GATE Electronics and Communication Engineering

Sample Paper – 4

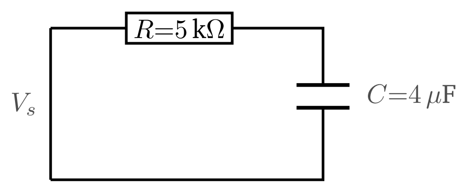
Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Electronics and Communication 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 $n_i = 1.5 \times 10^{10}$ cm^{-3} for silicon, thermal voltage $V_T = 25$ mV at room temperature, $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m and $c = 3 \times 10^8$ m/s.

Networks and Circuit Analysis

Q1. In the series RC circuit shown, an initially uncharged capacitor is connected to a d.c. source through the resistor at $t = 0$. With $R = 5$ kΩ and $C = 4$ μF, the charging time constant $\tau = RC$ is: **[1 mark]**



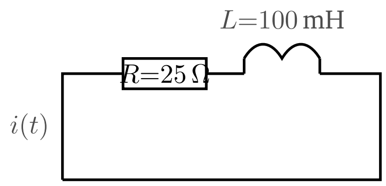
(A) 5 ms

(B) 100 ms

(C) 50 ms

(D) 20 ms

Q2. The source-free series RL circuit shown has $R = 25\ \Omega$ and $L = 100$ mH. The time constant $\tau = L/R$ of its natural (decaying) current response is: **[1 mark]**



(A) 25 ms

(B) 0.4 ms

(C) 4 ms

(D) 40 ms

Q3. A first-order RC circuit charges an initially uncharged capacitor toward a final voltage of 10 V. Using $v_C(t) = V_f\left(1 - e^{-t/\tau}\right)$, the capacitor voltage reached after exactly one time constant ($t = \tau$) is nearest to: **[1 mark]**

(A) 3.68 V

(B) 6.32 V

(C) 10 V

(D) 0 V

Q4. A charged capacitor of initial voltage 100 V discharges through a resistor. Using $v_C(t) = V_0\, e^{-t/\tau}$, the capacitor voltage after two time constants ($t = 2\tau$) is nearest to: **[1 mark]**

(A) 36.8 V

(B) 50 V

(C) 0 V

(D) 13.5 V

Q5. A d.c. current source of 12 A feeds two resistors of 4 Ω and 2 Ω connected in parallel. By the current-divider rule, the current flowing through the 4 Ω resistor is: **[1 mark]**

(A) 8 A

(B) 6 A

(C) 2 A

(D) 4 A

Q6. An ideal capacitor of $C = 1\ \mu$F is driven by a sinusoidal source of angular frequency $\omega = 1000$ rad/s. The magnitude of its capacitive reactance $X_C = 1/(\omega C)$ is: **[1 mark]**

(A) 1 Ω

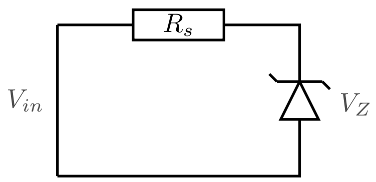
(B) 100 Ω

(C) 1000 Ω

(D) 10 Ω

Electronic Devices

Q7. In the Zener shunt regulator shown, the input is $V_{in} = 12$ V, the series resistor is $R_s = 100\ \Omega$ and the Zener holds $V_Z = 6$ V. With the load open, the current through the series resistor $I = (V_{in} - V_Z)/R_s$ is: **[1 mark]**



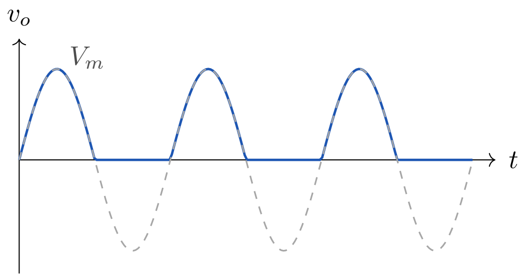
(A) 60 mA

(B) 120 mA

(C) 6 mA

(D) 18 mA

Q8. A single-diode half-wave rectifier is fed from a sinusoid of peak value $V_m = 10$ V, giving the output waveform sketched. The average (d.c.) value of the output, $V_{dc} = V_m/\pi$, is nearest to: **[1 mark]**



(A) 10 V

(B) 6.37 V

(C) 3.18 V

(D) 5 V

Q9. A full-wave bridge rectifier is fed from a sinusoidal secondary of peak voltage $V_m = 100$ V. For the bridge configuration the peak inverse voltage (PIV) that each diode must withstand is: **[1 mark]**

(A) 100 V

(B) 200 V

(C) 50 V

(D) 141 V

Q10. For a full-wave rectifier the ripple factor (ratio of the r.m.s. ripple component to the d.c. value of the output) is a standard constant. Its value is nearest to: **[1 mark]**

(A) 1.21

(B) 0.21

(C) 0.48

(D) 0.5

Q11. A silicon pn junction is doped with $N_a = N_d = 10^{16}$ cm^{-3} on each side. Taking $n_i = 1.5 \times 10^{10}$ cm^{-3} and $V_T = 0.025$ V, the built-in (contact) potential $V_{bi} = V_T \ln\left(N_a N_d / n_i^2\right)$ is nearest to: **[1 mark]**

(A) 0.35 V

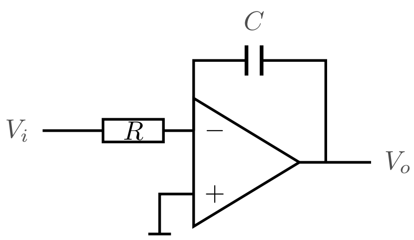
(B) 0.67 V

(C) 1.12 V

(D) 0.026 V

Analog Circuits

Q12. The ideal-op-amp integrator shown uses an input resistor $R = 10$ kΩ and a feedback capacitor $C = 0.1$ μF. The integrating time constant RC of the circuit is: **[1 mark]**



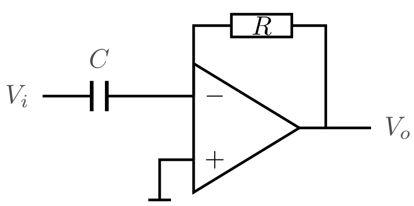
(A) 10 ms

(B) 0.1 ms

(C) 100 ms

(D) 1 ms

Q13. The ideal-op-amp differentiator shown has input capacitor $C = 10$ μF and feedback resistor $R = 50$ kΩ. A ramp $v_i(t) = 2t$ volts (slope 2 V/s) is applied. Using $v_o = -RC\,\dfrac{dv_i}{dt}$, the steady output voltage is: **[1 mark]**



(A) -1 V

(B) $+1$ V

(C) -2 V

(D) -0.5 V

Q14. An ideal-op-amp integrator has $R = 100$ kΩ and $C = 1$ μF, with the output initially at 0 V. A constant input $V_{in} = 1$ V is applied at $t = 0$. Using $v_o(t) = -\frac{1}{RC} V_{in}\, t$, the output at $t = 0.5$ s is: **[1 mark]**

(A) -10 V

(B) -5 V

(C) -2.5 V

(D) $+5$ V

Q15. An op-amp has a slew rate of 1 V/μs. For an undistorted sinusoidal output of peak amplitude 10 V, the full-power bandwidth $f_{\max} = \frac{\text{SR}}{2\pi V_p}$ is nearest to: **[1 mark]**

(A) 15.9 kHz

(B) 159 kHz

(C) 1.59 kHz

(D) 100 kHz

Q16. An ideal-op-amp difference amplifier has matched resistors with $R_1 = 10$ kΩ (input) and $R_2 = 50$ kΩ (feedback), so that $v_o = \frac{R_2}{R_1}(v_2 - v_1)$. If $v_2 - v_1 = 0.1$ V, the output voltage is: **[1 mark]**

(A) 0.5 V

(B) 5 V

(C) 0.05 V

(D) 1 V

Q17. An ideal-op-amp integrator uses $R = 1$ kΩ and $C = 0.16$ μF. Its unity-gain (0 dB) frequency, at which the integrator gain magnitude equals 1, is $f = \frac{1}{2\pi RC}$, which is nearest to: **[1 mark]**

(A) 10 kHz

(B) 100 Hz

(C) 16 kHz

(D) 1 kHz

Q18. A BJT is biased at a quiescent collector current $I_C = 2$ mA. Taking the thermal voltage $V_T = 25$ mV, the small-signal transconductance $g_m = I_C/V_T$ is: **[1 mark]**

(A) 8 mS

(B) 40 mS

(C) 80 mS

(D) 0.08 mS

Digital Circuits

Q19. Using the rules of Boolean algebra, the expression $Y = (A+B)(A+\bar{B})$ simplifies to: **[1 mark]**

(A) A

(B) B

(C) $A+B$

(D) AB

Q20. The hexadecimal number $(2A)_{16}$ has the decimal (base-10) value: **[1 mark]**

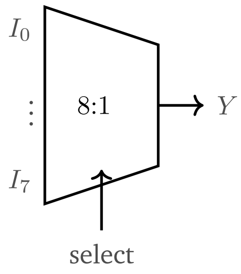
(A) 20

(B) 26

(C) 52

(D) 42

Q21. An 8:1 multiplexer, whose symbol is shown, is to be constructed entirely out of 2:1 multiplexers. The minimum number of 2:1 multiplexers required is: **[2 marks]**



(A) 3

(B) 7

(C) 8

(D) 4

Q22. The three-variable function $F(A,B,C) = \sum m(1,3,5,7)$ is plotted on the Karnaugh map shown (row A, columns BC). The minimal sum-of-products expression for F is: **[2 marks]**

$A\backslash BC$	00	01	11	10
0	0	1	1	0
1	0	1	1	0

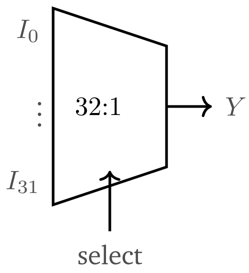
(A) A

(B) B

(C) $A+B$

(D) C

Q23. A digital multiplexer routes one of its 32 data inputs to a single output, as indicated by the symbol shown. The number of select (control) lines required is: **[2 marks]**



(A) 5

(B) 32

(C) 6

(D) 4

Q24. A two-input Exclusive-OR (XOR) gate is to be realised using only two-input NAND gates. The minimum number of NAND gates required is: **[2 marks]**

(A) 2

(B) 3

(C) 4

(D) 5

Signals and Systems

Q25. The continuous-time Fourier transform of the unit impulse $\delta(t)$ is: **[2 marks]**

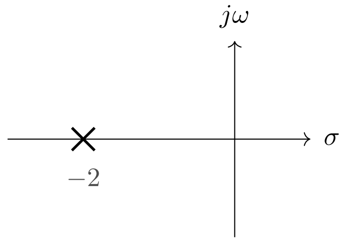
(A) 1

(B) $\delta(\omega)$

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

(D) 2π

Q26. A stable LTI system has the single-pole transfer function $H(s) = \dfrac{1}{s+2}$, whose pole–zero plot is shown (pole marked $\times$ at $s = -2$). The magnitude of its d.c. gain $|H(j0)|$ is: **[2 marks]**



(A) 2

(B) 1

(C) 0.25

(D) 0.5

Q27. A continuous-time signal $x(t)$ is a rectangular pulse of amplitude 3 that lasts from $t = -1$ to $t = +1$ (width 2). The value of its Fourier transform at zero frequency, $X(0) = \int_{-\infty}^{\infty} x(t)\,dt$ (the area under the signal), is: **[2 marks]**

(A) 2

(B) 3

(C) 6

(D) 0

Q28. A voltage signal $x(t) = 5\cos(\omega_0 t)$ volts appears across a $1\ \Omega$ resistor. The average power of the signal, $P = \dfrac{A^2}{2}$ for a sinusoid of amplitude A, is: **[2 marks]**

(A) 25 W

(B) 5 W

(C) 12.5 W

(D) 6.25 W

Q29. For two continuous-time signals $x(t)$ and $h(t)$ with Fourier transforms $X(\omega)$ and $H(\omega)$, the convolution theorem states that the Fourier transform of $x(t) * h(t)$ equals: **[2 marks]**

(A) $X(\omega)\,H(\omega)$

(B) $X(\omega) + H(\omega)$

(C) $X(\omega)/H(\omega)$

(D) $X(\omega) * H(\omega)$

Q30. A continuous-time signal has a Fourier transform that is non-zero only up to 3 kHz. According to the sampling theorem, the minimum sampling rate (Nyquist rate) needed to reconstruct it without aliasing is: **[2 marks]**

(A) 3 kHz

(B) 6 kHz

(C) 1.5 kHz

(D) 12 kHz

Control Systems

Q31. The characteristic equation of a feedback system is $s^3 + 6s^2 + 11s + 6 = 0$. Using the Routh–Hurwitz criterion, the number of closed-loop poles lying in the right half of the s-plane is: **[2 marks]**

(A) 3

(B) 0

(C) 1

(D) 2

Q32. The characteristic equation of a feedback system is $s^3 + s^2 + 3s - 5 = 0$. 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) 3

(C) 1

(D) 2

Q33. A unity-feedback system has the characteristic equation $s^3+2s^2+s+K = 0$. By the Routh–Hurwitz criterion the system stays stable for $0 < K < K_{\text{max}}$. The value of K_{max} (the marginal gain) is: **[2 marks]**

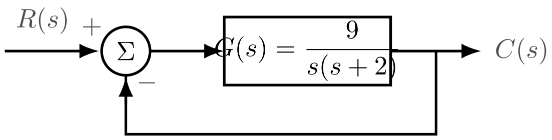
(A) 2

(B) 4

(C) 1

(D) 6

Q34. For the unity-feedback control system shown, the forward path is $G(s) = \dfrac{9}{s(s+2)}$, so the closed-loop characteristic equation is $s^2+2s+9 = 0$. The undamped natural frequency ω_n of the closed-loop system is: **[2 marks]**



(A) 9 rad/s

(B) 3 rad/s

(C) 1.5 rad/s

(D) 6 rad/s

Q35. A standard second-order system has the characteristic equation $s^2 + 6s + 25 = 0$. The damping ratio ζ of the system is: **[2 marks]**

(A) 1

(B) 0.3

(C) 0.6

(D) 0.5

Communications

Q36. In a PCM system a speech signal is sampled at 8 kHz and each sample is encoded with 12 bits. The output bit rate, (sampling rate) $\times$ (bits per sample), is: **[2 marks]**

(A) 96 kbps

(B) 8 kbps

(C) 12 kbps

(D) 40 kbps

Q37. In a PCM system each sample is encoded with $n = 10$ bits. The number of distinct uniform quantization levels, $L = 2^n$, is: **[2 marks]**

(A) 10

(B) 1024

(C) 512

(D) 100

Q38. A PCM system uses $n = 8$ bits per sample with uniform quantization. Using the standard rule $\mathrm{SNR}_q(\mathrm{dB}) = 6.02\,n + 1.76$, the signal-to-quantization-noise ratio is nearest to: **[2 marks]**

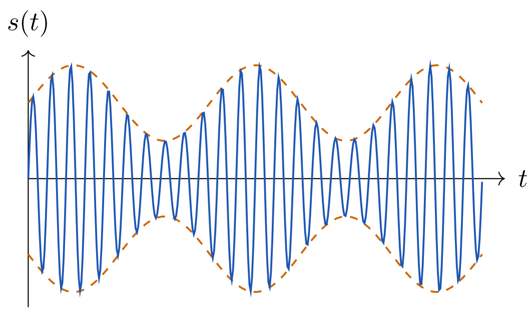
(A) 8 dB

(B) 49.9 dB

(C) 16 dB

(D) 25 dB

Q39. A carrier of power $P_c = 200$ W is amplitude-modulated to a modulation index $\mu = 0.5$, giving the envelope shown. The total transmitted power, $P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$, is: **[2 marks]**



(A) 225 W

(B) 200 W

(C) 250 W

(D) 400 W

Q40. An FM signal has a peak frequency deviation of $\Delta f = 5$ kHz for a modulating tone of frequency $f_m = 1$ kHz. By Carson's rule the transmission bandwidth $B = 2(\Delta f + f_m)$ is: **[2 marks]**

(A) 5 kHz

(B) 12 kHz

(C) 10 kHz

(D) 6 kHz

Q41. A signal band-limited to 10 kHz is to be sampled at exactly the Nyquist rate. The sampling interval $T_s = 1/f_s$ between consecutive samples is: **[2 marks]**

(A) 20 μs

(B) 10 μs

(C) 100 μs

(D) 50 μs

Electromagnetics

Q42. Among Maxwell's equations in differential form, the one expressing the absence of isolated magnetic charges (no magnetic monopoles) is: **[2 marks]**

(A) $\nabla \cdot \mathbf{D} = \rho$

(B) $\nabla \cdot \mathbf{B} = 0$

(C) $\nabla \times \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t}$

(D) $\nabla \times \mathbf{H} = \mathbf{J} + \dfrac{\partial \mathbf{D}}{\partial t}$

Q43. The differential (point) form of Faraday's law of electromagnetic induction is: **[2 marks]**

(A) $\nabla\cdot\mathbf{D} = \rho$

(B) $\nabla\times\mathbf{H} = \mathbf{J} + \dfrac{\partial\mathbf{D}}{\partial t}$

(C) $\nabla\times\mathbf{E} = -\dfrac{\partial\mathbf{B}}{\partial t}$

(D) $\nabla\cdot\mathbf{B} = 0$

Q44. A uniform plane wave propagates in a lossless non-magnetic dielectric of relative permittivity $\varepsilon_r = 4$. Its phase velocity $v_p = c/\sqrt{\varepsilon_r}$ is: **[2 marks]**

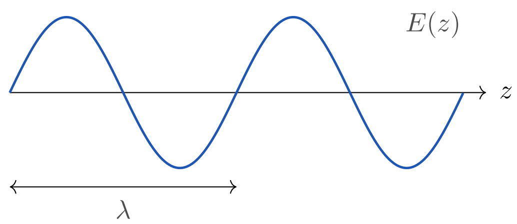
(A) 3×10^8 m/s

(B) 1.5×10^8 m/s

(C) 0.75×10^8 m/s

(D) 6×10^8 m/s

Q45. A uniform plane wave of frequency 300 MHz propagates in free space, as sketched. Its wavelength $\lambda = c/f$ is: **[2 marks]**



(A) 3 m

(B) 0.3 m

(C) 10 m

(D) 1 m

Q46. A uniform plane wave travels in a lossless non-magnetic dielectric of relative permittivity $\varepsilon_r = 4$. Using $\eta = \eta_0/\sqrt{\varepsilon_r}$ with $\eta_0 = 377\ \Omega$, the intrinsic impedance of the medium is nearest to: **[2 marks]**

(A) $377\ \Omega$

(B) $75\ \Omega$

(C) $50\ \Omega$

(D) $188.5\ \Omega$

Detailed Solutions

Q1.

Solution

Concept – time constant of a charging RC circuit: For a first-order RC circuit the time constant is $\tau = RC$.

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

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

Step 2 – multiply the two quantities: $\tau = (5 \times 10^3) \times (4 \times 10^{-6})$

Step 3 – multiply the mantissas: $5 \times 4 = 20$

Step 4 – combine the powers of ten: $10^3 \times 10^{-6} = 10^{-3}$

Step 5 – assemble the result: $\tau = 20 \times 10^{-3}$ s

$\tau = 20$ ms

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

Answer: (D) **Go Back to Q1**

Q2.

Solution

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

Step 1 – convert the values to base units: $L = 100\ \text{mH} = 100 \times 10^{-3}\ \text{H} = 0.1$ H

$R = 25\ \Omega$

Step 2 – form the ratio: $\tau = \dfrac{0.1}{25}$

Step 3 – carry out the division: $\tau = 0.004$ s

Step 4 – express in milliseconds: $\tau = 4 \times 10^{-3}\ \text{s} = 4$ ms

Final Answer: $\tau = 4\ \text{ms} \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q2**

Q3.

Solution

Concept – capacitor voltage during charging: A capacitor charging toward V_f follows $v_C(t) = V_f\left(1 - e^{-t/\tau}\right)$.

Step 1 – set the time equal to one time constant: $t = \tau$, so $t/\tau = 1$.

Step 2 – evaluate the exponential term: $e^{-1} = 0.368$

Step 3 – form the bracket: $1 - e^{-1} = 1 - 0.368 = 0.632$

Step 4 – multiply by the final voltage: $v_C = 10 \times 0.632$

$v_C = 6.32$ V

Step 5 – interpret: After one time constant a charging capacitor reaches 63.2% of its final value.

Why the other options are wrong:

- A, 3.68 V: is $10\,e^{-1}$, the value for a **discharging** capacitor after one time constant.
- C, 10 V: is the final steady value reached only as $t \to \infty$.
- D, 0 V: is the initial value at $t = 0$.

Final Answer: $v_C = 6.32$ V $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept – capacitor voltage during discharge: A capacitor discharging from V_0 follows $v_C(t) = V_0\, e^{-t/\tau}$.

Step 1 – set the time to two time constants: $t = 2\tau$, so $t/\tau = 2$.

Step 2 – evaluate the exponential term: $e^{-2} = 0.135$

Step 3 – multiply by the initial voltage: $v_C = 100 \times 0.135$

Step 4 – state the result: $v_C = 13.5$ V

Why the other options are wrong:

- A, 36.8 V: is $100\,e^{-1}$, the value after only **one** time constant.
- B, 50 V: would be half of V_0, which does not match an exponential decay.
- C, 0 V: is the limiting value as $t \to \infty$, not at $t = 2\tau$.

Final Answer: $v_C = 13.5 \text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept – current-divider rule: For two resistors in parallel, the current in one branch is the total current times the *opposite* resistance over the sum, $I_1 = I\,\dfrac{R_2}{R_1 + R_2}$.

Step 1 – list the data: $I = 12$ A, branch of interest $R_1 = 4\ \Omega$, other branch $R_2 = 2\ \Omega$.

Step 2 – form the sum of resistances: $R_1 + R_2 = 4 + 2 = 6\ \Omega$

Step 3 – write the divider fraction for the $4\ \Omega$ branch (uses the opposite $2\ \Omega$): $\dfrac{R_2}{R_1 + R_2} = \dfrac{2}{6} = \dfrac{1}{3}$

Step 4 – multiply by the total current: $I_{4\Omega} = 12 \times \dfrac{1}{3}$

$I_{4\Omega} = 4$ A

Step 5 – sanity check: The larger $4\ \Omega$ branch carries the smaller share, and 4 A < 8 A (the $2\ \Omega$ branch current), as expected.

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

Answer: (D) Go Back to Q5

Q6.

Solution

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

Step 1 – convert the capacitance: $C = 1\ \mu\text{F} = 1 \times 10^{-6}$ F

Step 2 – form the product ωC in the denominator: $\omega C = 1000 \times (1 \times 10^{-6})$

$\omega C = 1 \times 10^{-3}$

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

Step 4 – evaluate: $X_C = 1000\ \Omega$

Final Answer: $X_C = 1000\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept – series resistor current in a Zener shunt regulator: With the load removed, all of the current flows through the series resistor and into the Zener, and it equals the voltage across R_s divided by R_s: $I = \dfrac{V_{in} - V_Z}{R_s}$.

Step 1 – find the voltage across the series resistor: $V_{R_s} = V_{in} - V_Z = 12 - 6 = 6$ V

Step 2 – divide by the resistance: $I = \dfrac{6}{100}$

Step 3 – evaluate: $I = 0.06$ A

Step 4 – express in milliamperes: $I = 60$ mA

Final Answer: $I = 60$ mA $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q7**

Q8.

Solution

Concept – d.c. output of a half-wave rectifier: The average (d.c.) value of a half-wave rectified sinusoid is $V_{dc} = \dfrac{V_m}{\pi}$.

Step 1 – list the data: $V_m = 10$ V, $\pi \approx 3.1416$.

Step 2 – substitute into the formula: $V_{dc} = \dfrac{10}{3.1416}$

Step 3 – carry out the division: $V_{dc} = 3.183$ V

Step 4 – round: $V_{dc} \approx 3.18$ V

Why the other options are wrong:

- A, 10 V: is the peak V_m, not the average.
- B, 6.37 V: is $2V_m/\pi$, the d.c. value of a **full-wave** rectifier.
- D, 5 V: is $V_m/2$, which is not the correct average of a rectified sine.

Final Answer: $V_{dc} \approx 3.18$ V $\Rightarrow \boxed{\text{C}}$

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

Q9.

Solution

Concept – peak inverse voltage of a bridge rectifier: In a full-wave *bridge* rectifier two diodes conduct while the other two are reverse biased; the reverse-biased diodes see only the peak secondary voltage, so PIV $= V_m$.

Step 1 – identify the peak secondary voltage: $V_m = 100$ V

Step 2 – apply the bridge PIV relation: PIV $= V_m = 100$ V

Why the other options are wrong:

- B, 200 V: is $2V_m$, the PIV of a **centre-tapped** full-wave rectifier, not the bridge.
- C, 50 V: is $V_m/2$, which has no physical basis here.
- D, 141 V: is $\sqrt{2} \times 100$, confusing an r.m.s. figure with the peak.

Final Answer: PIV $= 100$ V $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept – ripple factor of a rectifier: The ripple factor r measures the residual a.c. content of the rectified output; it is a fixed number for an ideal rectifier of a given type.

Step 1 – recall the standard result for a full-wave rectifier: $r = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$ evaluates to 0.483 for a full-wave rectified sine.

Step 2 – round to two figures: $r \approx 0.48$

Why the other options are wrong:

- A, 1.21: is the ripple factor of a **half-wave** rectifier.
- B, 0.21 and D, 0.5: do not correspond to any standard rectifier ripple figure.

Final Answer: $r \approx 0.48 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – built-in potential of a pn junction: $V_{bi} = V_T \ln\left(\dfrac{N_a N_d}{n_i^2}\right)$.

Step 1 – form the product of the doping concentrations: $N_a N_d = (10^{16}) \times (10^{16}) = 10^{32}\ \text{cm}^{-6}$

Step 2 – square the intrinsic concentration: $n_i^2 = (1.5 \times 10^{10})^2 = 2.25 \times 10^{20}\ \text{cm}^{-6}$

Step 3 – form the ratio inside the logarithm: $\dfrac{N_a N_d}{n_i^2} = \dfrac{10^{32}}{2.25 \times 10^{20}} = 4.44 \times 10^{11}$

Step 4 – take the natural logarithm: $\ln(4.44 \times 10^{11}) = \ln(4.44) + 11 \ln(10)$

$= 1.49 + 11(2.303) = 1.49 + 25.33 = 26.82$

Step 5 – multiply by the thermal voltage: $V_{bi} = 0.025 \times 26.82$

$V_{bi} = 0.67$ V

Final Answer: $V_{bi} \approx 0.67\ \text{V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept – integrating time constant of an op-amp integrator: The op-amp integrator obeys $v_o = -\dfrac{1}{RC}\displaystyle\int v_i\, dt$, so its characteristic time constant is $\tau = RC$.

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

$C = 0.1\ \mu\text{F} = 0.1 \times 10^{-6}\ \text{F} = 1 \times 10^{-7}\ \text{F}$

Step 2 – multiply: $\tau = (10 \times 10^3) \times (1 \times 10^{-7})$

Step 3 – combine the powers of ten: $\tau = 10 \times 10^{-4} = 1 \times 10^{-3}$

Step 4 – express in milliseconds: $\tau = 1$ ms

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

Answer: (D) Go Back to Q12

Q13.

Solution

Concept – output of an op-amp differentiator: The op-amp differentiator gives $v_o = -RC\,\dfrac{dv_i}{dt}$.

Step 1 – find the input slope: $v_i(t) = 2t \Rightarrow \dfrac{dv_i}{dt} = 2$ V/s

Step 2 – convert the component values: $R = 50\ \text{k}\Omega = 50 \times 10^3\ \Omega$

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

Step 3 – form the product RC: $RC = (50 \times 10^3) \times (10 \times 10^{-6})$

$RC = 500 \times 10^{-3} = 0.5$ s

Step 4 – substitute into the differentiator relation: $v_o = -RC\,\dfrac{dv_i}{dt} = -(0.5) \times (2)$

Step 5 – evaluate: $v_o = -1$ V

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

Answer: (A) Go Back to Q13

Q14.

Solution

Concept – ramp output of an op-amp integrator: With a constant input V_{in} and zero initial output, the integrator ramps linearly, $v_o(t) = -\dfrac{1}{RC}\,V_{in}\,t$.

Step 1 – form the time constant RC: $RC = (100 \times 10^3) \times (1 \times 10^{-6})$

$RC = 100 \times 10^{-3} = 0.1$ s

Step 2 – form the reciprocal of the time constant: $\dfrac{1}{RC} = \dfrac{1}{0.1} = 10\ \text{s}^{-1}$

Step 3 – substitute $V_{in} = 1$ V and $t = 0.5$ s: $v_o = -(10) \times (1) \times (0.5)$

Step 4 – evaluate: $v_o = -5$ V

Final Answer: $v_o = -5\ \text{V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept – full-power (slew-rate-limited) bandwidth: The largest frequency an op-amp can deliver at peak output V_p without slewing is $f_{\max} = \dfrac{\text{SR}}{2\pi V_p}$.

Step 1 – convert the slew rate to base units: $\text{SR} = 1\ \text{V}/\mu\text{s} = 1 \times 10^6$ V/s

Step 2 – form the denominator: $2\pi V_p = 2\pi \times 10 = 62.83$

Step 3 – divide: $f_{\max} = \dfrac{1 \times 10^6}{62.83}$

Step 4 – evaluate: $f_{\max} = 15\,915\ \text{Hz} \approx 15.9\ \text{kHz}$

Final Answer: $f_{\max} \approx 15.9\ \text{kHz} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept – gain of a difference amplifier: For matched resistors, $v_o = \dfrac{R_2}{R_1}(v_2 - v_1)$.

Step 1 – form the resistor ratio: $\dfrac{R_2}{R_1} = \dfrac{50\ \text{k}\Omega}{10\ \text{k}\Omega} = 5$

Step 2 – multiply by the differential input: $v_o = 5 \times 0.1$

Step 3 – evaluate: $v_o = 0.5\ \text{V}$

Why the other options are wrong:

- B, 5 V: uses the differential input as 1 V instead of 0.1 V.
- C, 0.05 V: takes the ratio as 0.5 instead of 5.
- D, 1 V: ignores the factor of 5 gain.

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

Answer: (A) Go Back to Q16

Q17.

Solution

Concept – unity-gain frequency of an integrator: The magnitude of the ideal integrator gain is $|H(j\omega)| = \dfrac{1}{\omega RC}$; it equals 1 at $f = \dfrac{1}{2\pi RC}$.

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

$C = 0.16\ \mu\text{F} = 0.16 \times 10^{-6}\ \text{F} = 1.6 \times 10^{-7}\ \text{F}$

Step 2 – form the product RC: $RC = (1 \times 10^3) \times (1.6 \times 10^{-7}) = 1.6 \times 10^{-4}\ \text{s}$

Step 3 – form $2\pi RC$: $2\pi RC = 6.283 \times 1.6 \times 10^{-4} = 1.005 \times 10^{-3}$

Step 4 – take the reciprocal: $f = \dfrac{1}{1.005 \times 10^{-3}}$

Step 5 – evaluate: $f = 995\ \text{Hz} \approx 1\ \text{kHz}$

Final Answer: $f \approx 1$ kHz $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q17

Q18.

Solution

Concept – transconductance of a BJT: The small-signal transconductance is $g_m = \frac{I_C}{V_T}$.

Step 1 – convert the two quantities to base units: $I_C = 2\text{ mA} = 2 \times 10^{-3}$ A

$V_T = 25\text{ mV} = 25 \times 10^{-3}$ V

Step 2 – form the ratio: $g_m = \dfrac{2 \times 10^{-3}}{25 \times 10^{-3}}$

Step 3 – cancel the common 10^{-3}: $g_m = \dfrac{2}{25}$

Step 4 – evaluate: $g_m = 0.08$ S

Step 5 – express in millisiemens: $g_m = 80$ mS

Final Answer: $g_m = 80$ mS $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q18

Q19.

Solution

Concept – Boolean simplification by the distributive law: The product of sums $(A + B)(A + \bar{B})$ can be expanded and reduced.

Step 1 – multiply the two brackets out: $(A+B)(A+\bar{B}) = A\cdot A + A\bar{B} + BA + B\bar{B}$

Step 2 – apply $A \cdot A = A$ and $B\bar{B} = 0$: $= A + A\bar{B} + AB + 0$

Step 3 – factor A from the first three terms: $= A\,(1 + \bar{B} + B)$

Step 4 – use $\bar{B} + B = 1$ and $1 +$ anything $= 1$: $= A\,(1)$

Step 5 – state the result: $Y = A$

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

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – hexadecimal to decimal conversion: Each hex digit is weighted by a power of 16; digit A equals decimal 10.

Step 1 – write the place values of $(2A)_{16}$: $2 \to 16^1$ place, A $\to 16^0$ place.

Step 2 – convert the most significant digit: $2 \times 16^1 = 2 \times 16 = 32$

Step 3 – convert the least significant digit: A $= 10$, so $10 \times 16^0 = 10 \times 1 = 10$

Step 4 – add the contributions: $32 + 10 = 42$

Final Answer: $(2A)_{16} = 42 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept – building a large MUX from $2{:}1$ blocks: An $N{:}1$ multiplexer built as a tree of $2{:}1$ blocks needs $N - 1$ of them (each $2{:}1$ block removes one input from the count).

Step 1 – identify the size: $N = 8$.

Step 2 – count the blocks stage by stage: First stage reduces $8 \to 4$ using 4 blocks.

Second stage reduces $4 \to 2$ using 2 blocks.

Third stage reduces $2 \to 1$ using 1 block.

Step 3 – add the blocks: $4 + 2 + 1 = 7$

Step 4 – cross-check with the formula: $N - 1 = 8 - 1 = 7$

Final Answer: 7 two-to-one MUXes $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – Karnaugh-map grouping: Adjacent 1s that form a power-of-two block are combined; the variables that stay constant over the block survive.

Step 1 – place the minterms $m(1, 3, 5, 7)$ on the map: $m1 = 001,\ m3 = 011,\ m5 = 101,\ m7 = 111$ – every one of these has $C = 1$.

Step 2 – observe the pattern on the map: The four 1s fill the two middle columns

($BC = 01$ and $BC = 11$), which are exactly the columns where $C = 1$.

Step 3 – read the surviving variable: Across this group A takes both values and B takes both values, so they drop out; only C stays at 1.

Step 4 – write the minimal expression: $F = C$

Why the other options are wrong:

- A, A and B, B: both A and B change within the group, so neither can be the answer.
- C, $A + B$: is a sum term, but the group reduces to a single literal.

Final Answer: $F = C \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept – select lines of a multiplexer: An N-input MUX needs $\log_2 N$ select lines to address one input uniquely.

Step 1 – identify the number of inputs: $N = 32$.

Step 2 – express 32 **as a power of two:** $32 = 2^5$

Step 3 – take the base-2 logarithm: $\log_2(2^5) = 5$

Step 4 – state the result: 5 select lines are required.

Why the other options are wrong:

- B, 32: is the number of data inputs, not the number of select lines.
- C, 6: would address $2^6 = 64$ inputs, more than needed.
- D, 4: addresses only $2^4 = 16$ inputs, too few for 32.

Final Answer: 5 select lines $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept – XOR from NAND gates: The two-input XOR, $Y = A\bar{B} + \bar{A}B$, has a standard NAND-only realisation.

Step 1 – form the first NAND: $G_1 = \overline{A\,B}$

Step 2 – form two more NANDs using G_1: $G_2 = \overline{A\,G_1}$ and $G_3 = \overline{B\,G_1}$

Step 3 – combine them in a final NAND: $Y = \overline{G_2\,G_3}$

Step 4 – count the gates used: G_1, G_2, G_3, Y – that is 4 NAND gates.

Why the other options are wrong:

- A, 2 and B, 3: too few to generate both product terms and combine them.
- D, 5: one more than the minimal count; the 4-gate network already realises XOR.

Final Answer: 4 NAND gates $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept – Fourier transform of an impulse: The Fourier transform is $X(\omega) = \int_{-\infty}^{\infty} x(t)\, e^{-j\omega t}\, dt$.

Step 1 – substitute $x(t) = \delta(t)$: $X(\omega) = \int_{-\infty}^{\infty} \delta(t)\, e^{-j\omega t}\, dt$

Step 2 – apply the sifting property of the impulse: The integral picks out the value of $e^{-j\omega t}$ at $t = 0$.

Step 3 – evaluate the exponential at $t = 0$: $e^{-j\omega\cdot 0} = e^0 = 1$

Step 4 – state the transform: $X(\omega) = 1$ for all ω (a flat, all-frequency spectrum).

Why the other options are wrong:

- B, $\delta(\omega)$: is the transform of a d.c. constant $x(t) = 1$, the dual situation.
- C, $1/j\omega$: is (part of) the transform of the unit step, not the impulse.
- D, 2π: is the transform of the constant $x(t) = 1$ up to the $2\pi\delta(\omega)$ factor, not of $\delta(t)$.

Final Answer: $X(\omega) = 1 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – d.c. gain of a transfer function: The d.c. gain is the frequency response at $\omega = 0$, i.e. $H(s)$ evaluated at $s = 0$.

Step 1 – write the frequency response: $H(j\omega) = \dfrac{1}{j\omega + 2}$

Step 2 – set $\omega = 0$: $H(j0) = \dfrac{1}{0+2}$

Step 3 – evaluate: $H(j0) = \dfrac{1}{2}$

Step 4 – take the magnitude: $|H(j0)| = 0.5$

Why the other options are wrong:

- A, 2: inverts the fraction.
- B, 1: uses the numerator alone and ignores the pole at -2.
- C, 0.25: squares the correct value, as if computing a power ratio.

Final Answer: $|H(j0)| = 0.5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q26

Q27.

Solution

Concept – Fourier transform at zero frequency equals the signal's area: Setting $\omega = 0$ in $X(\omega) = \int x(t)e^{-j\omega t}dt$ gives $X(0) = \int_{-\infty}^{\infty} x(t)\,dt$.

Step 1 – describe the pulse: Amplitude 3, extending from $t = -1$ to $t = +1$.

Step 2 – find the width of the pulse: width $= 1 - (-1) = 2$

Step 3 – compute the area (height times width): $X(0) = 3 \times 2$

Step 4 – evaluate: $X(0) = 6$

Why the other options are wrong:

- A, 2: is the width alone.
- B, 3: is the height alone.
- D, 0: would require a signal with zero net area.

Final Answer: $X(0) = 6 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept – average power of a sinusoid: For $x(t) = A\cos(\omega_0 t)$ the average power (across a $1\ \Omega$ reference) is $P = \dfrac{A^2}{2}$.

Step 1 – identify the amplitude: $A = 5$ V.

Step 2 – square the amplitude: $A^2 = 5^2 = 25$

Step 3 – divide by two: $P = \dfrac{25}{2}$

Step 4 – evaluate: $P = 12.5$ W

Why the other options are wrong:

- A, 25 W: forgets the factor $\frac{1}{2}$ (uses peak-squared as power).
- B, 5 W: uses the amplitude itself as the power.
- D, 6.25 W: is $(A/2)^2$, an incorrect r.m.s. handling.

Final Answer: $P = 12.5$ W $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q28

Q29.

Solution

Concept – convolution theorem of the Fourier transform: Convolution in the time domain becomes multiplication in the frequency domain.

Step 1 – write the time-domain operation: $y(t) = x(t) * h(t)$

Step 2 – transform both sides: $\mathcal{F}\{x(t) * h(t)\} = X(\omega)\, H(\omega)$

Step 3 – state the property in words: The transform of a convolution is the *product* of the individual transforms.

Why the other options are wrong:

- B, $X(\omega) + H(\omega)$: addition corresponds to time-domain addition, not convolution.
- C, $X(\omega)/H(\omega)$: division corresponds to deconvolution, the inverse operation.
- D, $X(\omega) * H(\omega)$: convolution in frequency corresponds to **multiplication** in time (the dual), not to time-domain convolution.

Final Answer: $X(\omega)\,H(\omega) \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept – Nyquist rate: A signal band-limited to f_m must be sampled at a rate of at least $2f_m$ to avoid aliasing.

Step 1 – identify the highest frequency: $f_m = 3$ kHz.

Step 2 – apply the Nyquist relation: $f_s^{\min} = 2f_m = 2 \times 3$ kHz

Step 3 – evaluate: $f_s^{\min} = 6$ kHz

Why the other options are wrong:

- A, 3 kHz: equals f_m and would cause severe aliasing.
- C, 1.5 kHz: is half of f_m, far below the requirement.
- D, 12 kHz: is $4f_m$; valid but not the **minimum** rate asked for.

Final Answer: $f_s^{\min} = 6$ kHz $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q30

Q31.

Solution

Concept – Routh–Hurwitz criterion: The number of right-half-plane (RHP) roots equals the number of sign changes in the first column of the Routh array.

Step 1 – write the coefficients of $s^3 + 6s^2 + 11s + 6$**:** $s^3 : 1,\ 11 \quad s^2 : 6,\ 6$

Step 2 – compute the s^1 **row:** $\dfrac{(6)(11) - (1)(6)}{6} = \dfrac{66 - 6}{6} = \dfrac{60}{6} = 10$

Step 3 – compute the s^0 **row:** It equals the last coefficient, 6.

Step 4 – list the first column: $1,\ 6,\ 10,\ 6$

Step 5 – count the sign changes: All four entries are positive, so there are **no** sign changes.

Step 6 – conclude: Number of RHP poles $= 0$; the system is stable.

Final Answer: 0 RHP poles $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q31

Q32.

Solution

Concept – Routh–Hurwitz with a sign change: Again the first-column sign changes count the RHP roots. A negative constant term already signals at least one RHP root.

Step 1 – write the coefficients of $s^3 + s^2 + 3s - 5$: $s^3 : 1,\ 3 \quad s^2 : 1,\ -5$

Step 2 – compute the s^1 row: $\dfrac{(1)(3) - (1)(-5)}{1} = \dfrac{3+5}{1} = 8$

Step 3 – compute the s^0 row: It equals the last coefficient, -5.

Step 4 – list the first column: $1,\ 1,\ 8,\ -5$

Step 5 – count the sign changes: $1 \to 1$ (none), $1 \to 8$ (none), $8 \to -5$ (one change). Total $= 1$.

Step 6 – conclude: There is exactly 1 pole in the right half plane.

Why the other options are wrong:

- A, 0: a negative coefficient makes stability impossible.
- B, 3: would need three sign changes, but only one occurs.
- D, 2: a second-order factor $s^2 + 2s + 5$ (roots $-1 \pm j2$) is stable, leaving only one RHP root.

Final Answer: 1 RHP pole $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q32

Q33.

Solution

Concept – marginal gain from the Routh array: The system is stable while every first-column entry stays positive; the gain at which an entry reaches zero is the marginal (critical) gain.

Step 1 – write the coefficients of $s^3 + 2s^2 + s + K$: $s^3 : 1,\ 1 \quad s^2 : 2,\ K$

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

Step 3 – apply the stability condition on this entry: $\dfrac{2-K}{2} > 0 \Rightarrow 2 - K > 0 \Rightarrow K < 2$

Step 4 – apply the s^0 condition: The s^0 row is K, so $K > 0$.

Step 5 – combine and read the upper limit: Stable for $0 < K < 2$, so $K_{\max} = 2$.

Final Answer: $K_{\max} = 2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q33

Q34.

Solution

Concept – natural frequency of a standard second-order system: Comparing $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$ with the given equation identifies ω_n from the constant term.

Step 1 – write the characteristic equation: $s^2 + 2s + 9 = 0$

Step 2 – match the constant term to ω_n^2: $\omega_n^2 = 9$

Step 3 – take the square root: $\omega_n = \sqrt{9}$

Step 4 – evaluate: $\omega_n = 3$ rad/s

Why the other options are wrong:

- A, 9 rad/s: mistakes ω_n^2 for ω_n.
- C, 1.5 rad/s: halves the correct value.
- D, 6 rad/s: doubles the correct value.

Final Answer: $\omega_n = 3$ rad/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q34

Q35.

Solution

Concept – damping ratio of a second-order system: 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 – match the constant term: $\omega_n^2 = 25 \Rightarrow \omega_n = 5$ rad/s

Step 2 – match the middle term: $2\zeta\omega_n = 6$

Step 3 – substitute $\omega_n = 5$: $2\zeta(5) = 6 \Rightarrow 10\zeta = 6$

Step 4 – solve for ζ: $\zeta = \dfrac{6}{10}$

Step 5 – evaluate: $\zeta = 0.6$

Step 6 – interpret: Since $0 < \zeta < 1$, the response is underdamped, consistent with a 6-rad/s natural frequency.

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

Answer: (C) Go Back to Q35

Q36.

Solution

Concept – PCM bit rate: The output bit rate is the sampling rate multiplied by the number of bits per sample, $R_b = f_s \times n$.

Step 1 – list the data: $f_s = 8$ kHz $= 8000$ samples/s, $n = 12$ bits/sample.

Step 2 – multiply: $R_b = 8000 \times 12$

Step 3 – evaluate: $R_b = 96\,000$ bits/s

Step 4 – express in kbps: $R_b = 96$ kbps

Why the other options are wrong:

- B, 8 kbps: is the sampling rate alone, missing the $\times 12$.
- C, 12 kbps: uses the bits per sample as a rate.
- D, 40 kbps: does not follow from 8000×12.

Final Answer: $R_b = 96$ kbps $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q36

Q37.

Solution

Concept – quantization levels in PCM: With n bits per sample the number of distinct levels is $L = 2^n$.

Step 1 – identify the word length: $n = 10$ bits.

Step 2 – raise two to the power n: $L = 2^{10}$

Step 3 – evaluate the power: $2^{10} = 1024$

Step 4 – state the result: $L = 1024$ levels

Why the other options are wrong:

- A, 10: is the number of bits, not the level count.
- C, 512: is 2^9, one bit short.
- D, 100: is 10^2, using base ten instead of base two.

Final Answer: $L = 1024$ levels $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – signal-to-quantization-noise ratio of PCM: For an n-bit uniform quantizer, $\text{SNR}_q(\text{dB}) \approx 6.02\,n + 1.76$.

Step 1 – identify the word length: $n = 8$ bits.

Step 2 – multiply by 6.02**:** $6.02 \times 8 = 48.16$

Step 3 – add the constant 1.76**:** $48.16 + 1.76 = 49.92$

Step 4 – round: $\text{SNR}_q \approx 49.9$ dB

Why the other options are wrong:

- A, 8 dB: uses the bit count directly as decibels.
- C, 16 dB: doubles the bit count, ignoring the 6.02 rule.
- D, 25 dB: does not follow from $6.02n + 1.76$.

Final Answer: $\text{SNR}_q \approx 49.9 \text{ dB} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept – total power of an AM signal: $P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$, where P_c is the carrier power and μ the modulation index.

Step 1 – square the modulation index: $\mu^2 = (0.5)^2 = 0.25$

Step 2 – halve it: $\frac{\mu^2}{2} = \frac{0.25}{2} = 0.125$

Step 3 – add one: $1 + 0.125 = 1.125$

Step 4 – multiply by the carrier power: $P_t = 200 \times 1.125$

Step 5 – evaluate: $P_t = 225$ W

Why the other options are wrong:

- B, 200 W: is the carrier power alone, ignoring the sidebands.
- C, 250 W: uses $\mu = 1$ instead of 0.5.
- D, 400 W: doubles the carrier, which no AM relation gives.

Final Answer: $P_t = 225 \text{ W} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q39

Q40.

Solution

Concept – Carson's rule for FM bandwidth: $B = 2(\Delta f + f_m)$, with Δf the peak deviation and f_m the modulating frequency.

Step 1 – add the deviation and the modulating frequency: $\Delta f + f_m = 5 + 1 = 6$ kHz

Step 2 – multiply by two: $B = 2 \times 6$

Step 3 – evaluate: $B = 12$ kHz

Why the other options are wrong:

- A, 5 kHz: is the deviation alone.
- C, 10 kHz: is $2\Delta f$, dropping the f_m term.
- D, 6 kHz: is $(\Delta f + f_m)$ without the factor of two.

Final Answer: $B = 12$ kHz $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q40

Q41.

Solution

Concept – Nyquist sampling interval: At the Nyquist rate $f_s = 2f_m$, and the sampling interval is $T_s = 1/f_s$.

Step 1 – find the Nyquist rate: $f_s = 2 \times 10$ kHz $= 20$ kHz $= 20\,000$ Hz

Step 2 – take the reciprocal: $T_s = \dfrac{1}{20\,000}$

Step 3 – evaluate: $T_s = 5 \times 10^{-5}$ s

Step 4 – express in microseconds: $T_s = 50\ \mu$s

Why the other options are wrong:

- A, 20 μs: is $1/(50$ kHz$)$, an over-sampling case.
- B, 10 μs: is $1/(100$ kHz$)$, unrelated to the Nyquist rate here.
- C, 100 μs: is $1/(10$ kHz$)$, using f_m instead of $2f_m$.

Final Answer: $T_s = 50\ \mu$s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q41

Q42.

Solution

Concept – Maxwell's equation for magnetic flux: Gauss's law for magnetism states that magnetic field lines have no sources or sinks, because isolated magnetic charges do not exist.

Step 1 – write the divergence of B: $\nabla \cdot \mathrm{B} = 0$

Step 2 – interpret it: The net magnetic flux out of any closed surface is zero, i.e. no magnetic monopoles.

Why the other options are wrong:

- A, $\nabla \cdot \mathbf{D} = \rho$: is Gauss's law for electricity, where charge ρ is the source.
- C, $\nabla \times \mathbf{E} = -\partial \mathrm{B}/\partial t$: is Faraday's law of induction.
- D, $\nabla \times \mathbf{H} = \mathbf{J} + \partial \mathrm{D}/\partial t$: is the Ampere–Maxwell law.

Final Answer: $\nabla \cdot \mathbf{B} = 0 \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q42

Q43.

Solution

Concept – Faraday's law in point form: A time-varying magnetic field induces a circulating electric field; the curl of **E** equals the negative rate of change of **B**.

Step 1 – write the differential form: $\nabla \times \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t}$

Step 2 – read the meaning of the negative sign: The minus sign encodes Lenz's law – the induced effect opposes the change in flux.

Why the other options are wrong:

- A, $\nabla \cdot \mathbf{D} = \rho$: is Gauss's law for electricity.
- B, $\nabla \times \mathbf{H} = \mathbf{J} + \partial \mathrm{D}/\partial t$: is the Ampere–Maxwell law, which includes displacement current.
- D, $\nabla \cdot \mathbf{B} = 0$: is Gauss's law for magnetism.

Final Answer: $\nabla \times \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t} \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – phase velocity in a dielectric: In a lossless non-magnetic dielectric the phase velocity is $v_p = \dfrac{c}{\sqrt{\varepsilon_r}}$.

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 it: $v_p = \dfrac{3 \times 10^8}{2}$

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

Why the other options are wrong:

- A, 3×10^8 m/s: is the free-space speed, ignoring the dielectric.
- C, 0.75×10^8 m/s: divides by $\varepsilon_r = 4$ instead of $\sqrt{\varepsilon_r} = 2$.
- D, 6×10^8 m/s: exceeds c, which is physically impossible.

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

Answer: (B) Go Back to Q44

Q45.

Solution

Concept – wavelength of a plane wave: $\lambda = \dfrac{c}{f}$, with c the free-space speed of light.

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

Step 2 – divide: $\lambda = \dfrac{3 \times 10^8}{3 \times 10^8}$

Step 3 – simplify: $\lambda = 1$ m

Why the other options are wrong:

- A, 3 m: divides by 100 MHz instead of 300 MHz.
- B, 0.3 m: is the wavelength at 1 GHz.
- C, 10 m: is off by a factor of ten in the frequency.

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

Answer: (D) Go Back to Q45

Q46.

Solution

Concept – intrinsic impedance of a dielectric: For a lossless non-magnetic dielectric, $\eta = \dfrac{\eta_0}{\sqrt{\varepsilon_r}}$, with $\eta_0 = 377\ \Omega$ the free-space value.

Step 1 – take the square root of the permittivity: $\sqrt{\varepsilon_r} = \sqrt{4} = 2$

Step 2 – divide the free-space impedance by it: $\eta = \dfrac{377}{2}$

Step 3 – evaluate: $\eta = 188.5\ \Omega$

Why the other options are wrong:

- A, $377\ \Omega$: is the free-space value, ignoring the dielectric.
- B, $75\ \Omega$ and C, $50\ \Omega$: are common coaxial-cable characteristic impedances, unrelated to this medium.

Final Answer: $\eta = 188.5\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q46

Answer Key

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