GATE Electronics and Communication Engineering

Sample Paper – 1

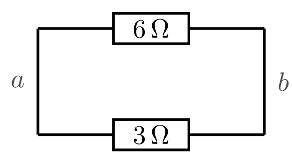
Duration: 128 Minutes **Maximum Marks: 72**

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. Two resistors of $6\ \Omega$ and $3\ \Omega$ are connected in parallel between nodes a and b, as shown. The equivalent resistance seen between a and b is: **[1 mark]**



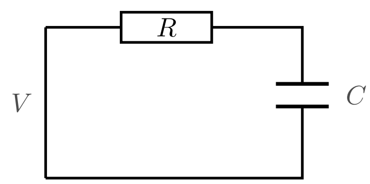
(A) $9\ \Omega$

(B) $2\ \Omega$

(C) $4.5\ \Omega$

(D) $18\ \Omega$

Q2. In the series RC circuit shown, a d.c. source is switched on at $t = 0$. With $R = 10$ kΩ and $C = 10$ μF, the time constant of the circuit is: **[1 mark]**



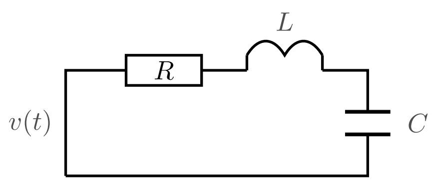
(A) 0.1 s

(B) 100 s

(C) 0.01 s

(D) 10 s

Q3. A series RLC circuit has $L = 10$ mH and $C = 1$ μF, as shown. The undamped natural (resonant) angular frequency ω_0 of the circuit is: **[1 mark]**



(A) 1000 rad/s

(B) 10000 rad/s

(C) 100000 rad/s

(D) 5000 rad/s

Q4. A one-port network is reduced to its Thevenin equivalent with open-circuit voltage $V_{th} = 20$ V and Thevenin resistance $R_{th} = 5\ \Omega$. When a matched load is connected for maximum power transfer, the power delivered to the load is: **[1 mark]**

(A) 80 W

(B) 40 W

(C) 10 W

(D) 20 W

Q5. An ideal inductor of $L = 50$ mH is driven by a sinusoidal source of angular frequency $\omega = 1000$ rad/s. The magnitude of the inductive reactance is: **[1 mark]**

(A) $5\ \Omega$

(B) $500\ \Omega$

(C) $50\ \Omega$

(D) $0.05\ \Omega$

Q6. A source-free series RL circuit has an inductance $L = 2$ H and a resistance $R = 4\ \Omega$. The time constant of the natural (transient) response is: **[1 mark]**

(A) 8 s

(B) 2 s

(C) 0.25 s

(D) 0.5 s

Electronic Devices

Q7. A silicon sample is uniformly doped with donor atoms of concentration $N_d = 10^{16}$ cm^{-3}. Taking $n_i = 1.5 \times 10^{10}$ cm^{-3} and full ionisation, the equilibrium hole concentration is nearest to: **[1 mark]**

(A) 1.5×10^{10} cm^{-3}

(B) 1×10^{16} cm^{-3}

(C) 2.25×10^{20} cm^{-3}

(D) 2.25×10^{4} cm^{-3}

Q8. The energy band gap of intrinsic silicon at room temperature (300 K) is closest to: **[1 mark]**

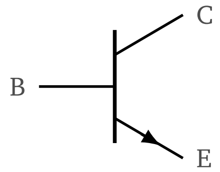
(A) 1.12 eV

(B) 0.66 eV

(C) 1.42 eV

(D) 5.5 eV

Q9. An npn bipolar junction transistor is biased so that its base–emitter junction is forward biased ($V_{BE} = +0.7$ V) and its collector–base junction is reverse biased ($V_{BC} = -5$ V), as indicated below. The transistor is operating in the: **[1 mark]**



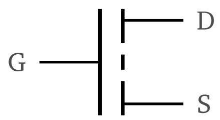
(A) cut-off region

(B) saturation region

(C) active region

(D) breakdown region

Q10. An n-channel enhancement MOSFET has threshold voltage $V_t = 1$ V and process transconductance parameter $k_n = 1$ mA/V^2. It is biased in saturation with $V_{GS} = 3$ V, as shown. Using $I_D = \frac{1}{2}k_n(V_{GS} - V_t)^2$, the drain current is: **[1 mark]**



(A) 2 mA

(B) 4 mA

(C) 1 mA

(D) 8 mA

Q11. A silicon bar is doped n-type with electron concentration $n = 10^{17}$ cm^{-3} and electron mobility $\mu_n = 1000$ cm^2/V $\cdot$ s. Neglecting the hole contribution, the electrical conductivity of the bar is (take $q = 1.6 \times 10^{-19}$ C): **[1 mark]**

(A) 16 S/cm

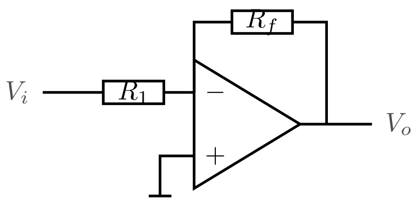
(B) 1.6 S/cm

(C) 160 S/cm

(D) 0.16 S/cm

Analog Circuits

Q12. For the ideal-op-amp inverting amplifier shown, $R_1 = 10$ kΩ and $R_f = 100$ kΩ. The magnitude of the closed-loop voltage gain $|V_o/V_i|$ is: **[1 mark]**



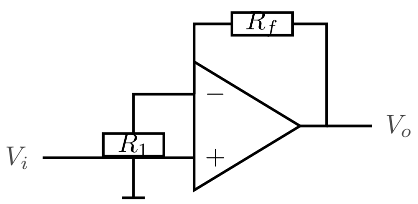
(A) 100

(B) 11

(C) 0.1

(D) 10

Q13. For the ideal-op-amp non-inverting amplifier shown, $R_1 = 10$ kΩ (from the inverting node to ground) and $R_f = 20$ kΩ (feedback). The closed-loop voltage gain V_o/V_i is: **[1 mark]**



(A) 2

(B) 21

(C) 3

(D) 0.5

Q14. An ideal op-amp is used as an inverting summing amplifier with feedback resistor $R_f = 10$ kΩ and two input branches $R_1 = R_2 = 10$ kΩ carrying $V_1 = 1$ V and $V_2 = 2$ V. The output voltage $V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2\right)$ is: **[1 mark]**

(A) -1 V

(B) $+3$ V

(C) -3 V

(D) -30 V

Q15. An op-amp has a gain–bandwidth product (unity-gain frequency) of 1 MHz. When it is connected for a closed-loop gain of 100, the resulting -3 dB bandwidth is: **[1 mark]**

(A) 1 MHz

(B) 100 kHz

(C) 1 kHz

(D) 10 kHz

Q16. An amplifier with open-loop gain $A = 1000$ is placed in a negative-feedback loop with feedback factor $\beta = 0.1$. The closed-loop gain $A_f = A/(1 + A\beta)$ is nearest to: **[1 mark]**

(A) 100

(B) 9.9

(C) 10

(D) 1000

Q17. A Wien-bridge oscillator uses equal resistors $R = 10$ kΩ and equal capacitors $C = 10$ nF in its frequency-selective network. The frequency of oscillation $f_0 = 1/(2\pi RC)$ is nearest to: **[1 mark]**

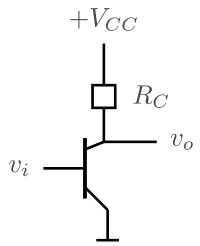
(A) 159 Hz

(B) 1.59 kHz

(C) 15.9 kHz

(D) 100 Hz

Q18. A common-emitter BJT amplifier operates at a quiescent collector current $I_C = 1$ mA with a collector resistor $R_C = 5$ kΩ, as shown. Taking $V_T = 25$ mV and neglecting r_o, the magnitude of the small-signal voltage gain $|A_v| = g_m R_C$ is: **[1 mark]**



(A) 200

(B) 40

(C) 5

(D) 1000

Digital Circuits

Q19. The unsigned binary number $(1101)_2$ has the decimal (base-10) value: **[1 mark]**

(A) 11

(B) 15

(C) 14

(D) 13

Q20. Using the rules of Boolean algebra, the expression $Y = A + \bar{A}B$ simplifies to: **[1 mark]**

(A) $A + B$

(B) A

(C) B

(D) AB

Q21. The four-variable function $F(A, B, C, D) = \sum m(0, 1, 4, 5)$ is plotted on the Karnaugh map shown (rows AB, columns CD). The minimal sum-of-products expression for F is: **[2 marks]**

$AB \backslash CD$	00	01	11	10
00	1	1	0	0
01	1	1	0	0
11	0	0	0	0
10	0	0	0	0

(A) $\bar{A}C$

(B) $\bar{A}\,\bar{C}$

(C) $A\bar{C}$

(D) $\bar{B}\,\bar{C}$

Q22. A synchronous decade (mod-10) counter is to be built. The minimum number of flip-flops required so that the counter has at least 10 distinct states is: **[2 marks]**

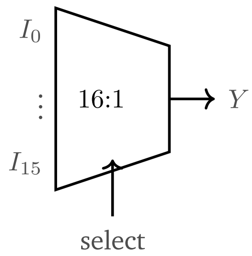
(A) 10

(B) 3

(C) 4

(D) 5

Q23. A digital multiplexer selects one of its 16 data inputs and routes it to a single output, as shown. The number of select (control) lines required is: **[2 marks]**



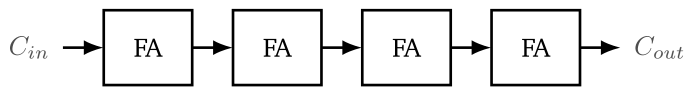
(A) 4

(B) 16

(C) 8

(D) 2

Q24. A 4-bit ripple-carry adder is built from four full-adder stages, as shown. If the carry propagation delay of each full adder is 2 ns, the worst-case time for the final carry-out to become valid is: **[2 marks]**



$t_{carry} = 2$ ns per stage

(A) 2 ns

(B) 4 ns

(C) 16 ns

(D) 8 ns

Signals and Systems

Q25. A continuous-time signal is band-limited to a maximum frequency of 5 kHz. According to the sampling theorem, the minimum sampling rate (Nyquist rate) required to reconstruct it without aliasing is: **[2 marks]**

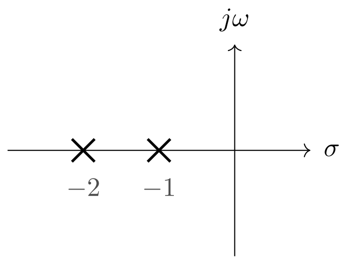
(A) 2.5 kHz

(B) 20 kHz

(C) 10 kHz

(D) 5 kHz

Q26. A stable LTI system has the transfer function $H(s) = \dfrac{10}{s^2 + 3s + 2}$, whose pole–zero plot is shown (poles marked $\times$). The d.c. gain $H(0)$ of the system is: **[2 marks]**



(A) 10

(B) 2

(C) 0.5

(D) 5

Q27. A discrete-time signal is $x[n] = (0.5)^n\, u[n]$. The sum of all its samples, $\displaystyle\sum_{n=-\infty}^{\infty} x[n]$, is: **[2 marks]**

(A) 0.5

(B) 1

(C) 2

(D) ∞

Q28. A periodic voltage signal is $x(t) = 4\cos(\omega_0 t)$ volts across a $1\ \Omega$ resistor. The average power of the signal is: **[2 marks]**

(A) 16 W

(B) 4 W

(C) 8 W

(D) 2 W

Q29. Two finite-length discrete sequences of lengths 4 and 3 samples respectively are linearly convolved. The length (number of samples) of the resulting sequence is: **[2 marks]**

(A) 6

(B) 7

(C) 12

(D) 4

Q30. A continuous-time signal is sampled at a rate of 8 kHz. The highest signal frequency that can be represented without aliasing (the folding frequency) is: **[2 marks]**

(A) 4 kHz

(B) 8 kHz

(C) 16 kHz

(D) 2 kHz

Control Systems

Q31. A standard second-order system has the characteristic equation $s^2 + 4s + 16 = 0$. The damping ratio ζ of the system is: **[2 marks]**

(A) 1

(B) 0.5

(C) 0.25

(D) 2

Q32. The characteristic equation of a feedback system is $s^3 + 2s^2 + 3s + 10 = 0$. Using the Routh–Hurwitz criterion, the number of closed-loop poles lying in the right half of the s-plane is: **[2 marks]**

(A) 0

(B) 3

(C) 1

(D) 2

Q33. A unity-feedback system has open-loop transfer function $G(s) = \dfrac{10}{(s+1)(s+2)}$. The steady-state error for a unit-step input, $e_{ss} = 1/(1+K_p)$ with $K_p = \lim_{s\to 0} G(s)$, is nearest to: **[2 marks]**

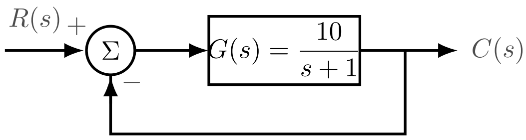
(A) 0

(B) 0.5

(C) 1

(D) 0.167

Q34. For the unity-feedback control system shown, the forward-path transfer function is $G(s) = \dfrac{10}{s+1}$. The d.c. gain of the closed-loop transfer function $\dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)}$ (its value at $s = 0$) is nearest to: **[2 marks]**



(A) 10

(B) 0.909

(C) 1

(D) 0.5

Q35. A unity-feedback second-order system has damping ratio $\zeta = 0.5$. For a unit-step input the peak percentage overshoot, $M_p = e^{-\pi\zeta/\sqrt{1-\zeta^2}} \times 100\%$, is nearest to: **[2 marks]**

(A) 50%

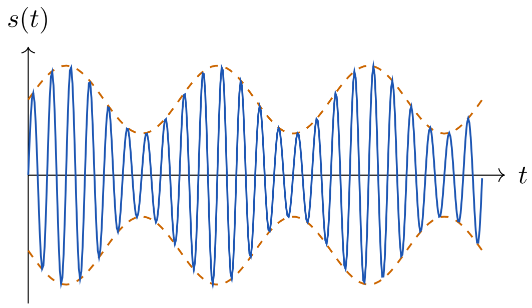
(B) 25%

(C) 16.3%

(D) 4.3%

Communications

Q36. A carrier of power 100 W is amplitude-modulated to a modulation index $\mu = 1$, giving the envelope shown. The total transmitted power, $P_t = P_c\left(1 + \frac{\mu^2}{2}\right)$, is: **[2 marks]**



(A) 100 W

(B) 200 W

(C) 50 W

(D) 150 W

Q37. A commercial FM signal has a peak frequency deviation of $\Delta f = 75$ kHz for a modulating tone of frequency $f_m = 15$ kHz. The modulation index $\beta = \Delta f / f_m$ is: **[2 marks]**

(A) 15

(B) 5

(C) 0.2

(D) 75

Q38. A speech signal band-limited to 4 kHz is sampled at 8 kHz and each sample is encoded with 256 uniform quantization levels in a PCM system. The output bit rate is: **[2 marks]**

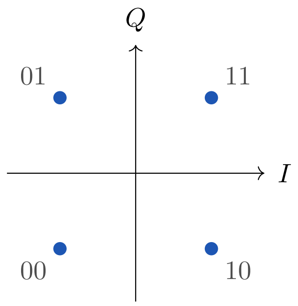
(A) 64 kbps

(B) 8 kbps

(C) 256 kbps

(D) 32 kbps

Q39. A digital link transmits data at a bit rate of 2 Mbps using QPSK, whose four signal points are shown. Since QPSK carries 2 bits per symbol, the symbol rate is: **[2 marks]**



(A) 4 Msym/s

(B) 1 Msym/s

(C) 2 Msym/s

(D) 0.5 Msym/s

Q40. A discrete memoryless source emits four symbols that are all equally likely. The entropy of the source is: **[2 marks]**

(A) 4 bits/symbol

(B) 2 bits/symbol

(C) 1 bit/symbol

(D) 8 bits/symbol

Q41. A communication channel of bandwidth 3 kHz has a signal-to-noise ratio of 7 (as a power ratio). By the Shannon–Hartley law $C = B\log_2(1+\text{SNR})$, the channel capacity is: **[2 marks]**

(A) 3 kbps

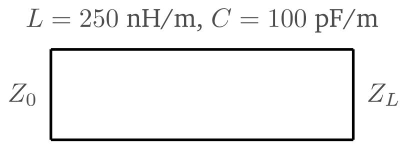
(B) 21 kbps

(C) 9 kbps

(D) 24 kbps

Electromagnetics

Q42. A lossless transmission line has distributed inductance $L = 250$ nH/m and distributed capacitance $C = 100$ pF/m, as indicated. Its characteristic impedance $Z_0 = \sqrt{L/C}$ is: **[2 marks]**



(A) $100\ \Omega$

(B) $50\ \Omega$

(C) $75\ \Omega$

(D) $25\ \Omega$

Q43. A transmission line of characteristic impedance $Z_0 = 50\ \Omega$ is terminated in a load $Z_L = 100\ \Omega$. Using $\Gamma = (Z_L - Z_0)/(Z_L + Z_0)$ and VSWR $= (1 + |\Gamma|)/(1 - |\Gamma|)$, the voltage standing-wave ratio on the line is: **[2 marks]**

(A) 2

(B) 0.333

(C) 3

(D) 1

Q44. A uniform plane wave of frequency 3 GHz propagates in free space. Its wavelength $\lambda = c/f$ (with $c = 3 \times 10^8$ m/s) is: **[2 marks]**

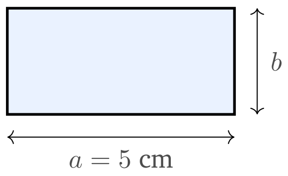
(A) 10 cm

(B) 1 cm

(C) 100 cm

(D) 30 cm

Q45. An air-filled rectangular waveguide has a broad-wall dimension $a = 5$ cm, as shown. For the dominant TE_{10} mode the cut-off frequency $f_c = c/(2a)$ is: **[2 marks]**



(A) 1.5 GHz

(B) 3 GHz

(C) 6 GHz

(D) 30 GHz

Q46. The intrinsic (wave) impedance of free space, $\eta_0 = \sqrt{\mu_0/\varepsilon_0} = 120\pi\ \Omega$, is nearest to: **[2 marks]**

(A) $50\ \Omega$

(B) $75\ \Omega$

(C) $377\ \Omega$

(D) $120\ \Omega$

Detailed Solutions

Q1.

Solution

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

Step 1 – list the data: $R_1 = 6\ \Omega$, $R_2 = 3\ \Omega$.

Step 2 – form the product of the resistances: $R_1 R_2 = 6 \times 3 = 18$

Step 3 – form the sum of the resistances: $R_1 + R_2 = 6 + 3 = 9$

Step 4 – divide: $R_{eq} = \dfrac{18}{9}$

$R_{eq} = 2\ \Omega$

Step 5 – sanity check: A parallel combination is always smaller than the smallest branch ($3\ \Omega$), and $2 < 3$, so the result is consistent.

Final Answer: $R_{eq} = 2\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q1

Q2.

Solution

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

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

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

Step 2 – multiply: $\tau = (10 \times 10^3) \times (10 \times 10^{-6})$

Step 3 – combine the powers of ten: $\tau = 100 \times 10^{-3}$

$\tau = 0.1\ \text{s}$

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

Answer: (A) Go Back to Q2

Q3.

Solution

Concept – resonant frequency of a series RLC circuit: The undamped natural frequency is $\omega_0 = \dfrac{1}{\sqrt{LC}}$.

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

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

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

$LC = 10 \times 10^{-9} = 1 \times 10^{-8}$

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

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

$\omega_0 = 10000 \text{ rad/s}$

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

Answer: (B) Go Back to Q3

Q4.

Solution

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

Step 1 – list the data: $V_{th} = 20$ V, $R_{th} = 5 \ \Omega$.

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

Step 3 – form the denominator: $4R_{th} = 4 \times 5 = 20$

Step 4 – divide: $P_{\max} = \dfrac{400}{20}$

$P_{\max} = 20$ W

Final Answer: $P_{\max} = 20 \text{ W} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept – inductive reactance: The reactance of an inductor is $X_L = \omega L$.

Step 1 – convert the inductance: $L = 50 \text{ mH} = 50 \times 10^{-3} \text{ H} = 0.05 \text{ H}$

Step 2 – substitute the values: $X_L = 1000 \times 0.05$

Step 3 – evaluate: $X_L = 50\ \Omega$

Final Answer: $X_L = 50\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Q6.

Solution

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

Step 1 – list the data: $L = 2$ H, $R = 4\ \Omega$.

Step 2 – substitute: $\tau = \frac{2}{4}$

Step 3 – evaluate: $\tau = 0.5$ s

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

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – mass-action law in a doped semiconductor: At equilibrium $n\,p = n_i^2$. For an n-type sample $n \approx N_d$, so $p = \frac{n_i^2}{N_d}$.

Step 1 – square the intrinsic concentration: $n_i^2 = (1.5 \times 10^{10})^2$

$n_i^2 = 2.25 \times 10^{20}$ cm^{-6}

Step 2 – take the majority-carrier concentration: $n \approx N_d = 1 \times 10^{16}$ cm^{-3}

Step 3 – divide to get the hole concentration: $p = \frac{2.25 \times 10^{20}}{1 \times 10^{16}}$

Step 4 – combine the powers of ten: $p = 2.25 \times 10^4$ cm^{-3}

Final Answer: $p = 2.25 \times 10^4$ cm$^{-3} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – band gap of common semiconductors: The band gap is a material property fixed at a given temperature.

Step 1 – recall the standard room-temperature values: Silicon $E_g \approx 1.12$ eV, germanium ≈ 0.66 eV, gallium arsenide ≈ 1.42 eV.

Step 2 – pick the value for silicon: $E_g(\text{Si}) = 1.12$ eV

Why the other options are wrong:

- B, 0.66 eV: is the band gap of **germanium**.
- C, 1.42 eV: is the band gap of **gallium arsenide**.
- D, 5.5 eV: is the band gap of **diamond**, an insulator.

Final Answer: $E_g \approx 1.12 \text{ eV} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – regions of operation of a BJT depend on the two junction biases: A BJT is in the active region when the emitter junction is forward biased and the collector junction is reverse biased.

Step 1 – read the emitter-junction bias: $V_{BE} = +0.7$ V, so the base–emitter junction is **forward** biased.

Step 2 – read the collector-junction bias: $V_{BC} = -5$ V (equivalently $V_{CB} = +5$ V), so the collector–base junction is **reverse** biased.

Step 3 – match to the region table: Forward emitter junction $+$ reverse collector junction $=$ **active region**.

Why the other options are wrong:

- A, cut-off: needs both junctions reverse biased.
- B, saturation: needs both junctions forward biased.
- D, breakdown: needs a junction voltage beyond its avalanche/Zener limit, not the case here.

Final Answer: active region $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – saturation drain current of a MOSFET: In saturation $I_D = \frac{1}{2}k_n\,(V_{GS} - V_t)^2$.

Step 1 – compute the overdrive voltage: $V_{GS} - V_t = 3 - 1 = 2$ V

Step 2 – square the overdrive: $(V_{GS} - V_t)^2 = 2^2 = 4$ V^2

Step 3 – substitute into the current equation: $I_D = \frac{1}{2} \times (1\ \text{mA/V}^2) \times 4$

Step 4 – evaluate: $I_D = 0.5 \times 4$

$I_D = 2$ mA

Final Answer: $I_D = 2$ mA $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept – conductivity of an extrinsic semiconductor: For an n-type sample the conductivity is $\sigma = q\,n\,\mu_n$.

Step 1 – list the data: $q = 1.6 \times 10^{-19}$ C, $n = 10^{17}$ cm^{-3}, $\mu_n = 1000$ cm^2/V · s.

Step 2 – multiply charge and concentration: $q\,n = (1.6 \times 10^{-19}) \times (10^{17})$

$q\,n = 1.6 \times 10^{-2}$

Step 3 – multiply by the mobility: $\sigma = (1.6 \times 10^{-2}) \times 1000$

Step 4 – evaluate: $\sigma = 16$ S/cm

Final Answer: $\sigma = 16$ S/cm $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept – gain of an inverting op-amp: For an ideal inverting amplifier $\frac{V_o}{V_i} = -\frac{R_f}{R_1}$, so the magnitude is $\frac{R_f}{R_1}$.

Step 1 – list the resistor values: $R_f = 100$ kΩ, $R_1 = 10$ kΩ.

Step 2 – form the ratio: $|A_v| = \frac{100\ \text{k}\Omega}{10\ \text{k}\Omega}$

Step 3 – evaluate: $|A_v| = 10$

Final Answer: $|A_v| = 10 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept – gain of a non-inverting op-amp: For an ideal non-inverting amplifier $\dfrac{V_o}{V_i} = 1 + \dfrac{R_f}{R_1}$.

Step 1 – form the resistor ratio: $\dfrac{R_f}{R_1} = \dfrac{20\ \text{k}\Omega}{10\ \text{k}\Omega} = 2$

Step 2 – add one: $A_v = 1 + 2$

Step 3 – evaluate: $A_v = 3$

Why the other options are wrong:

- A, 2: is just R_f/R_1; it forgets the "+1" of the non-inverting topology.
- B, 21: wrongly uses $R_f/R_1 = 20$.
- D, 0.5: inverts the ratio.

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

Answer: (C) Go Back to Q13

Q14.

Solution

Concept – inverting summing amplifier: $V_o = -\left(\dfrac{R_f}{R_1}V_1 + \dfrac{R_f}{R_2}V_2\right)$.

Step 1 – form the two gain factors: $\dfrac{R_f}{R_1} = \dfrac{10}{10} = 1$ and $\dfrac{R_f}{R_2} = \dfrac{10}{10} = 1$

Step 2 – weight each input: $\dfrac{R_f}{R_1}V_1 = 1 \times 1 = 1$

$\dfrac{R_f}{R_2}V_2 = 1 \times 2 = 2$

Step 3 – add the weighted inputs: $1 + 2 = 3$

Step 4 – apply the inverting sign: $V_o = -3\ \text{V}$

Final Answer: $V_o = -3\ \text{V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – constant gain–bandwidth product: For a dominant-pole op-amp, (closed-loop gain) $\times$ (bandwidth) $=$ unity-gain frequency (GBW).

Step 1 – list the data: $\text{GBW} = 1 \text{ MHz} = 1 \times 10^6$ Hz, closed-loop gain $A_{CL} = 100$.

Step 2 – rearrange for bandwidth: $\text{BW} = \dfrac{\text{GBW}}{A_{CL}}$

Step 3 – substitute: $\text{BW} = \dfrac{1 \times 10^6}{100}$

Step 4 – evaluate: $\text{BW} = 1 \times 10^4 \text{ Hz} = 10 \text{ kHz}$

Final Answer: $\text{BW} = 10 \text{ kHz} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – closed-loop gain with negative feedback: $A_f = \dfrac{A}{1 + A\beta}$.

Step 1 – form the loop gain: $A\beta = 1000 \times 0.1 = 100$

Step 2 – form the denominator: $1 + A\beta = 1 + 100 = 101$

Step 3 – divide: $A_f = \dfrac{1000}{101}$

Step 4 – evaluate: $A_f = 9.90$

Step 5 – interpret: The ideal value $1/\beta = 10$ is only approached for very large loop gain; here the loop gain is finite, so $A_f = 9.9$ is slightly below 10.

Final Answer: $A_f \approx 9.9 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept – oscillation frequency of a Wien-bridge oscillator: $f_0 = \dfrac{1}{2\pi RC}$.

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

$RC = 100 \times 10^{-6} = 1 \times 10^{-4}$ s

Step 2 – form $2\pi RC$: $2\pi RC = 2\pi \times (1 \times 10^{-4})$

$2\pi RC = 6.283 \times 10^{-4}$

Step 3 – invert: $f_0 = \dfrac{1}{6.283 \times 10^{-4}}$

Step 4 – evaluate: $f_0 = 1591.5\ \text{Hz} \approx 1.59\ \text{kHz}$

Final Answer: $f_0 \approx 1.59\ \text{kHz} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept – voltage gain of a common-emitter stage: The transconductance is $g_m = \dfrac{I_C}{V_T}$ and the magnitude of the gain is $|A_v| = g_m R_C$.

Step 1 – compute the transconductance: $g_m = \dfrac{I_C}{V_T} = \dfrac{1\ \text{mA}}{25\ \text{mV}}$

$g_m = 0.04\ \text{A/V} = 40\ \text{mA/V}$

Step 2 – convert the collector resistor: $R_C = 5\ \text{k}\Omega = 5000\ \Omega$

Step 3 – form the gain: $|A_v| = g_m R_C = 0.04 \times 5000$

Step 4 – evaluate: $|A_v| = 200$

Final Answer: $|A_v| = 200 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept – binary to decimal conversion: Each bit is weighted by a power of two, $(b_3 b_2 b_1 b_0)_2 = b_3\, 2^3 + b_2\, 2^2 + b_1\, 2^1 + b_0\, 2^0$.

Step 1 – write the place values for 1101: bit $2^3 = 8$: 1; bit $2^2 = 4$: 1; bit $2^1 = 2$: 0; bit $2^0 = 1$: 1.

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

$1 \times 4 = 4$

$0 \times 2 = 0$

$1 \times 1 = 1$

Step 3 – add the contributions: $8 + 4 + 0 + 1 = 13$

Final Answer: $(1101)_2 = 13 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – absorption/redundancy theorem of Boolean algebra: The identity $A + \bar{A}B = A + B$ holds.

Step 1 – expand A using $A = A + AB$ (since $A(1 + B) = A$): $A + \bar{A}B = A + AB + \bar{A}B$

Step 2 – group the last two terms and factor B: $A + AB + \bar{A}B = A + B(A + \bar{A})$

Step 3 – use $A + \bar{A} = 1$: $A + B(A + \bar{A}) = A + B(1)$

Step 4 – simplify: $= A + B$

Final Answer: $A + \bar{A}B = A + B \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – grouping ones on a Karnaugh map: Adjacent ones are grouped in powers of two; the variables that stay constant over a group form its product term.

Step 1 – place the minterms: $\sum m(0, 1, 4, 5)$ fills the cells in rows $AB = 00$ and $AB = 01$, columns $CD = 00$ and $CD = 01$, forming a 2×2 block of ones (shown boxed).

Step 2 – find which variables are constant over the block: Across rows 00 and 01 the bit $A = 0$ (so $\bar{A}$), while B changes.

Step 3 – examine the columns: Across columns 00 and 01 the bit $C = 0$ (so $\bar{C}$), while D changes.

Step 4 – keep only the constant literals: The constant literals are $\bar{A}$ and $\bar{C}$, so the group is $\bar{A}\,\bar{C}$.

Step 5 – verify against the minterms: $\bar{A}\,\bar{C}$ covers all cells with $A = 0$ and $C = 0$, namely $m0, m1, m4, m5$, exactly the given ones.

Final Answer: $F = \bar{A}\,\bar{C} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – number of flip-flops for a given modulus: n flip-flops give 2^n distinct states; the smallest n with $2^n \geq M$ is required.

Step 1 – write the requirement for a mod-10 counter: $2^n \geq 10$

Step 2 – test $n = 3$: $2^3 = 8$, and $8 < 10$, so 3 flip-flops are not enough.

Step 3 – test $n = 4$: $2^4 = 16$, and $16 \geq 10$, so 4 flip-flops suffice.

Step 4 – conclude: The minimum number of flip-flops is 4.

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

Answer: (C) Go Back to Q22

Q23.

Solution

Concept – select lines of a multiplexer: A 2^n-to-1 multiplexer needs n select lines, so $n = \log_2(\text{number of inputs})$.

Step 1 – write the relation for 16 inputs: $2^n = 16$

Step 2 – express 16 as a power of two: $16 = 2^4$

Step 3 – match the exponents: $n = 4$

Final Answer: 4 select lines $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept – worst-case delay of a ripple-carry adder: In a ripple-carry adder the carry must propagate through every stage in turn, so the total carry delay is (number of stages) $\times$ (carry delay per stage).

Step 1 – list the data: Number of stages $= 4$, carry delay per full adder $= 2$ ns.

Step 2 – multiply: $t = 4 \times 2$

Step 3 – evaluate: $t = 8$ ns

Final Answer: $t = 8$ ns $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – Nyquist sampling rate: The minimum rate for alias-free sampling is twice the highest signal frequency, $f_s = 2f_{\max}$.

Step 1 – identify the maximum frequency: $f_{\max} = 5$ kHz.

Step 2 – double it: $f_s = 2 \times 5$

Step 3 – evaluate: $f_s = 10$ kHz

Final Answer: $f_s = 10$ kHz $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q25

Q26.

Solution

Concept – d.c. gain of a transfer function: The d.c. gain is the value of $H(s)$ at $s = 0$.

Step 1 – substitute $s = 0$ into the numerator and denominator: $H(0) = \dfrac{10}{0^2 + 3(0) + 2}$

Step 2 – simplify the denominator: $0 + 0 + 2 = 2$

Step 3 – divide: $H(0) = \dfrac{10}{2}$

Step 4 – evaluate: $H(0) = 5$

Step 5 – check stability from the plot: The poles are at $s = -1$ and $s = -2$, both in the left half-plane, so the system is stable and the d.c. gain is meaningful.

Final Answer: $H(0) = 5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q26

Q27.

Solution

Concept – sum of a geometric sequence: For $x[n] = a^n u[n]$ with $|a| < 1$, $\sum_{n=0}^{\infty} a^n = \dfrac{1}{1-a}$.

Step 1 – identify the ratio: $a = 0.5$, and $u[n]$ makes the sum start at $n = 0$.

Step 2 – form the denominator: $1 - a = 1 - 0.5 = 0.5$

Step 3 – take the reciprocal: $\sum = \dfrac{1}{0.5}$

Step 4 – evaluate: $\sum = 2$

Final Answer: $\sum x[n] = 2 \Rightarrow \boxed{\text{C}}$

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 is $P = \dfrac{A^2}{2}$ (across a $1\ \Omega$ resistor).

Step 1 – identify the amplitude: $A = 4$ V.

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

Step 3 – divide by two: $P = \dfrac{16}{2}$

Step 4 – evaluate: $P = 8$ W

Final Answer: $P = 8$ W $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q28

Q29.

Solution

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

Step 1 – list the lengths: $L_1 = 4$, $L_2 = 3$.

Step 2 – add the lengths: $L_1 + L_2 = 4 + 3 = 7$

Step 3 – subtract one: $7 - 1 = 6$

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

Answer: (A) Go Back to Q29

Q30.

Solution

Concept – folding (Nyquist) frequency: When a signal is sampled at f_s, the highest frequency that can be represented without aliasing is $f_s/2$.

Step 1 – identify the sampling rate: $f_s = 8$ kHz.

Step 2 – halve it: $\frac{f_s}{2} = \frac{8}{2}$

Step 3 – evaluate: $= 4$ kHz

Final Answer: folding frequency $= 4$ kHz $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q30

Q31.

Solution

Concept – standard second-order form: Comparing $s^2 + 2\zeta\omega_n s + \omega_n^2$ with the given equation gives ω_n and ζ.

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

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

Step 3 – substitute $\omega_n = 4$: $2\zeta(4) = 4$

$8\zeta = 4$

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

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

Answer: (B) Go Back to Q31

Q32.

Solution

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

Step 1 – write the first two rows from the coefficients of $s^3 + 2s^2 + 3s + 10$: s^3 row: 1 3

s^2 row: 2 10

Step 2 – compute the s^1 row entry: $\frac{(2)(3) - (1)(10)}{2} = \frac{6 - 10}{2}$

$= \frac{-4}{2} = -2$

Step 3 – write the s^0 row: s^0 row: 10

Step 4 – list the first column and its signs: $1,\ 2,\ -2,\ 10 \Rightarrow +,\ +,\ -,\ +$

Step 5 – count the sign changes: $+$ to $-$ is one change and $-$ to $+$ is a second change, giving 2 sign changes.

Step 6 – interpret: Two sign changes mean 2 poles in the right half-plane; the system is unstable.

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

Answer: (D) **Go Back to Q32**

Q33.

Solution

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

Step 1 – compute K_p by setting $s = 0$: $K_p = \dfrac{10}{(0+1)(0+2)}$

Step 2 – evaluate the denominator: $(1)(2) = 2$

Step 3 – finish K_p: $K_p = \dfrac{10}{2} = 5$

Step 4 – form $1 + K_p$: $1 + 5 = 6$

Step 5 – take the reciprocal: $e_{ss} = \dfrac{1}{6}$

Step 6 – evaluate: $e_{ss} = 0.167$

Final Answer: $e_{ss} = 0.167 \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q33**

Q34.

Solution

Concept – closed-loop d.c. gain of a unity-feedback loop: $\dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)}$, evaluated at $s = 0$ for the d.c. gain.

Step 1 – find the forward-path d.c. gain: $G(0) = \dfrac{10}{0+1} = 10$

Step 2 – substitute into the closed-loop formula: $\left.\dfrac{C}{R}\right|_{s=0} = \dfrac{10}{1+10}$

Step 3 – form the denominator: $1 + 10 = 11$

Step 4 – divide: $\dfrac{C}{R} = \dfrac{10}{11}$

Step 5 – evaluate: $\dfrac{C}{R} = 0.909$

Final Answer: d.c. gain $= 0.909 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q34

Q35.

Solution

Concept – peak overshoot of a second-order step response: $M_p = e^{-\pi\zeta/\sqrt{1-\zeta^2}} \times 100\%$.

Step 1 – compute $1-\zeta^2$: $1-(0.5)^2 = 1-0.25 = 0.75$

Step 2 – take its square root: $\sqrt{0.75} = 0.866$

Step 3 – form the exponent: $-\dfrac{\pi\zeta}{\sqrt{1-\zeta^2}} = -\dfrac{\pi \times 0.5}{0.866} = -\dfrac{1.5708}{0.866}$

$= -1.813$

Step 4 – take the exponential: $e^{-1.813} = 0.163$

Step 5 – convert to a percentage: $M_p = 0.163 \times 100\% = 16.3\%$

Final Answer: $M_p \approx 16.3\% \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q35

Q36.

Solution

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

Step 1 – square the modulation index: $\mu^2 = 1^2 = 1$

Step 2 – form the bracket: $1 + \dfrac{1}{2} = 1.5$

Step 3 – multiply by the carrier power: $P_t = 100 \times 1.5$

Step 4 – evaluate: $P_t = 150$ W

Final Answer: $P_t = 150$ W $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – FM modulation index: $\beta = \frac{\Delta f}{f_m}$, the ratio of peak frequency deviation to the modulating frequency.

Step 1 – list the data: $\Delta f = 75$ kHz, $f_m = 15$ kHz.

Step 2 – form the ratio: $\beta = \frac{75}{15}$

Step 3 – evaluate: $\beta = 5$

Final Answer: $\beta = 5 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – PCM bit rate: $R_b = n \times f_s$, where $n = \log_2 L$ bits encode L quantization levels sampled at f_s.

Step 1 – find the number of bits per sample: $n = \log_2(256) = \log_2(2^8) = 8$ bits

Step 2 – list the sampling rate: $f_s = 8$ kHz $= 8000$ samples/s

Step 3 – multiply: $R_b = 8 \times 8000$

Step 4 – evaluate: $R_b = 64000$ bps $= 64$ kbps

Final Answer: $R_b = 64$ kbps $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q38

Q39.

Solution

Concept – symbol rate of an M-ary scheme: $R_s = \frac{R_b}{\log_2 M}$; QPSK has $M = 4$, so $\log_2 4 = 2$ bits per symbol.

Step 1 – list the data: $R_b = 2$ Mbps, bits per symbol $= 2$.

Step 2 – divide the bit rate by the bits per symbol: $R_s = \frac{2\text{ Mbps}}{2}$

Step 3 – evaluate: $R_s = 1$ Msymbol/s

Final Answer: $R_s = 1$ Msym/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – entropy of a source with equally likely symbols: For M equiprobable symbols the entropy is $H = \log_2 M$ bits/symbol.

Step 1 – identify the number of symbols: $M = 4$.

Step 2 – take the base-2 logarithm: $H = \log_2(4)$

Step 3 – express 4 as a power of two: $4 = 2^2$, so $\log_2(2^2) = 2$

Step 4 – state the result: $H = 2$ bits/symbol

Final Answer: $H = 2$ bits/symbol $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q40

Q41.

Solution

Concept – Shannon–Hartley channel capacity: $C = B\log_2(1 + \text{SNR})$.

Step 1 – form the term inside the logarithm: $1 + \text{SNR} = 1 + 7 = 8$

Step 2 – take the base-2 logarithm: $\log_2(8) = \log_2(2^3) = 3$

Step 3 – multiply by the bandwidth: $C = 3000 \times 3$

Step 4 – evaluate: $C = 9000$ bps $= 9$ kbps

Final Answer: $C = 9$ kbps $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q41

Q42.

Solution

Concept – characteristic impedance of a lossless line: $Z_0 = \sqrt{\frac{L}{C}}$, with L and C the per-unit-length inductance and capacitance.

Step 1 – convert the values to base units: $L = 250$ nH/m $= 250 \times 10^{-9}$ H/m

$C = 100$ pF/m $= 100 \times 10^{-12}$ F/m

Step 2 – form the ratio L/C: $\frac{L}{C} = \frac{250 \times 10^{-9}}{100 \times 10^{-12}}$

Step 3 – simplify: $= 2.5 \times 10^3 = 2500$

Step 4 – take the square root: $Z_0 = \sqrt{2500}$

$Z_0 = 50\ \Omega$

Final Answer: $Z_0 = 50\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q42

Q43.

Solution

Concept – reflection coefficient and VSWR: $\Gamma = \dfrac{Z_L - Z_0}{Z_L + Z_0}$ and $\text{VSWR} = \dfrac{1+|\Gamma|}{1-|\Gamma|}$.

Step 1 – compute the numerator of Γ: $Z_L - Z_0 = 100 - 50 = 50$

Step 2 – compute the denominator of Γ: $Z_L + Z_0 = 100 + 50 = 150$

Step 3 – form Γ: $\Gamma = \dfrac{50}{150} = 0.333$

Step 4 – form the VSWR numerator and denominator: $1+|\Gamma| = 1+0.333 = 1.333$

$1 - |\Gamma| = 1 - 0.333 = 0.667$

Step 5 – divide: $\text{VSWR} = \dfrac{1.333}{0.667}$

$\text{VSWR} = 2$

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

Answer: (A) Go Back to Q43

Q44.

Solution

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

Step 1 – list the data: $c = 3 \times 10^8$ m/s, $f = 3$ GHz $= 3 \times 10^9$ Hz.

Step 2 – divide: $\lambda = \dfrac{3 \times 10^8}{3 \times 10^9}$

Step 3 – simplify the powers of ten: $\lambda = 1 \times 10^{-1}$ m

Step 4 – convert to centimetres: $\lambda = 0.1$ m $= 10$ cm

Final Answer: $\lambda = 10 \text{ cm} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q44

Q45.

Solution

Concept – cut-off frequency of the dominant waveguide mode: For the TE_{10} mode of an air-filled rectangular waveguide, $f_c = \dfrac{c}{2a}$.

Step 1 – convert the broad-wall dimension: $a = 5\text{ cm} = 0.05\text{ m}$

Step 2 – form the denominator: $2a = 2 \times 0.05 = 0.1\text{ m}$

Step 3 – divide the speed of light by $2a$: $f_c = \dfrac{3 \times 10^8}{0.1}$

Step 4 – evaluate: $f_c = 3 \times 10^9\text{ Hz} = 3\text{ GHz}$

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

Answer: (B) Go Back to Q45

Q46.

Solution

Concept – intrinsic impedance of free space: $\eta_0 = \sqrt{\dfrac{\mu_0}{\varepsilon_0}} = 120\pi\ \Omega$.

Step 1 – write the standard form: $\eta_0 = 120\pi\ \Omega$

Step 2 – substitute $\pi \approx 3.1416$: $\eta_0 = 120 \times 3.1416$

Step 3 – evaluate: $\eta_0 = 376.99\ \Omega \approx 377\ \Omega$

Why the other options are wrong:

- A, $50\ \Omega$ and B, $75\ \Omega$: are common coaxial-cable characteristic impedances, not the free-space intrinsic impedance.
- D, $120\ \Omega$: drops the factor π from 120π.

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

Answer: (C) Go Back to Q46

Answer Key

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