\Rightarrow \boxed{\text{A}}$

Answer: (A) 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 (half-cycle) value, $k_f = \dfrac{V_{rms}}{V_{avg}}$.

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

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

Step 3 – form the ratio: $k_f = \dfrac{0.707\,V_m}{0.637\,V_m}$

Step 4 – evaluate (V_m cancels): $k_f = \dfrac{0.707}{0.637} = 1.11$

Why the other options are wrong:

- C, 1.414: is $\sqrt{2}$, the ratio of peak to r.m.s.
- D, 0.707: is the r.m.s. value itself as a fraction of the peak.

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

Answer: (B) Go Back to Q41

Q42.

Solution

Concept – output frequency of a step-down cycloconverter: A cycloconverter converts a fixed input frequency directly to a lower output frequency, here a stated fraction of the input.

Step 1 – list the data: Input frequency $f_{in} = 50$ Hz, output fraction $= \frac{1}{5}$.

Step 2 – multiply the input frequency by the fraction: $f_{out} = \frac{1}{5} \times 50$

Step 3 – evaluate: $f_{out} = 10$ Hz

Step 4 – note the direction of conversion: A step-down cycloconverter always produces $f_{out} < f_{in}$, and $10 < 50$, consistent with the result.

Why the other options are wrong:

- A, 50 Hz: is the unchanged input frequency.
- D, 250 Hz: is a step-*up* value, which a simple cycloconverter cannot deliver.

Final Answer: $f_{out} = 10 \text{ Hz} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q42

Q43.

Solution

Concept – average output of a half-wave rectifier: A single-phase half-wave diode rectifier with a resistive load gives an average output of $V_{dc} = \frac{V_m}{\pi}$.

Step 1 – list the data: $V_m = 200$ V, $\pi = 3.1416$.

Step 2 – divide the peak by π: $V_{dc} = \frac{200}{3.1416}$

Step 3 – evaluate: $V_{dc} = 63.66$ V

Why the other options are wrong:

- A, 127.3 V: is $\frac{2V_m}{\pi}$, the full-wave value.
- C, 31.83 V: is half of the correct value.

Final Answer: $V_{dc} = 63.66 \text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q43

Q44.

Solution

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

Step 1 – list the data: $V_s = 100$ V, $D = 0.6$.

Step 2 – multiply the duty ratio by the supply: $V_o = 0.6 \times 100$

Step 3 – evaluate: $V_o = 60$ V

Step 4 – sanity check: A buck chopper always gives $V_o \leq V_s$, and $60 \leq 100$, so the value is physically reasonable.

Final Answer: $V_o = 60$ V $\Rightarrow \boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ Go Back to Q44

Q45.

Solution

Concept – r.m.s. output of an a.c. voltage controller: For a full-wave a.c. voltage controller with an R load fired at delay angle α, the r.m.s. output is $V_{o,rms} = \dfrac{V_m}{\sqrt{2}}\sqrt{\dfrac{1}{\pi}\left(\pi - \alpha + \dfrac{\sin 2\alpha}{2}\right)}$.

Step 1 – list the data: $V_m = 200$ V, $\alpha = 90^\circ = \dfrac{\pi}{2}$ rad.

Step 2 – evaluate $\sin 2\alpha$: $\sin(2 \times 90^\circ) = \sin 180^\circ = 0$

Step 3 – evaluate the bracket $\left(\pi - \alpha + \dfrac{\sin 2\alpha}{2}\right)$: $\pi - \dfrac{\pi}{2} + 0 = \dfrac{\pi}{2}$

Step 4 – divide the bracket by π and take the square root: $\sqrt{\dfrac{1}{\pi} \cdot \dfrac{\pi}{2}} = \sqrt{\dfrac{1}{2}} = 0.707$

Step 5 – form the source r.m.s. voltage $\dfrac{V_m}{\sqrt{2}}$: $\dfrac{V_m}{\sqrt{2}} = \dfrac{200}{\sqrt{2}} = 141.4$ V

Step 6 – multiply the source r.m.s. by the conduction factor: $V_{o,rms} = 141.4 \times 0.707$

Step 7 – evaluate: $V_{o,rms} = 100$ V

Why the other options are wrong:

- B, 141.4 V: is the full-conduction r.m.s. $\dfrac{V_m}{\sqrt{2}}$ that occurs only at $\alpha = 0$, before the conduction factor is applied.
- C, 200 V: is the peak voltage V_m, not an r.m.s. value.
- D, 173.2 V: corresponds to a much smaller delay angle, not $\alpha = 90^\circ$.

Final Answer: $V_{o,rms} = 100 \text{ V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – average output of a fully controlled bridge (inductive load): With a highly inductive (continuous) load the average output of a single-phase full converter is $V_{dc} = \dfrac{2V_m}{\pi}\cos\alpha$.

Step 1 – list the data: $V_m = 200$ V, $\alpha = 60°$, $\pi = 3.1416$.

Step 2 – evaluate the uncontrolled part: $\dfrac{2V_m}{\pi} = \dfrac{2 \times 200}{3.1416} = \dfrac{400}{3.1416} = 127.32$ V

Step 3 – evaluate the cosine of the firing angle: $\cos 60° = 0.5$

Step 4 – multiply: $V_{dc} = 127.32 \times 0.5$

Step 5 – evaluate: $V_{dc} = 63.66$ V

Why the other options are wrong:

- A, 127.3 V: forgets the $\cos\alpha$ factor ($\alpha = 0$ case).
- D, 0 V: would need $\alpha = 90°$, where $\cos\alpha = 0$.

Final Answer: $V_{dc} = 63.66 \text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q46

Answer Key

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