GATE Electrical Engineering

Sample Paper – 3

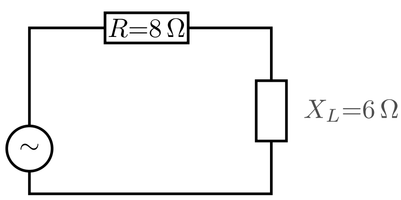
Duration: 128 Minutes **Maximum Marks: 72**

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 a.c. circuit driven at 50 Hz has a resistance $R = 8\ \Omega$ in series with an inductive reactance $X_L = 6\ \Omega$, as shown. The magnitude of the total impedance $|Z| = \sqrt{R^2 + X_L^2}$ is: **[1 mark]**



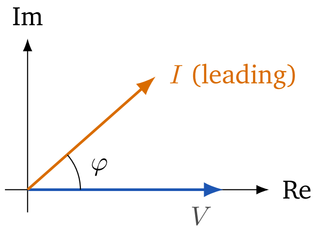
(A) $14\ \Omega$

(B) $10\ \Omega$

(C) $2\ \Omega$

(D) $48\ \Omega$

Q2. A single-phase load consists of a resistance $R = 6\ \Omega$ in series with a capacitive reactance $X_C = 8\ \Omega$. The phasor diagram places the current ahead of the voltage. The power factor $\cos\varphi = R/|Z|$ of this load is: **[1 mark]**



(A) 0.8

(B) 0.75

(C) 0.6

(D) 1.0

Q3. An a.c. single-phase load draws an r.m.s. current of 5 A at an r.m.s. voltage of 100 V, with a power factor of 0.8 (lagging). The real (average) power absorbed, $P = VI\cos\varphi$, is: **[1 mark]**

(A) 500 W

(B) 300 W

(C) 400 W

(D) 250 W

Q4. A single-phase load has an apparent power of $S = 1000$ VA at a power factor of 0.6 (lagging). The reactive power $Q = S\sin\varphi$ absorbed by the load is: **[1 mark]**

(A) 800 VAR

(B) 600 VAR

(C) 1000 VAR

(D) 480 VAR

Q5. A series RLC circuit has $L = 0.5$ H and $C = 2\ \mu$F. Its resonant angular frequency $\omega_0 = \dfrac{1}{\sqrt{LC}}$ is: **[1 mark]**

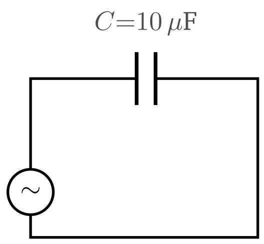
(A) 500 rad/s

(B) 1000 rad/s

(C) 2000 rad/s

(D) 100 rad/s

Q6. A capacitor of $C = 10\ \mu$F is driven by an a.c. source of angular frequency $\omega = 1000$ rad/s, as shown. Its capacitive reactance $X_C = \dfrac{1}{\omega C}$ is: **[1 mark]**



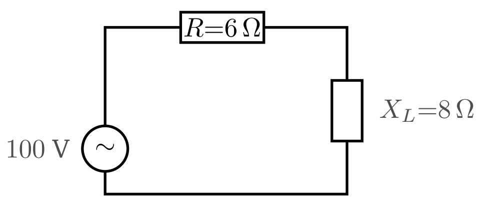
(A) 10 Ω

(B) 1000 Ω

(C) 100 Ω

(D) 0.01 Ω

Q7. In the series a.c. circuit shown, a source of r.m.s. voltage 100 V drives $R = 6\ \Omega$ in series with $X_L = 8\ \Omega$. The circuit current is $I = V/|Z|$, and the average power dissipated (all of it in R) is $P = I^2R$. This power is: **[1 mark]**



(A) 600 W

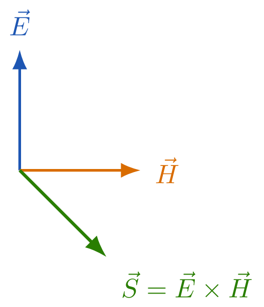
(B) 800 W

(C) 1000 W

(D) 1200 W

Electromagnetic Fields

Q8. A uniform plane wave in free space has, at a point, an electric field of magnitude $E = 30$ V/m and a magnetic field of magnitude $H = 0.1$ A/m, mutually perpendicular as shown. The magnitude of the Poynting vector $\vec{S} = \vec{E} \times \vec{H}$ (power density) is: **[1 mark]**



(A) 3 W/m^2

(B) 0.3 W/m^2

(C) 30 W/m^2

(D) 300 W/m^2

Q9. At the interface between two dielectric media, with no surface current present, the tangential component of the electric field is continuous ($E_{t1} = E_{t2}$). If the tangential field just inside medium 1 is $E_{t1} = 50$ V/m, the tangential field just inside medium 2 is: **[1 mark]**

(A) 100 V/m

(B) 25 V/m

(C) 0 V/m

(D) 50 V/m

Q10. At a charge-free interface between two dielectrics, the normal component of $\vec{D}$ is continuous, i.e. $\varepsilon_1 E_{n1} = \varepsilon_2 E_{n2}$. With relative permittivities

$\varepsilon_{r1} = 2$, $\varepsilon_{r2} = 3$ and $E_{n1} = 6$ V/m, the normal field E_{n2} in medium 2 is: **[1 mark]**

(A) 9 V/m

(B) 6 V/m

(C) 12 V/m

(D) 4 V/m

Q11. A uniform plane wave travels in a lossless dielectric of relative permittivity $\varepsilon_r = 4$ and relative permeability $\mu_r = 1$. Its phase velocity $v = \dfrac{c}{\sqrt{\varepsilon_r \mu_r}}$ is: **[1 mark]**

(A) 3×10^8 m/s

(B) 0.75×10^8 m/s

(C) 1.5×10^8 m/s

(D) 6×10^8 m/s

Signals and Systems

Q12. The unilateral z-transform of the discrete-time unit step $u[n]$, valid for $|z| > 1$, is: **[1 mark]**

(A) $\dfrac{1}{z-1}$

(B) $\dfrac{z}{z-1}$

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

(D) 1

Q13. The z-transform of the causal sequence $x[n] = (0.5)^n u[n]$, valid for $|z| > 0.5$, is $X(z) = \dfrac{z}{z-a}$ with $a = 0.5$. This equals: **[1 mark]**

(A) $\dfrac{z}{z-0.5}$

(B) $\dfrac{z}{z+0.5}$

(C) $\dfrac{1}{z-0.5}$

(D) $0.5\,z$

Q14. A discrete-time sequence is a shifted unit impulse, $x[n] = \delta[n-2]$. Its discrete-time Fourier transform is $X(e^{j\omega}) = e^{-j2\omega}$. The magnitude $|X(e^{j\omega})|$ at every frequency ω is: **[1 mark]**

(A) 2

(B) 0.5

(C) 1

(D) 0

Q15. If $X(z)$ is the z-transform of $x[n]$, then by the time-shifting property the sequence $x[n-2]$ has z-transform: **[1 mark]**

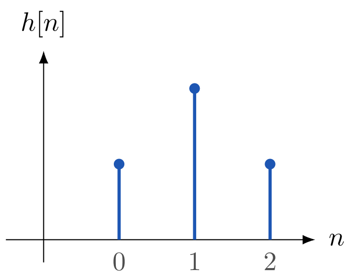
(A) $z^2 X(z)$

(B) $z^{-2} X(z)$

(C) $2X(z)$

(D) $\dfrac{X(z)}{2}$

Q16. A discrete-time LTI system has the finite impulse response $h[n]$ shown ($h[0] = 1$, $h[1] = 2$, $h[2] = 1$). The value of its DTFT at $\omega = \pi$, namely $H(e^{j\pi}) = \sum_n h[n](-1)^n$, is: **[1 mark]**



(A) 4

(B) 2

(C) 1

(D) 0

Electrical Machines

Q17. A three-phase induction motor is wound for 6 poles and supplied at 50 Hz. Its synchronous speed $N_s = \dfrac{120f}{P}$ is: **[1 mark]**

(A) 1500 rpm

(B) 3000 rpm

(C) 750 rpm

(D) 1000 rpm

Q18. A 4-pole, 50 Hz three-phase induction motor runs at a rotor speed of 1470 rpm. Its per-unit slip $s = \dfrac{N_s - N}{N_s}$ is: **[1 mark]**

(A) 2%

(B) 3%

(C) 4%

(D) 1%

Q19. A three-phase induction motor operates at a slip of $s = 0.04$ from a 50 Hz supply. The frequency of the rotor (slip) currents, $f_r = sf$, is: **[1 mark]**

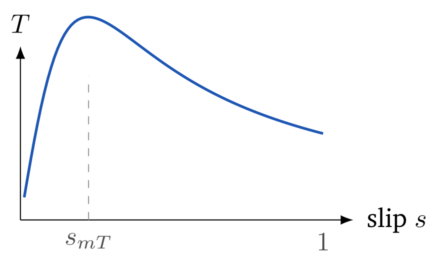
(A) 2 Hz

(B) 4 Hz

(C) 50 Hz

(D) 1 Hz

Q20. A three-phase induction motor has a per-phase rotor resistance $R_2 = 0.4\ \Omega$ and standstill rotor reactance $X_2 = 2\ \Omega$. The torque–slip curve peaks at the slip for maximum torque, $s_{mT} = \dfrac{R_2}{X_2}$, shown below. This slip is: **[1 mark]**



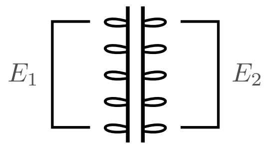
(A) 0.4

(B) 0.8

(C) 0.1

(D) 0.2

Q21. An ideal single-phase transformer, shown below, has $N_1 = 100$ primary turns and operates at 50 Hz with a peak mutual flux $\Phi_m = 0.02$ Wb. The r.m.s. primary induced e.m.f. $E_1 = 4.44\, f\, N_1\, \Phi_m$ is: **[2 marks]**



$N_1 = 100,\ f = 50$ Hz

(A) 444 V

(B) 222 V

(C) 888 V

(D) 400 V

Q22. In a three-phase induction motor the air-gap (rotor input) power is $P_{ag} = 10$ kW and the machine runs at a slip $s = 0.04$. The rotor copper loss, $P_{cu2} = s\, P_{ag}$, is: **[2 marks]**

(A) 1000 W

(B) 200 W

(C) 400 W

(D) 100 W

Q23. A three-phase induction motor has an air-gap power $P_{ag} = 10$ kW and runs at a slip $s = 0.05$. The gross mechanical power developed, $P_{mech} = (1 - s)P_{ag}$, is: **[2 marks]**

(A) 10 kW

(B) 9.5 kW

(C) 0.5 kW

(D) 5 kW

Power Systems

Q24. The three line currents of a balanced three-phase system add to zero. The zero-sequence component of the line currents, $I_0 = \frac{1}{3}(I_a + I_b + I_c)$, for such a balanced set is: **[2 marks]**

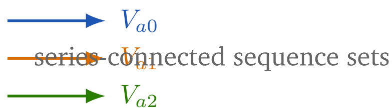
(A) I_a

(B) $\frac{1}{3}I_a$

(C) $3I_a$

(D) 0

Q25. An unloaded generator with pre-fault e.m.f. $E = 1.0$ pu has sequence reactances $Z_1 = Z_2 = Z_0 = 0.15$ pu. For a single-line-to-ground fault (sequence networks in series, as sketched), the fault current is $I_f = \dfrac{3E}{Z_1 + Z_2 + Z_0}$, which is: **[2 marks]**



(A) 2.22 pu

(B) 20 pu

(C) 6.67 pu

(D) 3.33 pu

Q26. On an unloaded generator with $E = 1.0$ pu and positive- and negative-sequence reactances $Z_1 = Z_2 = 0.2$ pu, a line-to-line fault occurs. The magnitude of the fault current, $|I_f| = \dfrac{\sqrt{3}\,E}{Z_1 + Z_2}$, is: **[2 marks]**

(A) 5 pu

(B) 2.5 pu

(C) 8.66 pu

(D) 4.33 pu

Q27. On a three-phase feeder only phase a carries current during a fault, with $I_a = 6$ A and $I_b = I_c = 0$. The zero-sequence current $I_0 = \frac{1}{3}(I_a + I_b + I_c)$ is: **[2 marks]**

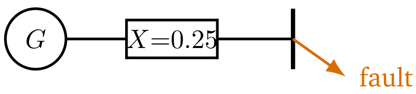
(A) 6 A

(B) 0 A

(C) 2 A

(D) 18 A

Q28. A generator feeds a bus through a per-unit reactance $X = 0.25$ pu on a 100 MVA base, as shown by the single-line diagram. For a three-phase symmetrical fault at the bus the short-circuit level $\text{MVA}_{fault} = \dfrac{\text{MVA}_{base}}{X_{pu}}$ is: **[2 marks]**



(A) 400 MVA

(B) 25 MVA

(C) 250 MVA

(D) 200 MVA

Q29. A per-unit study uses a base of 100 MVA at a base line voltage of 33 kV. The base impedance $Z_{base} = \dfrac{(kV_{base})^2}{MVA_{base}}$ is: **[2 marks]**

(A) 1.089 Ω

(B) 10.89 Ω

(C) 108.9 Ω

(D) 33 Ω

Q30. A three-phase system has a base of 100 MVA at a line voltage of 66 kV. The base current $I_{base} = \dfrac{\text{MVA}_{base}}{\sqrt{3}\,\text{kV}_{base}}$ is nearest to: **[2 marks]**

(A) 875 A

(B) 505 A

(C) 1515 A

(D) 100 A

Control Systems

Q31. A unity-feedback system has open-loop transfer function $G(s) = \dfrac{K}{s(s+2)(s+4)}$. The number of branches (loci) of its root locus, equal to the number of open-loop poles, is: **[2 marks]**

(A) 1

(B) 2

(C) 0

(D) 3

Q32. For the same open-loop transfer function $G(s) = \dfrac{K}{s(s+2)(s+4)}$ (three poles, no finite zeros), the number of root-locus asymptotes, $P - Z$, is: **[2 marks]**

(A) 0

(B) 1

(C) 2

(D) 3

Q33. A 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]**

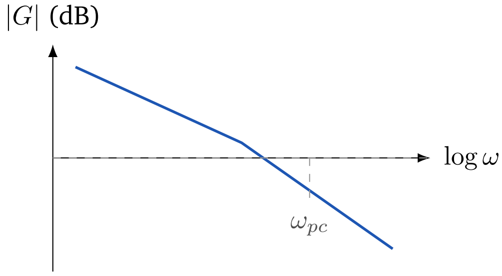
(A) 0.25

(B) 0.5

(C) 1

(D) 0.75

Q34. The open-loop frequency response of a unity-feedback system has a gain magnitude of 0.1 at the phase-crossover frequency (where the phase is $-180°$), as sketched on the Bode magnitude plot. The gain margin, GM $= 20\log_{10}\frac{1}{|G|}$, is: **[2 marks]**



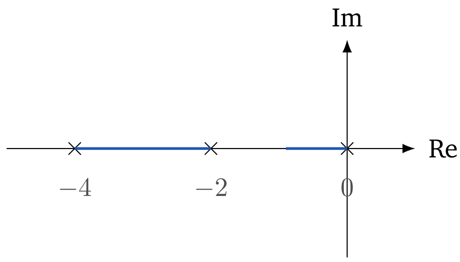
(A) 10 dB

(B) 20 dB

(C) 0 dB

(D) 40 dB

Q35. The root locus of $G(s)H(s) = \dfrac{K}{s(s+2)(s+4)}$ has three open-loop poles at 0, -2 and -4 (shown), and no finite zeros. The centroid of the asymptotes, $\sigma = \dfrac{\sum \text{poles} - \sum \text{zeros}}{P - Z}$, lies at: **[2 marks]**



(A) -1

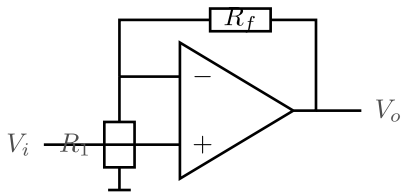
(B) -3

(C) -2

(D) 0

Analog, Digital and Measurements

Q36. For the ideal-op-amp non-inverting amplifier shown, $R_1 = 10$ kΩ (from the inverting node to ground) and $R_f = 20$ kΩ (feedback). The closed-loop voltage gain $\frac{V_o}{V_i} = 1 + \frac{R_f}{R_1}$ is: **[2 marks]**



(A) 2

(B) 3

(C) 20

(D) 0.5

Q37. The unsigned binary number $(1101)_2$ has the decimal (base-10) value: **[2 marks]**

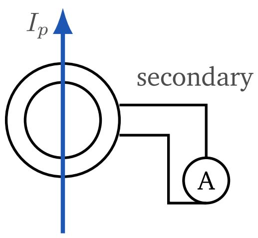
(A) 11

(B) 13

(C) 26

(D) 15

Q38. A current transformer (CT) has a nameplate ratio of $100/5$ A and feeds an ammeter, as shown. When the primary (line) current is 80 A, the secondary current $I_s = I_p \times \frac{5}{100}$ read by the meter is: **[2 marks]**



(A) 5 A

(B) 100 A

(C) 1 A

(D) 4 A

Q39. A potential transformer (PT) has a nameplate ratio of $11000/110$ V. When the primary line voltage is 6600 V, the secondary voltage $V_s = V_p \times \frac{110}{11000}$ presented to the meter is: **[2 marks]**

(A) 110 V

(B) 66 V

(C) 100 V

(D) 60 V

Q40. A single-phase energy meter has a meter constant of 1200 revolutions per kWh. During a test the aluminium disc completes 600 revolutions. The energy recorded, $E = \frac{\text{revolutions}}{\text{meter constant}}$, is: **[2 marks]**

(A) 2 kWh

(B) 1200 kWh

(C) 1 kWh

(D) 0.5 kWh

Q41. A moving-iron meter reads the r.m.s. value of a sinusoidal voltage whose average (over a half cycle) is 100 V. Using the form factor of a sine wave, $\text{FF} = \frac{V_{rms}}{V_{avg}} = 1.11$, the r.m.s. value is: **[2 marks]**

(A) 111 V

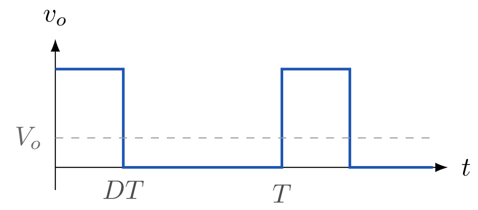
(B) 100 V

(C) 90 V

(D) 141 V

Power Electronics

Q42. A step-down (buck) d.c. chopper operates from a supply $V_s = 100$ V at a duty ratio $D = 0.3$, producing the switched output waveform shown. The average output voltage $V_o = D\,V_s$ is: **[2 marks]**



(A) 100 V

(B) 70 V

(C) 30 V

(D) 300 V

Q43. A step-up (boost) d.c.–d.c. converter operates from a supply $V_s = 50$ V at a duty ratio $D = 0.5$. In continuous conduction its output voltage $V_o = \dfrac{V_s}{1-D}$ is: **[2 marks]**

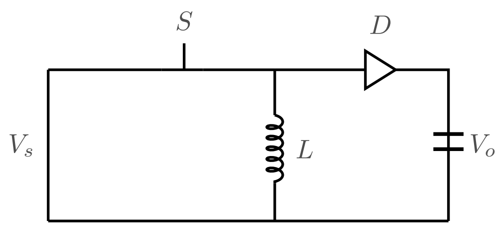
(A) 50 V

(B) 25 V

(C) 100 V

(D) 75 V

Q44. A buck–boost converter, shown below, operates from a supply $V_s = 100$ V at a duty ratio $D = 0.4$. In continuous conduction the magnitude of its output voltage $|V_o| = V_s\dfrac{D}{1-D}$ is: **[2 marks]**



(A) 40 V

(B) 66.67 V

(C) 150 V

(D) 100 V

Q45. A step-down (buck) chopper switches at $f_s = 10$ kHz with an on-time of $T_{on} = 25\ \mu$s per cycle. Its duty ratio $D = \dfrac{T_{on}}{T} = T_{on} f_s$ is: **[2 marks]**

(A) 0.25

(B) 0.5

(C) 0.75

(D) 0.4

Q46. A buck–boost converter is required to produce an output voltage equal in magnitude to its input, $|V_o| = V_s$. From $|V_o| = V_s \dfrac{D}{1-D}$, the duty ratio D that achieves this is: **[2 marks]**

(A) 0.5

(B) 0.25

(C) 0.75

(D) 0.4

Detailed Solutions

Q1.

Solution

Concept – impedance of a series RL circuit: Resistance and inductive reactance are at right angles in the impedance triangle, 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 component: $R^2 = 8^2 = 64$

$X_L^2 = 6^2 = 36$

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

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

$|Z| = 10\ \Omega$

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

Answer: (B) Go Back to Q1

Q2.

Solution

Concept – power factor of a series circuit: The power factor is the cosine of the impedance angle, $\cos\varphi = \dfrac{R}{|Z|}$.

Step 1 – find the impedance magnitude: $|Z| = \sqrt{R^2 + X_C^2} = \sqrt{6^2 + 8^2}$

$|Z| = \sqrt{36 + 64} = \sqrt{100} = 10\ \Omega$

Step 2 – form the ratio $R/|Z|$: $\cos\varphi = \dfrac{6}{10}$

Step 3 – evaluate: $\cos\varphi = 0.6$

Step 4 – note the sign of the phase: Because the reactance is capacitive, the current leads the voltage, so this is a 0.6 *leading* power factor; its numeric value is still 0.6.

Final Answer: $\cos\varphi = 0.6 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q2

Q3.

Solution

Concept – real power in a single-phase a.c. circuit: The average (real) power is $P = VI\cos\varphi$, using r.m.s. values.

Step 1 – list the data: $V = 100$ V, $I = 5$ A, $\cos\varphi = 0.8$.

Step 2 – multiply voltage and current: $VI = 100 \times 5 = 500$ VA

Step 3 – multiply by the power factor: $P = 500 \times 0.8$

Step 4 – evaluate: $P = 400$ W

Final Answer: $P = 400\text{ W} \Rightarrow \boxed{\text{C}}$

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

Q4.

Solution

Concept – reactive power from apparent power: The reactive power is $Q = S\sin\varphi$, where $\sin\varphi = \sqrt{1-\cos^2\varphi}$.

Step 1 – list the data: $S = 1000$ VA, $\cos\varphi = 0.6$.

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

$\sin\varphi = \sqrt{0.64} = 0.8$

Step 3 – multiply by the apparent power: $Q = 1000 \times 0.8$

Step 4 – evaluate: $Q = 800$ VAR

Final Answer: $Q = 800\text{ VAR} \Rightarrow \boxed{\text{A}}$

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

Q5.

Solution

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

Step 1 – list the data in base units: $L = 0.5$ H, $C = 2\ \mu\text{F} = 2 \times 10^{-6}$ F.

Step 2 – form the product LC: $LC = 0.5 \times 2 \times 10^{-6}$

$LC = 1 \times 10^{-6}$

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

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

$\omega_0 = 1000$ rad/s

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

Answer: (B) Go Back to Q5

Q6.

Solution

Concept – capacitive reactance: The opposition of a capacitor to a.c. is $X_C = \dfrac{1}{\omega C}$.

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

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

$\omega C = 10 \times 10^{-3} = 0.01$

Step 3 – invert: $X_C = \dfrac{1}{0.01}$

$X_C = 100\ \Omega$

Final Answer: $X_C = 100\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept – average power dissipated in a series RL circuit: Only the resistor absorbs average power, $P = I^2 R$, where $I = V/|Z|$.

Step 1 – find the impedance magnitude: $|Z| = \sqrt{R^2 + X_L^2} = \sqrt{6^2 + 8^2}$

$|Z| = \sqrt{36 + 64} = \sqrt{100} = 10\ \Omega$

Step 2 – find the circuit current: $I = \dfrac{V}{|Z|} = \dfrac{100}{10} = 10$ A

Step 3 – square the current: $I^2 = 10^2 = 100$

Step 4 – multiply by the resistance: $P = 100 \times 6$

$P = 600$ W

Step 5 – cross-check with the power factor form: $\cos\varphi = R/|Z| = 0.6$, so $P = VI\cos\varphi = 100 \times 10 \times 0.6 = 600$ W, which agrees.

Final Answer: $P = 600 \text{ W} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – Poynting vector of a plane wave: For mutually perpendicular $\vec{E}$ and $\vec{H}$ the instantaneous power density is $S = EH$.

Step 1 – list the data: $E = 30$ V/m, $H = 0.1$ A/m.

Step 2 – multiply the magnitudes: $S = 30 \times 0.1$

Step 3 – evaluate: $S = 3$ W/m^2

Step 4 – check the direction: $\vec{S} = \vec{E} \times \vec{H}$ points along the direction of propagation, perpendicular to both fields, consistent with the figure.

Final Answer: $S = 3$ W/m$^2 \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q8**

Q9.

Solution

Concept – boundary condition on tangential $\vec{E}$: Across any interface (with no impressed magnetic source) the tangential electric field is continuous, $E_{t1} = E_{t2}$.

Step 1 – state the boundary condition: $E_{t1} = E_{t2}$

Step 2 – insert the known value: $E_{t1} = 50$ V/m

Step 3 – conclude: $E_{t2} = 50$ V/m

Why the other options are wrong:

- A (100) and B (25): would require the tangential field to change across the boundary, which it does not.
- C (0): would only hold at the surface of a perfect conductor, not at a dielectric interface.

Final Answer: $E_{t2} = 50$ V/m $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q9**

Q10.

Solution

Concept – boundary condition on normal $\vec{D}$: With no free surface charge, the normal component of $\vec{D}$ is continuous, $\varepsilon_1 E_{n1} = \varepsilon_2 E_{n2}$.

Step 1 – write the condition with relative permittivities: $\varepsilon_{r1} E_{n1} = \varepsilon_{r2} E_{n2}$

Step 2 – solve for E_{n2}: $E_{n2} = \dfrac{\varepsilon_{r1}}{\varepsilon_{r2}} E_{n1}$

Step 3 – substitute the data: $E_{n2} = \dfrac{2}{3} \times 6$

Step 4 – evaluate: $E_{n2} = 4$ V/m

Final Answer: $E_{n2} = 4$ V/m $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept – phase velocity in a dielectric: A wave slows down in a dense medium, $v = \dfrac{c}{\sqrt{\varepsilon_r \mu_r}}$.

Step 1 – list the data: $c = 3 \times 10^8$ m/s, $\varepsilon_r = 4$, $\mu_r = 1$.

Step 2 – form the refractive factor: $\sqrt{\varepsilon_r \mu_r} = \sqrt{4 \times 1} = 2$

Step 3 – divide the speed of light by this factor: $v = \dfrac{3 \times 10^8}{2}$

Step 4 – evaluate: $v = 1.5 \times 10^8$ m/s

Final Answer: $v = 1.5 \times 10^8$ m/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept – z-transform of the unit step: The step $u[n]$ is a geometric series with ratio z^{-1}.

Step 1 – write the defining sum: $U(z) = \displaystyle\sum_{n=0}^{\infty} 1 \cdot z^{-n}$

Step 2 – recognise the geometric series (for $|z^{-1}| < 1$): $U(z) = \dfrac{1}{1 - z^{-1}}$

Step 3 – multiply top and bottom by z: $U(z) = \dfrac{z}{z - 1}$

Step 4 – note the region of convergence: The series converges when $|z| > 1$, as stated.

Final Answer: $U(z) = \dfrac{z}{z-1} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept – z-transform of a causal exponential: For $x[n] = a^n u[n]$ the transform is $X(z) = \dfrac{z}{z-a}$, valid for $|z| > |a|$.

Step 1 – identify the base: $a = 0.5$.

Step 2 – write the defining sum: $X(z) = \sum_{n=0}^{\infty} (0.5)^n z^{-n} = \sum_{n=0}^{\infty} \left(\dfrac{0.5}{z}\right)^n$

Step 3 – sum the geometric series: $X(z) = \dfrac{1}{1 - 0.5z^{-1}}$

Step 4 – multiply top and bottom by z: $X(z) = \dfrac{z}{z-0.5}$

Final Answer: $X(z) = \dfrac{z}{z-0.5} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept – DTFT of a shifted impulse: A pure time shift only adds linear phase; it does not change the magnitude.

Step 1 – write the DTFT of $\delta[n-2]$: $X(e^{j\omega}) = e^{-j2\omega}$

Step 2 – take the magnitude of a complex exponential: $|e^{-j2\omega}| = 1$ for every real ω.

Step 3 – conclude: $|X(e^{j\omega})| = 1$ at all frequencies; only the phase, -2ω, varies.

Final Answer: $|X(e^{j\omega})| = 1 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – time-shifting property of the z-transform: Delaying a sequence by k samples multiplies its transform by z^{-k}.

Step 1 – state the property: $x[n-k] \;\longleftrightarrow\; z^{-k}X(z)$

Step 2 – set the shift: Here the delay is $k = 2$.

Step 3 – apply the property: $x[n-2] \;\longleftrightarrow\; z^{-2}X(z)$

Why the other options are wrong:

- A ($z^2X(z)$): corresponds to a time *advance* $x[n+2]$, not a delay.
- C and D: scaling the transform by a constant scales the amplitude, not the time position.

Final Answer: $z^{-2}X(z) \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q15

Q16.

Solution

Concept – DTFT at $\omega = \pi$: Evaluating $H(e^{j\omega}) = \sum_n h[n]e^{-j\omega n}$ at $\omega = \pi$ gives $\sum_n h[n](-1)^n$, since $e^{-j\pi n} = (-1)^n$.

Step 1 – read the impulse response: $h[0] = 1,\ h[1] = 2,\ h[2] = 1.$

Step 2 – attach the alternating signs: $H(e^{j\pi}) = h[0](-1)^0 + h[1](-1)^1 + h[2](-1)^2$

Step 3 – substitute: $H(e^{j\pi}) = 1 - 2 + 1$

Step 4 – evaluate: $H(e^{j\pi}) = 0$

Step 5 – interpret: The zero at $\omega = \pi$ means this symmetric $\{1, 2, 1\}$ filter fully rejects the highest discrete frequency, i.e. it is a low-pass smoother.

Final Answer: $H(e^{j\pi}) = 0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – synchronous speed: The rotating field turns at $N_s = \dfrac{120f}{P}$ rpm.

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

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

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

Step 4 – evaluate: $N_s = 1000$ rpm

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

Answer: (D) Go Back to Q17

Q18.

Solution

Concept – per-unit slip: Slip measures how far the rotor lags the field, $s = \dfrac{N_s - N}{N_s}$.

Step 1 – find the synchronous speed (4-pole, 50 Hz): $N_s = \dfrac{120 \times 50}{4} = 1500$ rpm

Step 2 – form the speed difference: $N_s - N = 1500 - 1470 = 30$ rpm

Step 3 – divide by the synchronous speed: $s = \dfrac{30}{1500}$

Step 4 – evaluate and convert to percent: $s = 0.02 = 2\%$

Final Answer: $s = 2\% \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept – rotor (slip) frequency: The rotor currents alternate at the slip frequency, $f_r = sf$.

Step 1 – list the data: $s = 0.04$, $f = 50$ Hz.

Step 2 – multiply: $f_r = 0.04 \times 50$

Step 3 – evaluate: $f_r = 2$ Hz

Step 4 – sanity check: At standstill $s = 1$ gives $f_r = 50$ Hz; near synchronous speed $s \to 0$ gives $f_r \to 0$. A small slip of 0.04 correctly gives a small 2 Hz.

Final Answer: $f_r = 2$ Hz $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – slip at maximum torque: Maximum torque occurs where the rotor resistance equals the standstill reactance in the torque expression, $s_{mT} = \dfrac{R_2}{X_2}$.

Step 1 – list the data: $R_2 = 0.4\ \Omega$, $X_2 = 2\ \Omega$.

Step 2 – form the ratio: $s_{mT} = \dfrac{0.4}{2}$

Step 3 – evaluate: $s_{mT} = 0.2$

Step 4 – interpret the curve: The torque–slip sketch peaks at this slip, confirming that 0.2 locates the breakdown (pull-out) torque.

Final Answer: $s_{mT} = 0.2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept – transformer e.m.f. equation: The r.m.s. induced e.m.f. is $E = 4.44\, f\, N\, \Phi_m$.

Step 1 – list the data: $f = 50$ Hz, $N_1 = 100$, $\Phi_m = 0.02$ Wb.

Step 2 – multiply f and N_1: $fN_1 = 50 \times 100 = 5000$

Step 3 – multiply by the flux: $fN_1\Phi_m = 5000 \times 0.02 = 100$

Step 4 – multiply by the constant 4.44: $E_1 = 4.44 \times 100$

Step 5 – evaluate: $E_1 = 444$ V

Final Answer: $E_1 = 444$ V $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – rotor copper loss: Of the air-gap power, a fraction equal to the slip is dissipated as rotor copper loss, $P_{cu2} = s\,P_{ag}$.

Step 1 – list the data: $P_{ag} = 10$ kW $= 10000$ W, $s = 0.04$.

Step 2 – multiply: $P_{cu2} = 0.04 \times 10000$

Step 3 – evaluate: $P_{cu2} = 400$ W

Step 4 – interpret the power split: The remaining $(1-s)P_{ag} = 9600$ W is converted to mechanical power, so only 400 W is lost in the rotor copper.

Final Answer: $P_{cu2} = 400 \text{ W} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q22

Q23.

Solution

Concept – mechanical power developed: The mechanical power at the shaft (before friction) is $P_{mech} = (1-s)P_{ag}$.

Step 1 – list the data: $P_{ag} = 10$ kW, $s = 0.05$.

Step 2 – form the factor $(1-s)$: $1 - s = 1 - 0.05 = 0.95$

Step 3 – multiply by the air-gap power: $P_{mech} = 0.95 \times 10$

Step 4 – evaluate: $P_{mech} = 9.5$ kW

Final Answer: $P_{mech} = 9.5 \text{ kW} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – zero-sequence current of a balanced set: The zero-sequence component is the average of the three phase currents, $I_0 = \frac{1}{3}(I_a + I_b + I_c)$.

Step 1 – use the balanced condition: In a balanced three-phase system the three currents are equal in magnitude and 120° apart, so their phasor sum is zero, $I_a + I_b + I_c = 0$.

Step 2 – substitute into the definition: $I_0 = \frac{1}{3} \times 0$

Step 3 – conclude: $I_0 = 0$

Step 4 – interpret: A balanced (or any three-wire) system has no zero-sequence current; I_0 can be non-zero only when a ground return path carries unbalanced current.

Final Answer: $I_0 = 0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

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: $E = 1.0$ pu, $Z_1 = Z_2 = Z_0 = 0.15$ pu.

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

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

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

Step 5 – evaluate: $I_f = 6.67$ pu

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

Answer: (C) Go Back to Q25

Q26.

Solution

Concept – line-to-line fault current: An LL fault connects the positive- and negative-sequence networks in opposition; the phase (line) fault current magnitude is $|I_f| = \dfrac{\sqrt{3}\,E}{Z_1 + Z_2}$.

Step 1 – list the data: $E = 1.0$ pu, $Z_1 = Z_2 = 0.2$ pu.

Step 2 – add the two sequence impedances: $Z_1 + Z_2 = 0.2 + 0.2 = 0.4$ pu

Step 3 – form the numerator: $\sqrt{3}\,E = 1.732 \times 1.0 = 1.732$

Step 4 – divide: $|I_f| = \dfrac{1.732}{0.4}$

Step 5 – evaluate: $|I_f| = 4.33$ pu

Why the other options are wrong:

- C (8.66): drops the Z_2 term, halving the denominator.
- A/B: use $1/(Z_1 + Z_2)$ or $E/(Z_1 + Z_2)$ without the $\sqrt{3}$ factor that converts the sequence current to the line value.

Final Answer: $|I_f| = 4.33$ pu $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q26

Q27.

Solution

Concept – zero-sequence component: $I_0 = \frac{1}{3}(I_a + I_b + I_c)$.

Step 1 – list the currents: $I_a = 6$ A, $I_b = 0$, $I_c = 0$.

Step 2 – add them: $I_a + I_b + I_c = 6 + 0 + 0 = 6$ A

Step 3 – take one-third: $I_0 = \dfrac{6}{3}$

Step 4 – evaluate: $I_0 = 2$ A

Step 5 – interpret: Because only one phase carries current (a single-line-to-ground condition), the zero-sequence current is non-zero, unlike the balanced case of Q24.

Final Answer: $I_0 = 2$ A $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept – three-phase fault level in per unit: For a symmetrical fault fed through a per-unit reactance, $\text{MVA}_{fault} = \dfrac{\text{MVA}_{base}}{X_{pu}}$.

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

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

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

Step 4 – sanity check: A smaller reactance would give a larger fault level; 0.25 pu (four times the base admittance) giving 400 MVA is consistent.

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

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – base impedance: $Z_{base} = \dfrac{(kV_{base})^2}{MVA_{base}}$.

Step 1 – list the data: $kV_{base} = 33$ kV, $MVA_{base} = 100$.

Step 2 – square the base voltage: $(33)^2 = 1089$

Step 3 – divide by the base MVA: $Z_{base} = \dfrac{1089}{100}$

Step 4 – evaluate: $Z_{base} = 10.89\ \Omega$

Final Answer: $Z_{base} = 10.89\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – three-phase base current: $I_{base} = \dfrac{\text{MVA}_{base}}{\sqrt{3}\,\text{kV}_{base}}$, giving the answer in kA when MVA and kV are used.

Step 1 – list the data: $\text{MVA}_{base} = 100$, $\text{kV}_{base} = 66$.

Step 2 – form the denominator: $\sqrt{3} \times 66 = 1.732 \times 66 = 114.3$

Step 3 – divide: $I_{base} = \dfrac{100}{114.3} = 0.875$ kA

Step 4 – convert to amperes: $I_{base} = 0.875 \times 1000 = 875$ A

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

Answer: (A) Go Back to Q30

Q31.

Solution

Concept – number of root-locus branches: The root locus has as many branches as there are open-loop poles (assuming $P \geq Z$).

Step 1 – count the open-loop poles of $G(s)$: $G(s) = \dfrac{K}{s(s+2)(s+4)}$ has poles at $s = 0,\ -2,\ -4$.

Step 2 – state the number of poles: $P = 3$.

Step 3 – conclude: Number of branches $= P = 3$; each branch starts on a pole at $K = 0$ and one of them ends on the single infinite-zero direction as $K \to \infty$.

Final Answer: 3 branches $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q31

Q32.

Solution

Concept – number of asymptotes: Branches heading to infinity follow $P - Z$ asymptotes.

Step 1 – count poles and zeros: $P = 3$ (poles at $0, -2, -4$), $Z = 0$ (no finite zeros).

Step 2 – subtract: $P - Z = 3 - 0 = 3$

Step 3 – conclude: There are 3 asymptotes, at angles $\frac{(2k+1)180°}{3} = 60°, 180°, 300°$.

Final Answer: 3 asymptotes $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept – damping ratio from the characteristic equation: Compare $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$ term by term.

Step 1 – read the coefficients: The equation is $s^2 + 4s + 16 = 0$.

Step 2 – find the natural frequency: $\omega_n^2 = 16 \Rightarrow \omega_n = 4$ rad/s

Step 3 – match the middle term: $2\zeta\omega_n = 4$

Step 4 – solve for ζ: $\zeta = \frac{4}{2 \times 4} = \frac{4}{8}$

$\zeta = 0.5$

Step 5 – classify: Since $0 < \zeta < 1$, the system is under-damped, consistent with an oscillatory step response.

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

Answer: (B) Go Back to Q33

Q34.

Solution

Concept – gain margin: Gain margin is the reciprocal of the open-loop gain at the phase-crossover frequency, expressed in dB, $\text{GM} = 20\log_{10}\frac{1}{|G|}$.

Step 1 – read the gain at phase crossover: $|G| = 0.1$ where the phase is $-180°$.

Step 2 – form the reciprocal: $\frac{1}{|G|} = \frac{1}{0.1} = 10$

Step 3 – convert to decibels: $\text{GM} = 20\log_{10}(10)$

Step 4 – evaluate: $\text{GM} = 20 \times 1 = 20$ dB

Step 5 – interpret: A positive gain margin of 20 dB means the loop gain can be raised 10-fold before the system reaches the verge of instability.

Final Answer: $\text{GM} = 20$ dB $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q34

Q35.

Solution

Concept – centroid of the asymptotes: The asymptotes radiate from the real-axis point $\sigma = \frac{\sum \text{poles} - \sum \text{zeros}}{P - Z}$.

Step 1 – sum the poles: $\sum \text{poles} = 0 + (-2) + (-4) = -6$

Step 2 – sum the zeros: $\sum \text{zeros} = 0$ (no finite zeros)

Step 3 – form the numerator: $\sum \text{poles} - \sum \text{zeros} = -6 - 0 = -6$

Step 4 – divide by $P - Z = 3$: $\sigma = \frac{-6}{3}$

Step 5 – evaluate: $\sigma = -2$

Final Answer: $\sigma = -2 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q35

Q36.

Solution

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

Step 1 – list the data: $R_f = 20$ kΩ, $R_1 = 10$ kΩ.

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

Step 3 – add one: $A_v = 1 + 2$

Step 4 – evaluate: $A_v = 3$

Why the other options are wrong:

- A (2): uses R_f/R_1 only, forgetting the leading 1 of a non-inverting stage.
- C (20): mistakes R_f in kΩ for the gain.
- D (0.5): inverts the ratio.

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

Answer: (B) Go Back to Q36

Q37.

Solution

Concept – binary-to-decimal conversion: Each bit carries a weight 2^k according to its position.

Step 1 – write the place values for $(1101)_2$: Bits (MSB to LSB): 1, 1, 0, 1 with weights $2^3, 2^2, 2^1, 2^0$.

Step 2 – multiply each bit by its weight: $1 \times 8 = 8$

$1 \times 4 = 4$

$0 \times 2 = 0$

$1 \times 1 = 1$

Step 3 – add the contributions: $8 + 4 + 0 + 1$

Step 4 – evaluate: $(1101)_2 = 13$

Final Answer: $13 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – current transformer ratio: The secondary current scales down by the rated ratio, $I_s = I_p \times \dfrac{5}{100}$.

Step 1 – list the data: Ratio $100/5$, $I_p = 80$ A.

Step 2 – form the turns/ratio factor: $\dfrac{5}{100} = 0.05$

Step 3 – multiply by the primary current: $I_s = 80 \times 0.05$

Step 4 – evaluate: $I_s = 4$ A

Step 5 – interpret: A 5 A ammeter reads full scale at 100 A of line current, so 80 A gives 4 A, i.e. 80% of full scale.

Final Answer: $I_s = 4$ A $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q38

Q39.

Solution

Concept – potential transformer ratio: The secondary voltage scales down by the rated ratio, $V_s = V_p \times \frac{110}{11000}$.

Step 1 – find the ratio: $\frac{110}{11000} = \frac{1}{100}$

Step 2 – multiply by the primary voltage: $V_s = 6600 \times \frac{1}{100}$

Step 3 – evaluate: $V_s = 66$ V

Step 4 – sanity check: The rated primary 11000 V maps to 110 V; a lower primary of 6600 V (60%) gives 66 V (60% of 110), which is consistent.

Final Answer: $V_s = 66$ V $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – energy from an energy-meter disc: The meter constant relates disc revolutions to energy, so $E = \frac{\text{revolutions}}{\text{meter constant}}$.

Step 1 – list the data: Meter constant = 1200 rev/kWh, revolutions = 600.

Step 2 – divide the revolutions by the constant: $E = \frac{600}{1200}$

Step 3 – evaluate: $E = 0.5$ kWh

Step 4 – interpret: Half of 1200 revolutions corresponds to half a kilowatt-hour of registered energy.

Final Answer: $E = 0.5$ kWh $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – form factor of a sine wave: The form factor links r.m.s. and average values, FF $= \dfrac{V_{rms}}{V_{avg}} = 1.11$, so $V_{rms} = 1.11\, V_{avg}$.

Step 1 – list the data: $V_{avg} = 100$ V, FF $= 1.11$.

Step 2 – multiply: $V_{rms} = 1.11 \times 100$

Step 3 – evaluate: $V_{rms} = 111$ V

Why the other options are wrong:

- D (141): uses the peak factor $\sqrt{2}$ on the average instead of the form factor.
- C (90): divides by the form factor instead of multiplying.
- B (100): confuses average with r.m.s.

Final Answer: $V_{rms} = 111\text{ V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q41

Q42.

Solution

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

Step 1 – list the data: $V_s = 100$ V, $D = 0.3$.

Step 2 – multiply: $V_o = 0.3 \times 100$

Step 3 – evaluate: $V_o = 30$ V

Step 4 – interpret the waveform: The output is V_s for a fraction D of each period and zero otherwise, so its average is D times V_s, matching the dashed level in the figure.

Final Answer: $V_o = 30\text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q42

Q43.

Solution

Concept – output of a boost converter: In continuous conduction the boost converter steps the voltage up, $V_o = \dfrac{V_s}{1-D}$.

Step 1 – list the data: $V_s = 50$ V, $D = 0.5$.

Step 2 – form the factor $(1-D)$**:** $1 - D = 1 - 0.5 = 0.5$

Step 3 – divide the supply by this factor: $V_o = \dfrac{50}{0.5}$

Step 4 – evaluate: $V_o = 100$ V

Step 5 – check the direction of conversion: Since $V_o > V_s$, the converter indeed boosts the voltage, as expected.

Final Answer: $V_o = 100\text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – output of a buck–boost converter: The magnitude of the buck–boost output is $|V_o| = V_s \dfrac{D}{1-D}$.

Step 1 – list the data: $V_s = 100$ V, $D = 0.4$.

Step 2 – form the factor $(1-D)$**:** $1 - D = 1 - 0.4 = 0.6$

Step 3 – form the ratio $D/(1-D)$**:** $\dfrac{0.4}{0.6} = 0.6667$

Step 4 – multiply by the supply voltage: $|V_o| = 100 \times 0.6667$

Step 5 – evaluate: $|V_o| = 66.67$ V

Step 6 – interpret: With $D = 0.4 < 0.5$ the converter is stepping down ($|V_o| < V_s$); the output polarity is inverted relative to the input.

Final Answer: $|V_o| = 66.67\text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q44

Q45.

Solution

Concept – duty ratio from on-time and switching frequency: The duty ratio is the on-fraction of a period, $D = \dfrac{T_{on}}{T} = T_{on} f_s$.

Step 1 – find the period: $T = \dfrac{1}{f_s} = \dfrac{1}{10 \times 10^3} = 100\ \mu s$

Step 2 – form the ratio of on-time to period: $D = \dfrac{25\ \mu s}{100\ \mu s}$

Step 3 – evaluate: $D = 0.25$

Step 4 – sanity check: A duty ratio must lie between 0 and 1; 0.25 is valid and means the switch conducts one-quarter of each cycle.

Final Answer: $D = 0.25 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – unity-gain condition of a buck–boost converter: Setting $|V_o| = V_s$ in $|V_o| = V_s \dfrac{D}{1-D}$ forces $\dfrac{D}{1-D} = 1$.

Step 1 – impose the required condition: $\dfrac{D}{1-D} = 1$

Step 2 – cross-multiply: $D = 1 - D$

Step 3 – collect the D terms: $2D = 1$

Step 4 – solve for D: $D = \dfrac{1}{2} = 0.5$

Step 5 – interpret: At $D = 0.5$ the buck–boost sits exactly on the boundary between step-down and step-up operation, giving $|V_o| = V_s$.

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

Answer: (A) Go Back to Q46

Answer Key

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