GATE Electrical Engineering

Sample Paper – 7

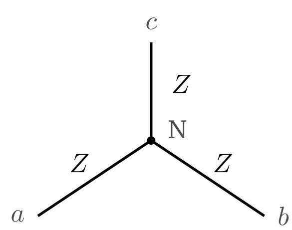
Duration: 128 Minutes **Maximum Marks: 72**

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 balanced three-phase star (wye) connected load is supplied from a line voltage of 400 V, as shown. Using $V_{ph} = V_L/\sqrt{3}$, the per-phase voltage across each branch impedance is nearest to: **[1 mark]**



(A) 400 V

(B) 692 V

(C) 231 V

(D) 200 V

Q2. A balanced three-phase delta-connected load carries a phase current of 10 A in each branch. Using the delta relation $I_L = \sqrt{3}\, I_{ph}$, the line current drawn from the supply is nearest to: **[1 mark]**

(A) 10 A

(B) 30 A

(C) 5.77 A

(D) 17.32 A

Q3. A balanced three-phase load draws a line current of 10 A at a line voltage of 400 V with a power factor of 0.8. The total real power $P = \sqrt{3}\, V_L I_L \cos\phi$ is nearest to: **[1 mark]**

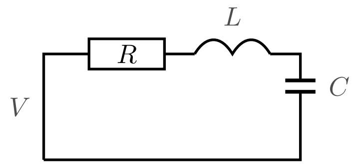
(A) 3.2 kW

(B) 9.6 kW

(C) 5.54 kW

(D) 4.0 kW

Q4. The series RLC circuit shown has $L = 1$ mH and $C = 1$ μF. Its resonant frequency $f_0 = \dfrac{1}{2\pi\sqrt{LC}}$ is nearest to: **[1 mark]**



(A) 5.03 kHz

(B) 1.59 kHz

(C) 10.1 kHz

(D) 3.18 kHz

Q5. A coil at a given frequency has an inductive reactance $X_L = 50\ \Omega$ and a resistance $R = 25\ \Omega$. Its quality factor $Q = X_L/R$ is: **[1 mark]**

(A) 0.5

(B) 2

(C) 1250

(D) 25

Q6. An a.c. impedance $Z = 3 + j4\ \Omega$ carries a steady r.m.s. current of 10 A. The average (real) power dissipated, $P = I^2R$, is: **[1 mark]**

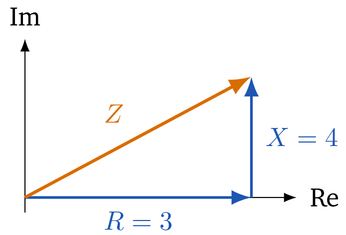
(A) 300 W

(B) 400 W

(C) 500 W

(D) 100 W

Q7. For the impedance $Z = 3 + j4\ \Omega$ drawn as the phasor triangle shown, the power factor $\cos\phi = R/|Z|$ of the load is: **[1 mark]**



(A) 0.8

(B) 1.0

(C) 0.6

(D) 0.75

Electromagnetic Fields

Q8. A uniform plane electromagnetic wave propagates in a lossless dielectric of relative permittivity $\varepsilon_r = 4$ (and $\mu_r = 1$). Using $v = c/\sqrt{\varepsilon_r}$, the phase velocity of the wave is: **[1 mark]**

(A) 1.5×10^8 m/s

(B) 3×10^8 m/s

(C) 0.75×10^8 m/s

(D) 6×10^8 m/s

Q9. For a uniform plane wave travelling in free space, the intrinsic (wave) impedance is $\eta_0 = \sqrt{\mu_0/\varepsilon_0}$. This evaluates to nearest: **[1 mark]**

(A) $277\ \Omega$

(B) $377\ \Omega$

(C) $500\ \Omega$

(D) $188\ \Omega$

Q10. A plane wave in free space has a frequency of 100 MHz. Using $\lambda = c/f$, the wavelength of the wave is: **[1 mark]**

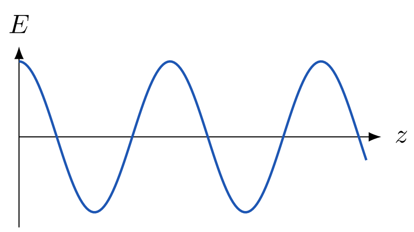
(A) 30 m

(B) 0.3 m

(C) 1 m

(D) 3 m

Q11. A uniform plane wave in free space, sketched below, has frequency 300 MHz. Using $\beta = 2\pi/\lambda$ with $\lambda = c/f$, its phase constant is nearest to: **[1 mark]**



(A) 3.14 rad/m

(B) 6.28 rad/m

(C) 1 rad/m

(D) 12.57 rad/m

Signals and Systems

Q12. A continuous-time LTI system has transfer function $H(s) = \dfrac{1}{s+3}$. For BIBO stability every pole must lie in the open left half of the s-plane; here the single pole is at $s = -3$. The system is therefore: **[1 mark]**

(A) stable

(B) unstable

(C) marginally stable

(D) undefined

Q13. A discrete-time LTI system has impulse response $h[n] = (0.5)^n u[n]$. It is BIBO stable because $\sum_n |h[n]|$ is finite; using $\sum_{n=0}^{\infty}(0.5)^n = \dfrac{1}{1-0.5}$, this sum equals: **[1 mark]**

(A) 2

(B) 0.5

(C) 1

(D) ∞

Q14. An analog signal is band-limited to a highest frequency of 4 kHz. By the sampling theorem the minimum (Nyquist) sampling rate to avoid aliasing, $f_s = 2f_m$, is: **[1 mark]**

(A) 2 kHz

(B) 4 kHz

(C) 16 kHz

(D) 8 kHz

Q15. A causal LTI system has $H(s) = \dfrac{s+1}{(s+2)(s+3)}$. Since a BIBO-stable system has no poles in the right half-plane, the number of poles of this system lying in the right half of the s-plane is: **[1 mark]**

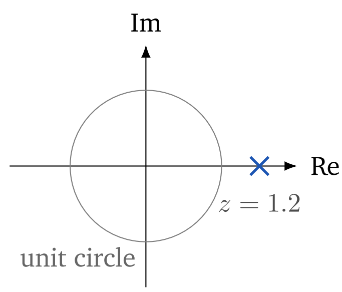
(A) 2

(B) 1

(C) 3

(D) 0

Q16. A discrete-time system has a single pole plotted at $z = 1.2$ on the z-plane shown, relative to the unit circle. Since BIBO stability needs every pole strictly inside $|z| = 1$ and $|1.2| > 1$, the system is: **[1 mark]**



(A) unstable

(B) stable

(C) marginally stable

(D) causal

Electrical Machines

Q17. A three-phase synchronous machine has 6 poles and is connected to a 50 Hz supply. Its synchronous speed $N_s = \dfrac{120f}{P}$ is: **[1 mark]**

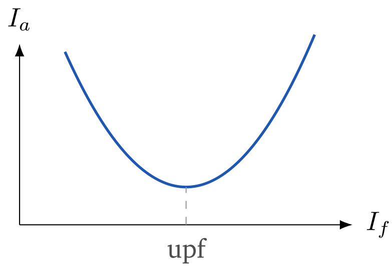
(A) 1000 rpm

(B) 1500 rpm

(C) 3000 rpm

(D) 750 rpm

Q18. The V-curve of a synchronous motor, sketched below, plots the armature current I_a against the field current I_f at constant load. The armature current reaches its minimum value when the operating power factor is: **[1 mark]**



(A) 0.8 lagging

(B) unity

(C) 0.8 leading

(D) zero

Q19. A three-phase synchronous motor is driven with its field winding over-excited beyond the value needed for unity power factor. Under this over-excited condition the motor draws a stator current at a power factor that is: **[1 mark]**

(A) lagging

(B) unity

(C) leading

(D) zero

Q20. A three-phase synchronous generator has 4 poles and runs at 1500 rpm. Using $f = \dfrac{PN}{120}$, the frequency of the generated e.m.f. is: **[1 mark]**

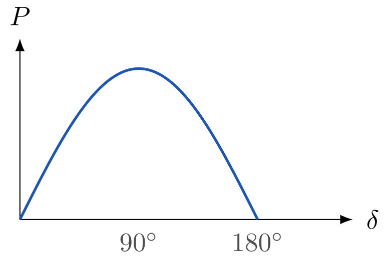
(A) 25 Hz

(B) 100 Hz

(C) 60 Hz

(D) 50 Hz

Q21. A cylindrical-rotor synchronous motor has terminal voltage $V = 1.0$ pu, excitation e.m.f. $E = 1.1$ pu and synchronous reactance $X_s = 0.5$ pu. Operating at a power angle $\delta = 30^\circ$ on the sinusoidal power-angle curve shown, the developed power $P = \dfrac{EV}{X_s}\sin\delta$ is: [2 marks]



(A) 2.2 pu

(B) 1.1 pu

(C) 0.55 pu

(D) 1.9 pu

Q22. A 6-pole, 50 Hz three-phase induction motor runs at a rotor speed of 950 rpm. With synchronous speed $N_s = 1000$ rpm and slip $s = \dfrac{N_s - N}{N_s}$, the rotor-circuit frequency $f_r = sf$ is: [2 marks]

(A) 50 Hz

(B) 5 Hz

(C) 2.5 Hz

(D) 0 Hz

Q23. A cylindrical-rotor synchronous motor has $V = 1.0$ pu, $E = 1.0$ pu and $X_s = 0.5$ pu. The steady-state pull-out (maximum) power occurs at $\delta = 90^\circ$, where $P_{max} = \dfrac{EV}{X_s}$. This maximum power is: [2 marks]

(A) 1.0 pu

(B) 2.0 pu

(C) 0.5 pu

(D) 4.0 pu

Power Systems

Q24. A 100 MVA synchronous generator stores 500 MJ of kinetic energy in its rotating mass at synchronous speed. Its inertia constant $H = \dfrac{\text{stored energy}}{\text{machine rating}}$ (in MJ/MVA, i.e. seconds) is: **[2 marks]**

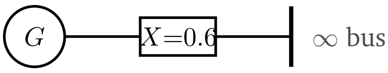
(A) 50 s

(B) 0.2 s

(C) 5 s

(D) 500 s

Q25. A generator is connected to an infinite bus through a total reactance $X = 0.6$ pu, as shown in the single-line diagram. With $E = 1.2$ pu and $V = 1.0$ pu, the steady-state stability limit $P_{max} = \dfrac{EV}{X}$ is: **[2 marks]**



(A) 1.0 pu

(B) 2.0 pu

(C) 0.72 pu

(D) 3.6 pu

Q26. In the swing equation $M\dfrac{d^2\delta}{dt^2} = P_m - P_e$, a machine has mechanical input $P_m = 1.0$ pu and electrical output $P_e = 0.6$ pu at the instant of a disturbance. The accelerating power $P_a = P_m - P_e$ is: **[2 marks]**

(A) 1.6 pu

(B) 0.6 pu

(C) 0.4 pu

(D) 1.0 pu

Q27. 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]**

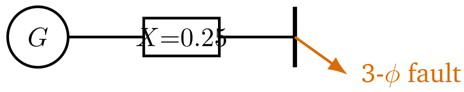
(A) 455 A

(B) 262 A

(C) 100 A

(D) 758 A

Q28. A generator of reactance $X = 0.25$ pu on a 100 MVA base feeds a bus where a three-phase symmetrical fault occurs, as shown. The short-circuit level $\text{MVA}_{fault} = \dfrac{\text{MVA}_{base}}{X_{pu}}$ is: **[2 marks]**



(A) 400 MVA

(B) 25 MVA

(C) 100 MVA

(D) 250 MVA

Q29. An unloaded generator with pre-fault e.m.f. $E = 1.0$ pu has a positive-sequence reactance $X_1 = 0.2$ pu. For a balanced three-phase fault at its terminals the fault current $I_f = \dfrac{E}{X_1}$ is: **[2 marks]**

(A) 0.2 pu

(B) 1.0 pu

(C) 10 pu

(D) 5 pu

Q30. In per-unit analysis a base of 100 MVA at 220 kV is chosen. The base impedance $Z_{base} = \dfrac{(\text{kV}_{base})^2}{\text{MVA}_{base}}$ is: **[2 marks]**

(A) 48.4 Ω

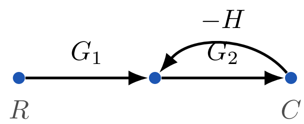
(B) 4.84 Ω

(C) 484 Ω

(D) 100 Ω

Control Systems

Q31. For the signal-flow graph shown, the single forward path has gain G_1G_2 and the single feedback loop has gain $-G_1G_2H$. Mason's gain formula gives $T = \frac{G_1G_2}{1+G_1G_2H}$. With $G_1 = 2$, $G_2 = 5$ and $H = 1$, the transfer function T is nearest to: **[2 marks]**



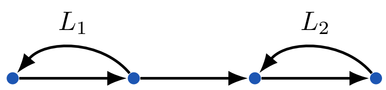
(A) 10

(B) 1

(C) 0.5

(D) 0.909

Q32. The signal-flow graph shown contains two individual feedback loops that do not touch each other, with loop gains $L_1 = -0.2$ and $L_2 = -0.3$. Mason's determinant is $\Delta = 1 - (L_1 + L_2) + (L_1L_2)$. Its value is: **[2 marks]**



(A) 1.0

(B) 1.56

(C) 0.5

(D) 1.44

Q33. A closed-loop 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) 0.707

(C) 2

(D) 1

Q34. A unity-feedback system has open-loop transfer function $G(s) = \dfrac{10}{s+5}$ (type-0). For a unit-step input the steady-state error is $e_{ss} = \dfrac{1}{1+K_p}$ with $K_p = \lim_{s\to 0} G(s)$. This error is nearest to: **[2 marks]**

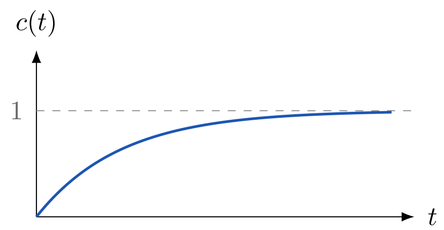
(A) 0

(B) 0.5

(C) 0.1

(D) 0.333

Q35. A unity-feedback second-order system with damping ratio $\zeta = 0.6$ is driven by a unit step, giving the response sketched below. Its peak percentage overshoot $M_p = e^{-\pi\zeta/\sqrt{1-\zeta^2}} \times 100\%$ is nearest to: **[2 marks]**



(A) 16.3%

(B) 25%

(C) 9.5%

(D) 50%

Analog, Digital and Measurements

Q36. In a balanced three-phase power measurement by the two-wattmeter method the two wattmeters read $W_1 = 1000$ W and $W_2 = 600$ W. The total three-phase power $P = W_1 + W_2$ is: **[2 marks]**

(A) 400 W

(B) 1600 W

(C) 1000 W

(D) 600 W

Q37. For the same two-wattmeter readings $W_1 = 1000$ W and $W_2 = 600$ W, the load power-factor angle satisfies $\tan\phi = \sqrt{3}\,\dfrac{W_1 - W_2}{W_1 + W_2}$. The angle ϕ is nearest to: **[2 marks]**

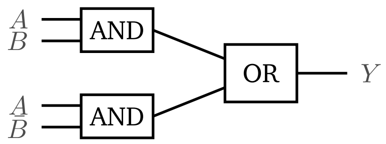
(A) $30°$

(B) $45°$

(C) $60°$

(D) $23.4°$

Q38. The combinational network shown realises $Y = AB + A\bar{B}$. Using $B + \bar{B} = 1$, the simplified output is: **[2 marks]**



(A) B

(B) AB

(C) $A + B$

(D) A

Q39. The unsigned binary number $(11011)_2$ has the decimal (base-10) value: **[2 marks]**

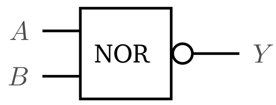
(A) 27

(B) 22

(C) 25

(D) 11

Q40. The two-input logic gate shown produces $Y = \overline{A + B}$ (NOR). By De Morgan's law $Y = \bar{A} \cdot \bar{B}$. For the input combination $A = 0$, $B = 0$, the output Y is: **[2 marks]**



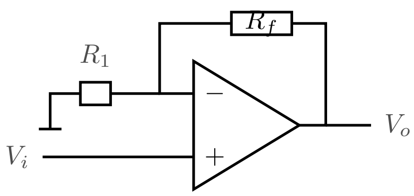
(A) 1

(B) 0

(C) A

(D) B

Q41. For the ideal-op-amp non-inverting amplifier shown, $R_1 = 10$ kΩ (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

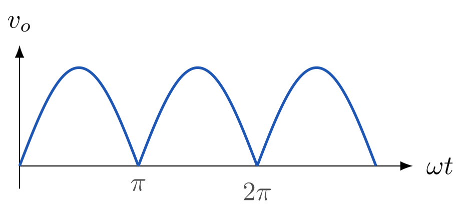
(B) 3

(C) 20

(D) 0.5

Power Electronics

Q42. 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 $\alpha = 0°$, giving the output waveform shown. The average output voltage $V_{dc} = \frac{2V_m}{\pi} \cos\alpha$ is nearest to: **[2 marks]**



(A) 63.66 V

(B) 90 V

(C) 127.3 V

(D) 200 V

Q43. The same single-phase fully controlled bridge with $V_m = 200$ V and a highly inductive load is now fired at $\alpha = 60°$. The average output voltage $V_{dc} = \frac{2V_m}{\pi} \cos\alpha$ is nearest to: **[2 marks]**

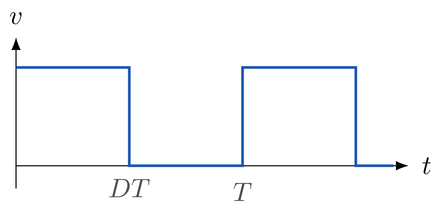
(A) 127.3 V

(B) 90 V

(C) 63.66 V

(D) 0 V

Q44. A step-up (boost) d.c. chopper operates from a supply $V_s = 100$ V at a duty ratio $D = 0.5$, with the switch-node waveform shown. The average output voltage $V_o = \frac{V_s}{1 - D}$ is: **[2 marks]**



(A) 200 V

(B) 150 V

(C) 50 V

(D) 100 V

Q45. A step-down (buck) d.c. chopper operates from a supply $V_s = 400$ V at a duty ratio $D = 0.25$. The average output voltage $V_o = DV_s$ is: **[2 marks]**

(A) 400 V

(B) 100 V

(C) 200 V

(D) 300 V

Q46. A single-phase fully controlled bridge rectifier feeding a highly inductive (constant-current) load has an input displacement power factor equal to $\cos\alpha$, where α is the firing angle. At $\alpha = 60^\circ$ the displacement power factor is: **[2 marks]**

(A) 0.5

(B) 0.866

(C) 1.0

(D) 0.707

Detailed Solutions

Q1.

Solution

Concept – star (wye) phase voltage: In a balanced star-connected system the phase (line-to-neutral) voltage is smaller than the line (line-to-line) voltage by a factor of $\sqrt{3}$, so $V_{ph} = \dfrac{V_L}{\sqrt{3}}$.

Step 1 – list the data: $V_L = 400$ V.

Step 2 – write the star relation: $V_{ph} = \dfrac{V_L}{\sqrt{3}}$

Step 3 – substitute the line voltage: $V_{ph} = \dfrac{400}{\sqrt{3}}$

Step 4 – use $\sqrt{3} = 1.732$: $V_{ph} = \dfrac{400}{1.732}$

Step 5 – evaluate: $V_{ph} = 231$ V

Why the other options are wrong:

- A, 400 V: that is the line voltage, not the phase voltage.
- B, 692 V: multiplies by $\sqrt{3}$ instead of dividing.

Final Answer: $V_{ph} = 231 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – delta line current: In a balanced delta (mesh) load, the line current is larger than the branch (phase) current by a factor of $\sqrt{3}$, so $I_L = \sqrt{3}\, I_{ph}$.

Step 1 – list the data: $I_{ph} = 10$ A.

Step 2 – write the delta relation: $I_L = \sqrt{3}\, I_{ph}$

Step 3 – substitute the phase current: $I_L = 1.732 \times 10$

Step 4 – evaluate: $I_L = 17.32$ A

Why the other options are wrong:

- A, 10 A: that is the phase current, not the line current.
- C, 5.77 A: divides by $\sqrt{3}$ (the star current relation), which does not apply here.

Final Answer: $I_L = 17.32$ A $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – three-phase real power: For any balanced three-phase load the total real power is $P = \sqrt{3}\, V_L I_L \cos\phi$, where V_L and I_L are line quantities.

Step 1 – list the data: $V_L = 400$ V, $I_L = 10$ A, $\cos\phi = 0.8$.

Step 2 – write the power equation: $P = \sqrt{3}\, V_L I_L \cos\phi$

Step 3 – substitute the values: $P = 1.732 \times 400 \times 10 \times 0.8$

Step 4 – multiply 400×10**:** $P = 1.732 \times 4000 \times 0.8$

Step 5 – multiply by 0.8**:** $P = 1.732 \times 3200$

Step 6 – evaluate: $P = 5542$ W ≈ 5.54 kW

Final Answer: $P \approx 5.54$ kW $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept – resonant frequency of a series RLC **circuit:** At resonance the inductive and capacitive reactances cancel, and the frequency is $f_0 = \dfrac{1}{2\pi\sqrt{LC}}$.

Step 1 – list the data in base units: $L = 1$ mH $= 1 \times 10^{-3}$ H, $C = 1\ \mu$F $= 1 \times 10^{-6}$ F.

Step 2 – form the product LC**:** $LC = (1 \times 10^{-3}) \times (1 \times 10^{-6}) = 1 \times 10^{-9}$

Step 3 – take the square root: $\sqrt{LC} = \sqrt{1 \times 10^{-9}} = 3.162 \times 10^{-5}$

Step 4 – form the denominator $2\pi\sqrt{LC}$**:** $2\pi\sqrt{LC} = 6.2832 \times 3.162 \times 10^{-5} = 1.987 \times 10^{-4}$

Step 5 – take the reciprocal: $f_0 = \dfrac{1}{1.987 \times 10^{-4}}$

Step 6 – evaluate: $f_0 = 5033$ Hz ≈ 5.03 kHz

Final Answer: $f_0 \approx 5.03$ kHz $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – quality factor of a coil: The quality factor is the ratio of the reactance to the resistance at the operating frequency, $Q = \dfrac{X_L}{R}$.

Step 1 – list the data: $X_L = 50\ \Omega$, $R = 25\ \Omega$.

Step 2 – write the ratio: $Q = \dfrac{X_L}{R}$

Step 3 – substitute the values: $Q = \dfrac{50}{25}$

Step 4 – evaluate: $Q = 2$

Step 5 – note: Q is a dimensionless number; a value of 2 is typical of a moderately lossy coil.

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

Answer: (B) Go Back to Q5

Q6.

Solution

Concept – real power in an a.c. impedance: Only the resistive part of an impedance dissipates average power, so $P = I^2R$ where I is the r.m.s. current.

Step 1 – identify the resistive part: $Z = 3 + j4\ \Omega$, so $R = 3\ \Omega$ (the reactance $X = 4\ \Omega$ stores, not dissipates, energy).

Step 2 – square the r.m.s. current: $I^2 = 10^2 = 100\ \text{A}^2$

Step 3 – multiply by the resistance: $P = 100 \times 3$

Step 4 – evaluate: $P = 300$ W

Why the other options are wrong:

- C, 500 W: uses $|Z| = 5$ instead of R, which gives apparent power magnitude, not real power.
- B, 400 W: uses the reactance $X = 4$ instead of R.

Final Answer: $P = 300\ \text{W} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q6

Q7.

Solution

Concept – power factor from impedance: The power factor is the cosine of the impedance angle, which equals resistance over the impedance magnitude, $\cos\phi = \dfrac{R}{|Z|}$.

Step 1 – list the impedance components: $R = 3\ \Omega$, $X = 4\ \Omega$.

Step 2 – find the impedance magnitude: $|Z| = \sqrt{R^2 + X^2} = \sqrt{3^2 + 4^2}$

Step 3 – evaluate the magnitude: $|Z| = \sqrt{9 + 16} = \sqrt{25} = 5\ \Omega$

Step 4 – form the power factor: $\cos\phi = \dfrac{R}{|Z|} = \dfrac{3}{5}$

Step 5 – evaluate: $\cos\phi = 0.6$

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

Answer: (C) Go Back to Q7

Q8.

Solution

Concept – phase velocity in a dielectric: An electromagnetic wave slows down in a dielectric by the factor $\sqrt{\varepsilon_r}$ (for $\mu_r = 1$), so $v = \dfrac{c}{\sqrt{\varepsilon_r}}$.

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

Step 2 – take the square root of the permittivity: $\sqrt{\varepsilon_r} = \sqrt{4} = 2$

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 $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – intrinsic impedance of free space: The ratio of the electric to the magnetic field amplitude in a plane wave in vacuum is $\eta_0 = \sqrt{\dfrac{\mu_0}{\varepsilon_0}}$.

Step 1 – list the constants: $\mu_0 = 4\pi \times 10^{-7}$ H/m, $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m.

Step 2 – form the ratio inside the root: $\dfrac{\mu_0}{\varepsilon_0} = \dfrac{4\pi \times 10^{-7}}{8.854 \times 10^{-12}}$

Step 3 – evaluate the ratio: $\dfrac{\mu_0}{\varepsilon_0} = 1.419 \times 10^5$

Step 4 – take the square root: $\eta_0 = \sqrt{1.419 \times 10^5}$

Step 5 – evaluate: $\eta_0 = 376.7\ \Omega \approx 377\ \Omega$ (i.e. $120\pi\ \Omega$)

Final Answer: $\eta_0 \approx 377\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

Q10.

Solution

Concept – wavelength of a plane wave: Wavelength is the distance the wave travels in one period, $\lambda = \dfrac{c}{f}$.

Step 1 – list the data: $c = 3 \times 10^8$ m/s, $f = 100$ MHz $= 1 \times 10^8$ Hz.

Step 2 – write the relation: $\lambda = \dfrac{c}{f}$

Step 3 – substitute the values: $\lambda = \dfrac{3 \times 10^8}{1 \times 10^8}$

Step 4 – combine the powers of ten: $\lambda = 3$ m

Final Answer: $\lambda = 3\text{ m} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept – phase constant of a plane wave: The phase constant is the spatial rate of phase change, $\beta = \dfrac{2\pi}{\lambda}$, with $\lambda = \dfrac{c}{f}$ in free space.

Step 1 – list the data: $f = 300$ MHz $= 3 \times 10^8$ Hz, $c = 3 \times 10^8$ m/s.

Step 2 – find the wavelength: $\lambda = \dfrac{c}{f} = \dfrac{3 \times 10^8}{3 \times 10^8} = 1$ m

Step 3 – write the phase constant: $\beta = \dfrac{2\pi}{\lambda}$

Step 4 – substitute the wavelength: $\beta = \dfrac{2\pi}{1}$

Step 5 – evaluate: $\beta = 6.283$ rad/m ≈ 6.28 rad/m

Final Answer: $\beta \approx 6.28\text{ rad/m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept – BIBO stability from pole location: A continuous-time LTI system is bounded-input bounded-output (BIBO) stable if and only if every pole of its transfer function lies in the open left half of the s-plane (negative real part).

Step 1 – locate the pole: $H(s) = \dfrac{1}{s+3}$ has its pole where $s+3=0$, i.e. at $s=-3$.

Step 2 – check the real part: $\text{Re}(s) = -3 < 0$, so the pole is in the left half-plane.

Step 3 – apply the stability criterion: A single pole with negative real part means the impulse response $e^{-3t}u(t)$ decays and is absolutely integrable.

Step 4 – conclude: The system is BIBO stable.

Final Answer: the system is **stable** $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – absolute summability of an impulse response: A discrete system is BIBO stable when $\sum_n |h[n]|$ is finite. For $h[n] = (0.5)^n u[n]$ this is a geometric series.

Step 1 – write the sum: $\displaystyle\sum_{n=0}^{\infty} (0.5)^n$

Step 2 – recall the geometric-series formula: For $|r| < 1$, $\displaystyle\sum_{n=0}^{\infty} r^n = \frac{1}{1-r}$.

Step 3 – substitute $r = 0.5$**:** $\displaystyle\sum_{n=0}^{\infty} (0.5)^n = \frac{1}{1-0.5}$

Step 4 – evaluate the denominator: $1 - 0.5 = 0.5$

Step 5 – take the reciprocal: $\dfrac{1}{0.5} = 2$

Step 6 – interpret: The sum is finite $(= 2)$, so the system is BIBO stable.

Final Answer: $\sum |h[n]| = 2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

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

Step 1 – list the data: $f_m = 4$ kHz.

Step 2 – write the Nyquist condition: $f_s = 2f_m$

Step 3 – substitute the highest frequency: $f_s = 2 \times 4$ kHz

Step 4 – evaluate: $f_s = 8$ kHz

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

Answer: (D) Go Back to Q14

Q15.

Solution

Concept – counting right half-plane poles: The poles are the roots of the denominator; a BIBO-stable causal system has all its poles in the left half-plane.

Step 1 – write the denominator: $(s+2)(s+3) = 0$

Step 2 – solve for the poles: $s + 2 = 0 \Rightarrow s = -2$

$s + 3 = 0 \Rightarrow s = -3$

Step 3 – check each real part: $\text{Re}(-2) = -2 < 0$ and $\text{Re}(-3) = -3 < 0$.

Step 4 – count poles with positive real part: Both poles are in the left half-plane, so none lie in the right half-plane.

Step 5 – conclude: Number of right half-plane poles $= 0$ (the zero at $s = -1$ does not affect stability).

Final Answer: 0 right half-plane poles $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – BIBO stability in the z-plane: A discrete-time causal LTI system is BIBO stable if and only if all its poles lie strictly inside the unit circle $|z| = 1$.

Step 1 – locate the pole: The single pole is at $z = 1.2$.

Step 2 – find its distance from the origin: $|z| = |1.2| = 1.2$

Step 3 – compare with the unit circle: $1.2 > 1$, so the pole lies outside the unit circle.

Step 4 – apply the criterion: A pole outside the unit circle gives a growing term $(1.2)^n$ in the impulse response, so it is not absolutely summable.

Step 5 – conclude: The system is BIBO unstable.

Final Answer: the system is **unstable** $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q16

Q17.

Solution

Concept – synchronous speed: The synchronous speed of the rotating magnetic field is set by the supply frequency and the pole number, $N_s = \dfrac{120f}{P}$.

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

Step 2 – write the relation: $N_s = \dfrac{120f}{P}$

Step 3 – substitute the values: $N_s = \dfrac{120 \times 50}{6}$

Step 4 – evaluate the numerator: $120 \times 50 = 6000$

Step 5 – divide by the pole number: $N_s = \dfrac{6000}{6} = 1000$ rpm

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

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – the synchronous-motor V-curve: A V-curve shows how the armature current varies with field current at constant shaft load. As the field current is increased from under- to over-excitation, the armature current first falls to a minimum and then rises, tracing a V shape.

Step 1 – interpret the minimum: At the bottom of the V the reactive component of the armature current is zero, so the motor draws only the real (in-phase) current needed for the load.

Step 2 – relate to power factor: Zero reactive current means the current is in phase with the voltage, i.e. the power factor is unity.

Step 3 – match to the sketch: The dashed vertical marks the minimum of the curve, which is the unity-power-factor field current.

Step 4 – conclude: The armature current is minimum at unity power factor.

Why the other options are wrong:

- A and C: at 0.8 lagging (under-excited) or 0.8 leading (over-excited) a reactive current adds to the real current, so I_a is larger.

Final Answer: minimum I_a at **unity** power factor $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – excitation and power factor of a synchronous motor: The field excitation controls the reactive current. Below the unity-power-factor value the motor is under-excited and draws lagging current; above it the motor is over-excited and draws leading current.

Step 1 – identify the excitation state: The motor is over-excited (field increased beyond the unity-power-factor point).

Step 2 – determine the reactive behaviour: An over-excited synchronous machine generates excess reactive power, so it supplies vars to the line and behaves like a capacitor.

Step 3 – relate to power factor: Capacitive (leading) reactive current means the stator current leads the terminal voltage.

Step 4 – conclude: The power factor is leading. (This is the basis of the synchronous condenser used for power-factor correction.)

Final Answer: over-excited $\Rightarrow$ **leading** power factor $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept – frequency of generated e.m.f.: The electrical frequency is fixed by the mechanical speed and the pole number, $f = \dfrac{PN}{120}$.

Step 1 – list the data: $P = 4$ poles, $N = 1500$ rpm.

Step 2 – write the relation: $f = \dfrac{PN}{120}$

Step 3 – substitute the values: $f = \dfrac{4 \times 1500}{120}$

Step 4 – evaluate the numerator: $4 \times 1500 = 6000$

Step 5 – divide: $f = \dfrac{6000}{120} = 50$ Hz

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

Answer: (D) Go Back to Q20

Q21.

Solution

Concept – power-angle equation of a cylindrical-rotor machine: The developed power of a round-rotor synchronous machine follows the sine of the load (power) angle, $P = \dfrac{EV}{X_s} \sin\delta$.

Step 1 – list the data: $E = 1.1$ pu, $V = 1.0$ pu, $X_s = 0.5$ pu, $\delta = 30°$.

Step 2 – form the coefficient $\dfrac{EV}{X_s}$**:** $\dfrac{EV}{X_s} = \dfrac{1.1 \times 1.0}{0.5}$

Step 3 – evaluate the coefficient: $\dfrac{1.1}{0.5} = 2.2$

Step 4 – evaluate the sine of the angle: $\sin 30° = 0.5$

Step 5 – multiply: $P = 2.2 \times 0.5$

Step 6 – evaluate: $P = 1.1$ pu

Why the other options are wrong:

- A, 2.2 pu: forgets the $\sin\delta$ factor (that is the pull-out value at $\delta = 90°$).

Final Answer: $P = 1.1$ pu $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – slip and rotor frequency: The rotor circuit frequency of an induction motor equals the slip times the supply frequency, $f_r = sf$, where $s = \dfrac{N_s - N}{N_s}$.

Step 1 – list the data: $N_s = 1000$ rpm, $N = 950$ rpm, $f = 50$ Hz.

Step 2 – find the slip: $s = \dfrac{N_s - N}{N_s} = \dfrac{1000 - 950}{1000}$

Step 3 – evaluate the numerator and divide: $s = \dfrac{50}{1000} = 0.05$

Step 4 – write the rotor frequency: $f_r = sf$

Step 5 – substitute the values: $f_r = 0.05 \times 50$

Step 6 – evaluate: $f_r = 2.5$ Hz

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

Answer: (C) Go Back to Q22

Q23.

Solution

Concept – pull-out (maximum) power: The power-angle curve $P = \dfrac{EV}{X_s}\sin\delta$ peaks when $\sin\delta = 1$, i.e. at $\delta = 90°$, giving $P_{max} = \dfrac{EV}{X_s}$.

Step 1 – list the data: $E = 1.0$ pu, $V = 1.0$ pu, $X_s = 0.5$ pu.

Step 2 – set $\sin\delta = 1$ at $\delta = 90°$: $P_{max} = \dfrac{EV}{X_s} \times 1$

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

Step 4 – divide by the reactance: $P_{max} = \dfrac{1.0}{0.5}$

Step 5 – evaluate: $P_{max} = 2.0$ pu

Why the other options are wrong:

- A, 1.0 pu: this would be the value if $X_s = 1.0$ pu, not 0.5 pu.
- C, 0.5 pu: inverts the ratio, dividing EV the wrong way.

Final Answer: $P_{max} = 2.0$ pu $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – inertia constant H: The inertia constant is the stored rotational kinetic energy at synchronous speed per unit of machine rating, $H = \dfrac{\text{stored energy (MJ)}}{\text{rating (MVA)}}$, and its unit MJ/MVA is the same as seconds.

Step 1 – list the data: Stored energy $= 500$ MJ, rating $= 100$ MVA.

Step 2 – write the relation: $H = \dfrac{\text{stored energy}}{\text{rating}}$

Step 3 – substitute the values: $H = \dfrac{500}{100}$

Step 4 – evaluate: $H = 5$ MJ/MVA $= 5$ s

Why the other options are wrong:

- B, 0.2 s: inverts the ratio.
- A, 50 s: misplaces a factor of ten.

Final Answer: $H = 5$ s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept – steady-state stability limit: For a machine tied to an infinite bus through a reactance, the maximum power that can be transferred (at $\delta = 90°$) is $P_{max} = \dfrac{EV}{X}$.

Step 1 – list the data: $E = 1.2$ pu, $V = 1.0$ pu, $X = 0.6$ pu.

Step 2 – form the numerator EV: $EV = 1.2 \times 1.0 = 1.2$

Step 3 – divide by the reactance: $P_{max} = \dfrac{1.2}{0.6}$

Step 4 – evaluate: $P_{max} = 2.0$ pu

Step 5 – interpret: Any attempt to transfer more than 2.0 pu would push δ beyond $90°$ and the machine would lose synchronism.

Final Answer: $P_{max} = 2.0$ pu $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – accelerating power in the swing equation: The right-hand side of the swing equation is the accelerating power, the difference between mechanical input and electrical output, $P_a = P_m - P_e$.

Step 1 – list the data: $P_m = 1.0$ pu, $P_e = 0.6$ pu.

Step 2 – write the relation: $P_a = P_m - P_e$

Step 3 – substitute the values: $P_a = 1.0 - 0.6$

Step 4 – evaluate: $P_a = 0.4$ pu

Step 5 – interpret: $P_a > 0$ means the rotor accelerates ($\frac{d^2\delta}{dt^2} > 0$) just after the disturbance.

Why the other options are wrong:

- A, 1.6 pu: adds the two powers instead of subtracting.

Final Answer: $P_a = 0.4$ pu $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q26

Q27.

Solution

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

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

Step 2 – form the denominator $\sqrt{3}\,\text{kV}_{base}$: $\sqrt{3} \times 220 = 1.732 \times 220 = 381.0$

Step 3 – write the current with consistent units: $I_{base} = \dfrac{100 \times 10^6}{381.0 \times 10^3}$

Step 4 – combine the powers of ten: $I_{base} = \dfrac{100 \times 10^3}{381.0}$

Step 5 – evaluate: $I_{base} = 262$ A

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

Answer: (B) Go Back to Q27

Q28.

Solution

Concept – short-circuit MVA: For a three-phase symmetrical 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: $\text{MVA}_{base} = 100$, $X_{pu} = 0.25$.

Step 2 – write the relation: $\text{MVA}_{fault} = \dfrac{\text{MVA}_{base}}{X_{pu}}$

Step 3 – substitute the values: $\text{MVA}_{fault} = \dfrac{100}{0.25}$

Step 4 – evaluate: $\text{MVA}_{fault} = 400$ MVA

Step 5 – sanity check: A smaller reactance allows a larger fault current, so a low $X = 0.25$ pu giving a high 400 MVA is consistent.

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

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – three-phase symmetrical fault current: For a balanced three-phase fault only the positive-sequence network is involved, so the per-unit fault current is $I_f = \dfrac{E}{X_1}$.

Step 1 – list the data: $E = 1.0$ pu, $X_1 = 0.2$ pu.

Step 2 – write the relation: $I_f = \dfrac{E}{X_1}$

Step 3 – substitute the values: $I_f = \dfrac{1.0}{0.2}$

Step 4 – evaluate: $I_f = 5$ pu

Step 5 – interpret: The fault current is five times the base (rated) current, a typical order of magnitude for a machine terminal fault.

Why the other options are wrong:

- A, 0.2 pu: inverts the ratio.
- C, 10 pu: would require $X_1 = 0.1$ pu.

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

Answer: (D) Go Back to Q29

Q30.

Solution

Concept – base impedance: The base impedance of a system is set by the base voltage and base power, $Z_{base} = \dfrac{(\text{kV}_{base})^2}{\text{MVA}_{base}}$.

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

Step 2 – square the base voltage: $(220)^2 = 48400$

Step 3 – write the relation: $Z_{base} = \dfrac{(\text{kV}_{base})^2}{\text{MVA}_{base}}$

Step 4 – substitute the values: $Z_{base} = \dfrac{48400}{100}$

Step 5 – evaluate: $Z_{base} = 484\ \Omega$

Final Answer: $Z_{base} = 484\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q30

Q31.

Solution

Concept – Mason's gain formula, single loop: With one forward path P_1 and one loop L_1 that touches it, the transfer function is $T = \dfrac{P_1}{1 - L_1}$.

Step 1 – identify the forward path gain: $P_1 = G_1G_2 = 2 \times 5 = 10$

Step 2 – identify the loop gain: $L_1 = -G_1G_2H = -(2)(5)(1) = -10$

Step 3 – form the determinant $\Delta = 1 - L_1$: $\Delta = 1 - (-10) = 1 + 10 = 11$

Step 4 – apply Mason's formula: $T = \dfrac{P_1}{\Delta} = \dfrac{10}{11}$

Step 5 – evaluate: $T = 0.909$

Why the other options are wrong:

- A, 10: forgets the feedback denominator (open-loop gain).
- B, 1: would need $G_1G_2H \to \infty$.

Final Answer: $T = 0.909 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q31

Q32.

Solution

Concept – Mason's determinant with non-touching loops: $\Delta = 1 - \sum L_i + \sum(\text{products of non-touching loop pairs}) - \cdots$. With two non-touching loops this is $\Delta = 1 - (L_1 + L_2) + L_1L_2$.

Step 1 – list the loop gains: $L_1 = -0.2$, $L_2 = -0.3$.

Step 2 – sum the loop gains: $L_1 + L_2 = -0.2 + (-0.3) = -0.5$

Step 3 – form the product of the (non-touching) pair: $L_1L_2 = (-0.2)(-0.3) = 0.06$

Step 4 – substitute into the determinant: $\Delta = 1 - (-0.5) + 0.06$

Step 5 – simplify term by term: $\Delta = 1 + 0.5 + 0.06$

Step 6 – evaluate: $\Delta = 1.56$

Why the other options are wrong:

- D, 1.44: drops the sign, using $1 - 0.5 - 0.06$ instead of $1 + 0.5 + 0.06$.

Final Answer: $\Delta = 1.56 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

Q33.

Solution

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

Step 1 – read the coefficients: $s^2 + 8s + 16 = 0$, so $\omega_n^2 = 16$ and $2\zeta\omega_n = 8$.

Step 2 – find the natural frequency: $\omega_n = \sqrt{16} = 4$ rad/s

Step 3 – write the middle-term equation: $2\zeta\omega_n = 8$

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

Step 5 – solve for ζ: $8\zeta = 8 \Rightarrow \zeta = 1$

Step 6 – interpret: $\zeta = 1$ means the system is critically damped.

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

Answer: (D) Go Back to Q33

Q34.

Solution

Concept – steady-state error of a type-0 system to a step: For a type-0 unity-feedback 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 – find the position error constant: $K_p = \lim_{s\to 0} \dfrac{10}{s+5} = \dfrac{10}{5} = 2$

Step 2 – write the steady-state error formula: $e_{ss} = \dfrac{1}{1+K_p}$

Step 3 – substitute $K_p = 2$: $e_{ss} = \dfrac{1}{1+2}$

Step 4 – evaluate the denominator: $1 + 2 = 3$

Step 5 – take the reciprocal: $e_{ss} = \dfrac{1}{3} = 0.333$

Why the other options are wrong:

- A, 0: would require a type-1 (or higher) system with an integrator, so that $K_p \to \infty$.

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

Answer: (D) Go Back to Q34

Q35.

Solution

Concept – peak overshoot of a second-order system: The fractional peak overshoot depends only on the damping ratio, $M_p = e^{-\pi\zeta/\sqrt{1-\zeta^2}}$.

Step 1 – list the data: $\zeta = 0.6$.

Step 2 – evaluate $1 - \zeta^2$: $1 - 0.6^2 = 1 - 0.36 = 0.64$

Step 3 – take the square root: $\sqrt{0.64} = 0.8$

Step 4 – form the exponent: $-\dfrac{\pi\zeta}{\sqrt{1-\zeta^2}} = -\dfrac{\pi \times 0.6}{0.8} = -\dfrac{1.885}{0.8} = -2.356$

Step 5 – take the exponential: $M_p = e^{-2.356} = 0.0948$

Step 6 – convert to percent: $M_p = 0.0948 \times 100\% = 9.48\% \approx 9.5\%$

Why the other options are wrong:

- A, 16.3%: corresponds to $\zeta = 0.5$, not 0.6.

Final Answer: $M_p \approx 9.5\% \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q35

Q36.

Solution

Concept – two-wattmeter method, total power: In the two-wattmeter method the algebraic sum of the two readings equals the total three-phase power, $P = W_1 + W_2$.

Step 1 – list the data: $W_1 = 1000$ W, $W_2 = 600$ W.

Step 2 – write the relation: $P = W_1 + W_2$

Step 3 – substitute the readings: $P = 1000 + 600$

Step 4 – evaluate: $P = 1600$ W

Why the other options are wrong:

- A, 400 W: this is the difference $W_1 - W_2$, which is used for the reactive power, not the total power.

Final Answer: $P = 1600$ W $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q36

Q37.

Solution

Concept – power-factor angle from two wattmeters: The load angle is found from the two readings by $\tan\phi = \sqrt{3}\,\dfrac{W_1 - W_2}{W_1 + W_2}$.

Step 1 – list the data: $W_1 = 1000$ W, $W_2 = 600$ W.

Step 2 – form the difference and the sum: $W_1 - W_2 = 400$, $W_1 + W_2 = 1600$

Step 3 – form the ratio: $\dfrac{W_1 - W_2}{W_1 + W_2} = \dfrac{400}{1600} = 0.25$

Step 4 – multiply by $\sqrt{3}$: $\tan\phi = 1.732 \times 0.25 = 0.433$

Step 5 – take the inverse tangent: $\phi = \tan^{-1}(0.433)$

Step 6 – evaluate: $\phi = 23.4°$ (so the power factor is $\cos 23.4° = 0.918$)

Final Answer: $\phi \approx 23.4° \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – Boolean simplification (distributive law): Factor the common variable and use the complement law $B + \bar{B} = 1$.

Step 1 – write the given expression: $Y = AB + A\bar{B}$

Step 2 – factor out the common term A: $Y = A(B + \bar{B})$

Step 3 – apply the complement law: $B + \bar{B} = 1$

Step 4 – substitute: $Y = A \times 1$

Step 5 – simplify: $Y = A$

Why the other options are wrong:

- C, $A + B$: would come from an OR of the inputs, not this factorisation.

- B, AB: keeps only one product term and drops the other.

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

Answer: (D) Go Back to Q38

Q39.

Solution

Concept – binary to decimal conversion: Each bit contributes its face value times the corresponding power of two, summed from the least significant bit.

Step 1 – write the bits with their weights: $(11011)_2 = 1{\cdot}2^4{+}1{\cdot}2^3{+}0{\cdot}2^2{+}1{\cdot}2^1{+}1{\cdot}2^0$

Step 2 – evaluate each power of two: $2^4 = 16$, $2^3 = 8$, $2^2 = 4$, $2^1 = 2$, $2^0 = 1$

Step 3 – keep only the bits that are 1**:** $16 + 8 + 0 + 2 + 1$

Step 4 – add the contributions: $16 + 8 = 24$

$24 + 2 = 26$

$26 + 1 = 27$

Step 5 – state the decimal value: $(11011)_2 = 27$

Final Answer: $27 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q39

Q40.

Solution

Concept – NOR gate output: A NOR gate outputs the complement of the OR of its inputs, $Y = \overline{A + B}$, which by De Morgan equals $\bar{A} \cdot \bar{B}$.

Step 1 – list the inputs: $A = 0$, $B = 0$.

Step 2 – form the OR of the inputs: $A + B = 0 + 0 = 0$

Step 3 – take the complement: $Y = \overline{0} = 1$

Step 4 – confirm with De Morgan: $Y = \bar{A} \cdot \bar{B} = \overline{0} \cdot \overline{0} = 1 \cdot 1 = 1$

Step 5 – conclude: The NOR output is high only when all inputs are low, which is the case here.

Why the other options are wrong:

- B, 0: that is the OR output before the inversion.

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

Answer: (A) Go Back to Q40

Q41.

Solution

Concept – non-inverting amplifier gain: 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: $R_1 = 10\ \text{k}\Omega$, $R_f = 20\ \text{k}\Omega$.

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

Step 3 – add one: $\frac{V_o}{V_i} = 1 + 2$

Step 4 – evaluate: $\frac{V_o}{V_i} = 3$

Why the other options are wrong:

- A, 2: uses the inverting-amplifier formula R_f/R_1 and forgets the "+1".

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

Answer: (B) Go Back to Q41

Q42.

Solution

Concept – average output of a fully controlled bridge: For a single-phase fully controlled bridge with a highly inductive (continuous-current) load, $V_{dc} = \frac{2V_m}{\pi}\cos\alpha$.

Step 1 – list the data: $V_m = 200$ V, $\alpha = 0°$, $\pi = 3.1416$.

Step 2 – evaluate the uncontrolled factor: $\frac{2V_m}{\pi} = \frac{2 \times 200}{3.1416} = \frac{400}{3.1416} = 127.3$ V

Step 3 – evaluate the cosine of the firing angle: $\cos 0° = 1$

Step 4 – multiply: $V_{dc} = 127.3 \times 1$

Step 5 – state the result: $V_{dc} = 127.3$ V

Why the other options are wrong:

- A, 63.66 V: uses V_m/π (a half-wave result) instead of $2V_m/\pi$.

Final Answer: $V_{dc} = 127.3\ \text{V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q42

Q43.

Solution

Concept – controlled-bridge output at a firing angle: The same relation $V_{dc} = \frac{2V_m}{\pi}\cos\alpha$ now includes the delay angle α.

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

Step 2 – evaluate the uncontrolled factor: $\frac{2V_m}{\pi} = \frac{400}{3.1416} = 127.3$ V

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

Step 4 – multiply: $V_{dc} = 127.3 \times 0.5$

Step 5 – evaluate: $V_{dc} = 63.66$ V

Why the other options are wrong:

- A, 127.3 V: the $\alpha = 0$ value, ignoring the delay.
- D, 0 V: would need $\alpha = 90°$.

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

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – output of a boost (step-up) chopper: For a boost converter in continuous conduction the output exceeds the input by the factor $\frac{1}{1-D}$, so $V_o = \frac{V_s}{1-D}$.

Step 1 – list the data: $V_s = 100$ V, $D = 0.5$.

Step 2 – form $1 - D$**:** $1 - D = 1 - 0.5 = 0.5$

Step 3 – write the relation: $V_o = \frac{V_s}{1-D}$

Step 4 – substitute the values: $V_o = \frac{100}{0.5}$

Step 5 – evaluate: $V_o = 200$ V

Why the other options are wrong:

- D, 100 V: forgets the boost action (equal to the input).
- C, 50 V: uses the buck relation DV_s instead of the boost relation.

Final Answer: $V_o = 200 \text{ V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q44

Q45.

Solution

Concept – output of a buck (step-down) chopper: For a buck chopper the average output is the input scaled by the duty ratio, $V_o = DV_s$.

Step 1 – list the data: $V_s = 400$ V, $D = 0.25$.

Step 2 – write the relation: $V_o = DV_s$

Step 3 – substitute the values: $V_o = 0.25 \times 400$

Step 4 – evaluate: $V_o = 100$ V

Step 5 – sanity check: A buck output must be less than the input $(100 < 400)$, which is consistent.

Why the other options are wrong:

- A, 400 V: that is the full input, i.e. $D = 1$.

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

Answer: (B) Go Back to Q45

Q46.

Solution

Concept – input power factor of a controlled bridge: For a single-phase fully controlled bridge feeding a highly inductive load, the fundamental input current lags the supply voltage by the firing angle α, so the displacement power factor is $\cos\alpha$.

Step 1 – list the data: $\alpha = 60°$.

Step 2 – write the displacement power factor: $\text{DPF} = \cos\alpha$

Step 3 – substitute the firing angle: $\text{DPF} = \cos 60°$

Step 4 – evaluate: $\cos 60° = 0.5$

Step 5 – interpret: Increasing the firing angle worsens the input power factor, an important drawback of phase-controlled rectifiers.

Why the other options are wrong:

- C, 1.0: would need $\alpha = 0°$.

- B, 0.866: is $\cos 30°$, the wrong angle.

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

Answer: (A) Go Back to Q46

Answer Key

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