GATE Electronics and Communication Engineering

Sample Paper – 10

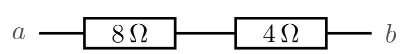
Duration: 128 Minutes **Maximum Marks: 72**

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 $8\ \Omega$ and $4\ \Omega$ are connected in series between nodes a and b, as shown. The equivalent resistance seen between a and b is: **[1 mark]**



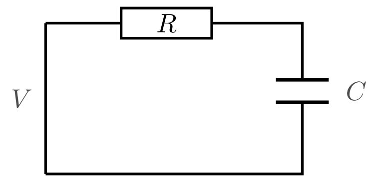
(A) $12\ \Omega$

(B) $32\ \Omega$

(C) $2.67\ \Omega$

(D) $4\ \Omega$

Q2. In the series RC circuit shown, a d.c. source is switched on at $t = 0$. With $R = 22$ kΩ and $C = 1\ \mu$F, the time constant of the circuit is: **[1 mark]**



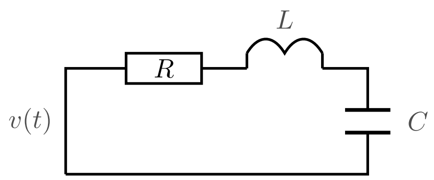
(A) 0.22 s

(B) 0.022 s

(C) 22 s

(D) 2.2 ms

Q3. A series RLC circuit has $L = 1$ mH and $C = 100$ nF, as shown. The undamped natural (resonant) angular frequency ω_0 of the circuit is: **[1 mark]**



(A) 100000 rad/s

(B) 10000 rad/s

(C) 1000 rad/s

(D) 1×10^6 rad/s

Q4. A source-free series RLC circuit has $R = 40\ \Omega$ and $L = 2$ mH. In its natural response the damping (neper) coefficient $\alpha = \dfrac{R}{2L}$ is: **[1 mark]**

(A) 5000 Np/s

(B) 10000 Np/s

(C) 20000 Np/s

(D) 2500 Np/s

Q5. An ideal capacitor of $C = 10\ \mu$F is driven by a sinusoidal source of angular frequency $\omega = 1000$ rad/s. The magnitude of the capacitive reactance $X_C = \dfrac{1}{\omega C}$ is: **[1 mark]**

(A) $100\ \Omega$

(B) $10\ \Omega$

(C) $1000\ \Omega$

(D) $0.01\ \Omega$

Q6. A source-free series RL circuit has an inductance $L = 100$ mH and a resistance $R = 50\ \Omega$. The time constant of the natural (transient) response is: **[1 mark]**

(A) 2 ms

(B) 0.5 ms

(C) 5 ms

(D) 20 ms

Electronic Devices

Q7. A silicon sample is uniformly doped with donor atoms of concentration $N_d = 5 \times 10^{16}$ 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) 5×10^{16} cm^{-3}

(C) 2.25×10^{20} cm^{-3}

(D) 4.5×10^{3} cm^{-3}

Q8. In the Ebers–Moll description of a bipolar transistor the common-base current gain is $\alpha = 0.98$. The corresponding common-emitter current gain $\beta = \dfrac{\alpha}{1-\alpha}$ is: **[1 mark]**

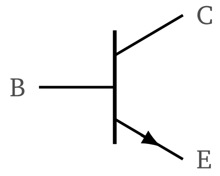
(A) 98

(B) 100

(C) 49

(D) 0.98

Q9. An npn bipolar junction transistor (shown) has a low-frequency common-emitter current gain $\beta_0 = 100$ and a β-cutoff (bandwidth) frequency $f_\beta = 2$ MHz. Its unity-gain (transition) frequency $f_T = \beta_0 f_\beta$ is: **[1 mark]**



(A) 2 MHz

(B) 200 MHz

(C) 100 MHz

(D) 20 MHz

Q10. A bipolar transistor is biased at a quiescent collector current $I_C = 2$ mA. Taking the thermal voltage $V_T = 25$ mV, its small-signal transconductance $g_m = \dfrac{I_C}{V_T}$ is: **[1 mark]**

(A) 40 mA/V

(B) 8 mA/V

(C) 80 mA/V

(D) 0.08 mA/V

Q11. A silicon bar is doped n-type with electron concentration $n = 2\times10^{16}$ cm^{-3} and electron mobility $\mu_n = 1350$ cm^2/V · s. Neglecting the hole contribution, the electrical conductivity of the bar is (take $q = 1.6 \times 10^{-19}$ C): [1 mark]

(A) 8.64 S/cm

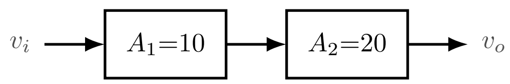
(B) 2.16 S/cm

(C) 4.32 S/cm

(D) 0.432 S/cm

Analog Circuits

Q12. A two-stage (multistage) voltage amplifier is formed by cascading a first stage of gain $A_1 = 10$ with a second stage of gain $A_2 = 20$, as shown. The overall voltage gain $A = A_1 A_2$ is: [1 mark]



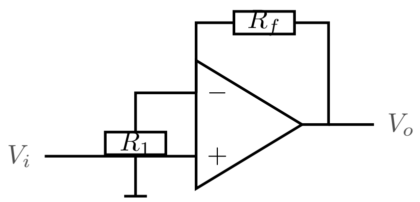
(A) 30

(B) 10

(C) 20

(D) 200

Q13. For the ideal-op-amp non-inverting amplifier shown, $R_1 = 25$ kΩ (from the inverting node to ground) and $R_f = 100$ kΩ (feedback). The closed-loop voltage gain $V_o/V_i = 1 + R_f/R_1$ is: [1 mark]



(A) 4

(B) 5

(C) 6

(D) 0.8

Q14. A differential amplifier has a differential-mode gain $A_d = 1000$ and a common-mode gain $A_c = 0.1$. Its common-mode rejection ratio in decibels, CMRR $= 20\log_{10}(A_d/A_c)$, is: **[1 mark]**

(A) 40 dB

(B) 100 dB

(C) 60 dB

(D) 80 dB

Q15. An op-amp has a gain–bandwidth product (unity-gain frequency) of 10 MHz. When it is connected for a closed-loop gain of 50, the resulting -3 dB bandwidth is: **[1 mark]**

(A) 10 MHz

(B) 50 kHz

(C) 200 kHz

(D) 2 MHz

Q16. An amplifier with open-loop gain $A = 10000$ is placed in a negative-feedback loop with feedback factor $\beta = 0.01$. The closed-loop gain $A_f = A/(1 + A\beta)$ is nearest to: **[1 mark]**

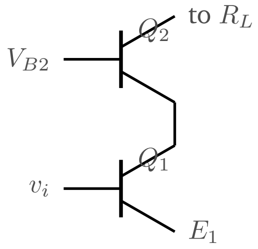
(A) 100

(B) 1000

(C) 99

(D) 10

Q17. The cascode amplifier shown stacks a common-emitter stage Q_1 under a common-base stage Q_2. Its low-frequency voltage gain magnitude is $|A_v| = g_m R_L$ with $g_m = 5$ mS and $R_L = 4$ kΩ. The gain magnitude is: **[2 marks]**



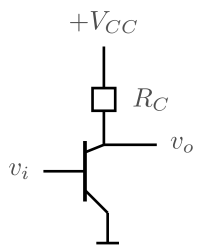
(A) 200

(B) 100

(C) 5

(D) 20

Q18. A common-emitter BJT amplifier operates at a quiescent collector current $I_C = 1$ mA with a collector resistor $R_C = 3$ 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: **[2 marks]**



(A) 120

(B) 40

(C) 30

(D) 12

Digital Circuits

Q19. A ROM has 8 address lines and an 8-bit-wide data output. Its total storage capacity (number of words × bits per word) is: **[1 mark]**

(A) 2048 bits

(B) 256 bits

(C) 64 bits

(D) 1024 bits

Q20. A memory chip is organised as 1024 words. The number of address lines needed to select any one of these words is: **[1 mark]**

(A) 8

(B) 1024

(C) 11

(D) 10

Q21. The four-variable function $F(A,B,C,D) = \sum m(0,2,8,10)$ 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	0	0	1
01	0	0	0	0
11	0	0	0	0
10	1	0	0	1

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

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

(C) BD

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

Q22. A synchronous mod-12 counter is to be built. The minimum number of flip-flops required so that the counter has at least 12 distinct states is: **[2 marks]**

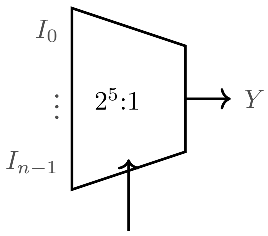
(A) 12

(B) 4

(C) 3

(D) 5

Q23. A digital multiplexer routes one of its data inputs to a single output using 5 select (control) lines, as shown. The maximum number of data inputs it can select from is: **[2 marks]**



(A) 5

(B) 10

(C) 25

(D) 32

Q24. A programmable logic array (PLA) has 4 inputs, 8 product terms and 3 outputs. In the fully-programmable AND array each product term can connect to the true and complemented form of every input. The number of programmable connection points (fusible links) in the AND array, = (product terms) × (2 × inputs), is: **[2 marks]**

(A) 32

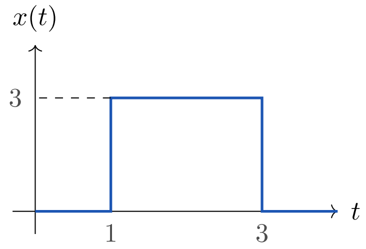
(B) 64

(C) 24

(D) 48

Signals and Systems

Q25. The energy signal $x(t)$ shown is a rectangular pulse of amplitude 3 V lasting from $t = 1$ s to $t = 3$ s and zero elsewhere. Its total energy $E = \int_{-\infty}^{\infty} x^2(t)\,dt$ is: **[2 marks]**



(A) 6 J

(B) 9 J

(C) 18 J

(D) 36 J

Q26. A periodic power signal is $x(t) = 5\cos(\omega_0 t)$ volts across a $1\ \Omega$ resistor. The average power of the signal, $P = \frac{A^2}{2}$, is: **[2 marks]**

(A) 25 W

(B) 5 W

(C) 6.25 W

(D) 12.5 W

Q27. For a power signal the autocorrelation evaluated at zero lag equals the average power, $R_{xx}(0) = P$. For $x(t) = 2\cos(\omega_0 t)$ (a $1\ \Omega$ reference), the value of $R_{xx}(0)$ is: **[2 marks]**

(A) 4 W

(B) 2 W

(C) 1 W

(D) 8 W

Q28. A finite-length discrete-time energy signal is $x[n] = \{1, 2, 2, 1\}$. Its total energy $E = \sum_n |x[n]|^2$ is: **[2 marks]**

(A) 10

(B) 6

(C) 36

(D) 5

Q29. The autocorrelation of the discrete sequence $x[n] = \{1, 2, 1\}$ evaluated at zero lag is $R_{xx}[0] = \sum_n x[n]\, x[n]$. Its value is: **[2 marks]**

(A) 1

(B) 4

(C) 6

(D) 2

Q30. The unit-step signal $u(t)$ is a power signal. Its average power, $P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} u^2(t)\, dt$, is: **[2 marks]**

(A) 1

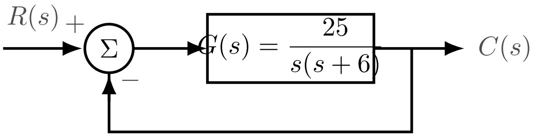
(B) 0.5

(C) ∞

(D) 0

Control Systems

Q31. The unity-feedback system shown has forward-path transfer function $G(s) = \frac{25}{s(s+6)}$, so its closed-loop characteristic equation is $s^2+6s+25 = 0$. The damping ratio ζ of the system is: **[2 marks]**



(A) 0.5

(B) 0.6

(C) 0.3

(D) 1

Q32. For the second-order system of the previous type with characteristic equation $s^2 + 6s + 25 = 0$ (so $\omega_n = 5$ rad/s and $\zeta = 0.6$), the damped natural frequency $\omega_d = \omega_n\sqrt{1-\zeta^2}$ is: **[2 marks]**

(A) 4 rad/s

(B) 3 rad/s

(C) 5 rad/s

(D) 2 rad/s

Q33. A second-order system has damped natural frequency $\omega_d = 4$ rad/s. For a unit-step input the peak time of its transient response, $t_p = \dfrac{\pi}{\omega_d}$, is nearest to: **[2 marks]**

(A) 0.5 s

(B) 1.57 s

(C) 0.785 s

(D) 0.25 s

Q34. A second-order system has $\zeta = 0.6$ and $\omega_n = 5$ rad/s. Using the 2% criterion, the settling time of its step response, $t_s = \dfrac{4}{\zeta\omega_n}$, is nearest to: **[2 marks]**

(A) 0.75 s

(B) 2 s

(C) 1.33 s

(D) 4 s

Q35. A unity-feedback second-order system has damping ratio $\zeta = 0.6$. 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) 16.3%

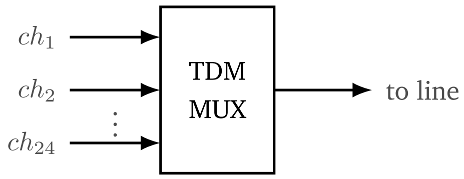
(B) 25%

(C) 50%

(D) 9.5%

Communications

Q36. A time-division-multiplexed (TDM) link combines 24 voice channels, each sampled at 8 kHz and encoded with 8 bits per sample, as shown. Neglecting framing bits, the aggregate output bit rate is: **[2 marks]**



(A) 1.536 Mbps

(B) 64 kbps

(C) 192 kbps

(D) 1.544 Mbps

Q37. Five voice channels, each band-limited to 4 kHz, are combined by frequency-division multiplexing (FDM) with no guard bands. The minimum total transmission bandwidth required is: **[2 marks]**

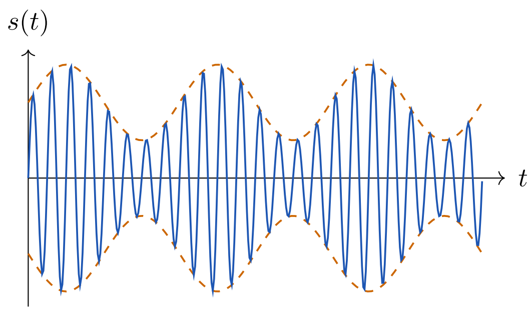
(A) 4 kHz

(B) 25 kHz

(C) 5 kHz

(D) 20 kHz

Q38. A carrier of power 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) 100 W

Q39. An FM signal has a peak frequency deviation of $\Delta f = 75$ kHz for a modulating tone of frequency $f_m = 10$ kHz. The modulation index $\beta = \Delta f / f_m$ is: **[2 marks]**

(A) 5

(B) 7.5

(C) 0.13

(D) 75

Q40. A direct-sequence spread-spectrum system spreads a 10 kbps data stream over a transmission bandwidth of 1 MHz. The processing gain in decibels, $G_p = 10 \log_{10}(W/R)$, is: **[2 marks]**

(A) 10 dB

(B) 40 dB

(C) 20 dB

(D) 30 dB

Q41. A direct-sequence spread-spectrum transmitter multiplies a 10 kbps data stream by a pseudo-noise code of length 127 chips per data bit. The resulting chip rate, $R_c = (\text{code length}) \times R_b$, is: **[2 marks]**

(A) 10 kcps

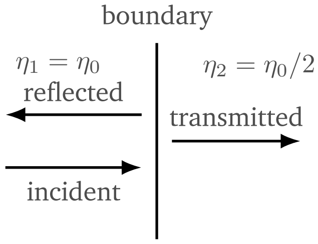
(B) 127 kcps

(C) 1.27 kcps

(D) 1.27 Mcps

Electromagnetics

Q42. A uniform plane wave in medium 1 ($\eta_1 = \eta_0$) is normally incident on the boundary of medium 2 ($\eta_2 = \eta_0/2$), as shown. The magnitude of the reflection coefficient, $\Gamma = \dfrac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$, is: **[2 marks]**



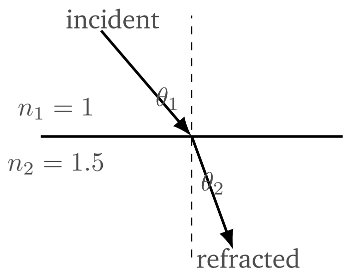
(A) 0.333

(B) 0.5

(C) 1

(D) 0.25

Q43. A ray travelling in air ($n_1 = 1$) strikes the surface of glass ($n_2 = 1.5$) at an angle of incidence $\theta_1 = 30^\circ$, as shown. By Snell's law $n_1 \sin\theta_1 = n_2 \sin\theta_2$, the angle of refraction θ_2 is nearest to: **[2 marks]**



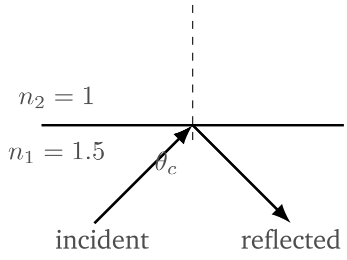
(A) 30°

(B) 19.5°

(C) 45°

(D) 48.6°

Q44. A ray travels inside glass ($n_1 = 1.5$) towards a glass–air ($n_2 = 1$) interface, as shown. The critical angle for total internal reflection, $\theta_c = \sin^{-1}(n_2/n_1)$, is nearest to: **[2 marks]**



(A) $30°$

(B) $48.6°$

(C) $41.8°$

(D) $90°$

Q45. A uniform plane wave of frequency 3 GHz propagates in a lossless dielectric of relative permittivity $\varepsilon_r = 4$. Its wavelength $\lambda = \dfrac{c}{f\sqrt{\varepsilon_r}}$ (with $c = 3 \times 10^8$ m/s) is: **[2 marks]**

(A) 10 cm

(B) 1 cm

(C) 2.5 cm

(D) 5 cm

Q46. The intrinsic (wave) impedance of a lossless dielectric of relative permittivity $\varepsilon_r = 4$ (and $\mu_r = 1$) is $\eta = \dfrac{\eta_0}{\sqrt{\varepsilon_r}}$, with $\eta_0 = 377\ \Omega$. Its value is nearest to: **[2 marks]**

(A) $377\ \Omega$

(B) $188.5\ \Omega$

(C) $94\ \Omega$

(D) $754\ \Omega$

Detailed Solutions

Q1.

Solution

Concept – two resistors in series: Resistances in series simply add, $R_{eq} = R_1 + R_2$.

Step 1 – list the data: $R_1 = 8\ \Omega$, $R_2 = 4\ \Omega$.

Step 2 – add the two resistances: $R_{eq} = 8 + 4$

Step 3 – evaluate: $R_{eq} = 12\ \Omega$

Step 4 – sanity check: A series combination is always larger than the largest branch ($8\ \Omega$), and $12 > 8$, so the result is consistent.

Why the other options are wrong:

- C, $2.67\ \Omega$: is the *parallel* value $\frac{8\times4}{8+4}$, not the series value.
- B, $32\ \Omega$: is the product of the resistances, which is not a resistance.

Final Answer: $R_{eq} = 12\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) 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: $R = 22\ \text{k}\Omega = 22 \times 10^3\ \Omega$

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

Step 2 – multiply: $\tau = (22 \times 10^3) \times (1 \times 10^{-6})$

Step 3 – combine the powers of ten: $\tau = 22 \times 10^{-3}$

$\tau = 0.022\ \text{s}$

Final Answer: $\tau = 0.022\ \text{s} \Rightarrow \boxed{\text{B}}$

Answer: (B) 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: $L = 1\text{ mH} = 1 \times 10^{-3}\text{ H}$

$C = 100\text{ nF} = 100 \times 10^{-9}\text{ F} = 1 \times 10^{-7}\text{ F}$

Step 2 – form the product LC: $LC = (1 \times 10^{-3}) \times (1 \times 10^{-7})$

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

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

Step 4 – invert: $\omega_0 = \dfrac{1}{1 \times 10^{-5}}$

$\omega_0 = 100000\text{ rad/s}$

Final Answer: $\omega_0 = 100000\text{ rad/s} \Rightarrow \boxed{\text{A}}$

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

Q4.

Solution

Concept – damping coefficient of a series RLC natural response: For a source-free series RLC circuit the natural response decays as $e^{-\alpha t}$, where the neper (damping) coefficient is $\alpha = \dfrac{R}{2L}$.

Step 1 – convert the inductance: $L = 2\text{ mH} = 2 \times 10^{-3}\text{ H}$

Step 2 – form the denominator $2L$: $2L = 2 \times (2 \times 10^{-3}) = 4 \times 10^{-3}$

Step 3 – divide R by $2L$: $\alpha = \dfrac{40}{4 \times 10^{-3}}$

Step 4 – evaluate: $\alpha = 10 \times 10^{3} = 10000\text{ Np/s}$

Final Answer: $\alpha = 10000\text{ Np/s} \Rightarrow \boxed{\text{B}}$

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

Q5.

Solution

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

Step 1 – convert the capacitance: $C = 10\ \mu\text{F} = 10 \times 10^{-6}\text{ F} = 1 \times 10^{-5}\text{ F}$

Step 2 – form the product ωC: $\omega C = 1000 \times (1 \times 10^{-5})$

$\omega C = 1 \times 10^{-2} = 0.01$

Step 3 – take the reciprocal: $X_C = \dfrac{1}{0.01}$

Step 4 – evaluate: $X_C = 100\ \Omega$

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

Answer: (A) Go Back to Q5

Q6.

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 inductance: $L = 100\ \text{mH} = 0.1\ \text{H}$

Step 2 – substitute: $\tau = \dfrac{0.1}{50}$

Step 3 – evaluate: $\tau = 0.002\ \text{s} = 2\ \text{ms}$

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

Answer: (A) 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 $p = \dfrac{n_i^2}{N_d}$.

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

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

Step 2 – take the majority-carrier concentration: $n \approx N_d = 5 \times 10^{16}\ \text{cm}^{-3}$

Step 3 – divide to get the hole concentration: $p = \dfrac{2.25 \times 10^{20}}{5 \times 10^{16}}$

Step 4 – divide the mantissas: $\dfrac{2.25}{5} = 0.45$

Step 5 – combine the powers of ten: $p = 0.45 \times 10^4 = 4.5 \times 10^3\ \text{cm}^{-3}$

Final Answer: $p = 4.5 \times 10^3\ \text{cm}^{-3} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – relating α and β of a BJT: The common-emitter and common-base current gains are linked by $\beta = \dfrac{\alpha}{1-\alpha}$.

Step 1 – form the denominator $1-\alpha$: $1 - 0.98 = 0.02$

Step 2 – divide α by $(1-\alpha)$: $\beta = \dfrac{0.98}{0.02}$

Step 3 – evaluate: $\beta = 49$

Why the other options are wrong:

- D, 0.98: is α itself, not β.
- B, 100: would require $\alpha \approx 0.99$, not 0.98.

Final Answer: $\beta = 49 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept – transition frequency of a BJT: The unity-gain (transition) frequency is the product of the low-frequency current gain and the β-cutoff frequency, $f_T = \beta_0 \, f_\beta$.

Step 1 – list the data: $\beta_0 = 100$, $f_\beta = 2$ MHz.

Step 2 – multiply: $f_T = 100 \times 2$ MHz

Step 3 – evaluate: $f_T = 200$ MHz

Step 4 – interpret: Above f_β the current gain rolls off at 20 dB/decade and reaches unity at f_T; the large factor β_0 pushes f_T far above f_β.

Final Answer: $f_T = 200$ MHz $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

Q10.

Solution

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

Step 1 – list the data: $I_C = 2$ mA, $V_T = 25$ mV.

Step 2 – form the ratio: $g_m = \dfrac{2 \text{ mA}}{25 \text{ mV}}$

Step 3 – convert to base units: $g_m = \dfrac{2 \times 10^{-3}}{25 \times 10^{-3}}$

Step 4 – evaluate: $g_m = 0.08$ A/V $= 80$ mA/V

Final Answer: $g_m = 80$ mA/V $\Rightarrow \boxed{\text{C}}$

Answer: (C) 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, $n = 2 \times 10^{16}$ cm^{-3}, $\mu_n = 1350$ cm^2/V $\cdot$ s.

Step 2 – multiply charge and concentration: $q\,n = (1.6 \times 10^{-19}) \times (2 \times 10^{16})$

$q\,n = 3.2 \times 10^{-3}$

Step 3 – multiply by the mobility: $\sigma = (3.2 \times 10^{-3}) \times 1350$

Step 4 – evaluate: $\sigma = 4.32$ S/cm

Final Answer: $\sigma = 4.32$ S/cm $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept – overall gain of cascaded stages: When two amplifier stages are cascaded, their voltage gains multiply, $A = A_1 \times A_2$.

Step 1 – list the stage gains: $A_1 = 10$, $A_2 = 20$.

Step 2 – multiply: $A = 10 \times 20$

Step 3 – evaluate: $A = 200$

Why the other options are wrong:

- A, 30: adds the gains instead of multiplying them.
- B, 10 and C, 20: are the individual stage gains, not the overall gain.

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

Answer: (D) Go Back to Q12

Q13.

Solution

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

Step 1 – form the resistor ratio: $\frac{R_f}{R_1} = \frac{100\ \text{k}\Omega}{25\ \text{k}\Omega} = 4$

Step 2 – add one: $A_v = 1 + 4$

Step 3 – evaluate: $A_v = 5$

Why the other options are wrong:

- A, 4: is just R_f/R_1; it forgets the "+1" of the non-inverting topology.
- D, 0.8: inverts the ratio.

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

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – common-mode rejection ratio in decibels: $\text{CMRR (dB)} = 20\log_{10}\left(\frac{A_d}{A_c}\right)$.

Step 1 – form the ratio of the gains: $\frac{A_d}{A_c} = \frac{1000}{0.1}$

Step 2 – evaluate the ratio: $= 10000$

Step 3 – express as a power of ten: $10000 = 10^4$

Step 4 – take the logarithm and multiply by 20**:** $20\log_{10}(10^4) = 20 \times 4$

Step 5 – evaluate: $\text{CMRR} = 80\ \text{dB}$

Final Answer: $\text{CMRR} = 80\ \text{dB} \Rightarrow \boxed{\text{D}}$

Answer: (D) 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: GBW $= 10$ MHz $= 10 \times 10^6$ Hz, closed-loop gain $A_{CL} = 50$.

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

Step 3 – substitute: BW $= \dfrac{10 \times 10^6}{50}$

Step 4 – evaluate: BW $= 0.2 \times 10^6$ Hz $= 200$ kHz

Final Answer: BW $= 200$ kHz $\Rightarrow \boxed{\text{C}}$

Answer: (C) 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: $A\beta = 10000 \times 0.01 = 100$

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

Step 3 – divide: $A_f = \dfrac{10000}{101}$

Step 4 – evaluate: $A_f = 99.0$

Step 5 – interpret: The ideal value $1/\beta = 100$ is only approached for very large loop gain; here the loop gain is finite, so $A_f = 99$ is slightly below 100.

Final Answer: $A_f \approx 99 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q16

Q17.

Solution

Concept – gain of a cascode amplifier: A cascode stacks a common-emitter transistor under a common-base transistor. The common-base upper device passes the lower device's collector current with near-unity gain, so the low-frequency magnitude is still $|A_v| = g_m R_L$, but with a much reduced Miller effect and hence wider bandwidth.

Step 1 – list the data: $g_m = 5$ mS $= 5 \times 10^{-3}$ S, $R_L = 4$ k$\Omega = 4000\ \Omega$.

Step 2 – form the product $g_m R_L$: $|A_v| = (5 \times 10^{-3}) \times 4000$

Step 3 – evaluate: $|A_v| = 20$

Step 4 – note the cascode advantage: The cascode's main benefit is not extra low-frequency gain but the higher output resistance and the wider bandwidth from suppressing the input Miller capacitance.

Final Answer: $|A_v| = 20 \Rightarrow \boxed{\text{D}}$

Answer: (D) 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: $R_C = 3 \text{ k}\Omega = 3000 \ \Omega$

Step 3 – form the gain: $|A_v| = g_m R_C = 0.04 \times 3000$

Step 4 – evaluate: $|A_v| = 120$

Final Answer: $|A_v| = 120 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept – capacity of a ROM: The number of words equals $2^{(\text{address lines})}$ and the total capacity is (number of words) $\times$ (bits per word).

Step 1 – find the number of words: $2^8 = 256$ words

Step 2 – read the word width: Each word is 8 bits wide.

Step 3 – multiply: 256×8

Step 4 – evaluate: $= 2048$ bits

Final Answer: capacity $= 2048$ bits $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – address lines for a given word count: A memory of N words needs n address lines with $2^n = N$, so $n = \log_2 N$.

Step 1 – write the requirement: $2^n = 1024$

Step 2 – express 1024 **as a power of two:** $1024 = 2^{10}$

Step 3 – match the exponents: $n = 10$

Why the other options are wrong:

- C, 11: gives $2^{11} = 2048$ words, twice too many.
- A, 8: gives only 256 words.

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

Answer: (D) Go Back to Q20

Q21.

Solution

Concept – grouping ones on a Karnaugh map: Adjacent ones (including the wrap-around four corners) are grouped in powers of two; the literals that stay constant over a group form its product term.

Step 1 – place the minterms: $\sum m(0, 2, 8, 10)$ fills the four corner cells of the map (circled).

Step 2 – write the corner cells in binary $ABCD$: $m0 = 0000$, $m2 = 0010$, $m8 = 1000$, $m10 = 1010$.

Step 3 – find which literals are constant across all four: In every one of these cells $B = 0$ and $D = 0$, while A and C both change.

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

Step 5 – verify: $\bar{B}\,\bar{D}$ covers exactly the cells with $B = 0$ and $D = 0$, namely $m0, m2, m8, m10$, matching the given ones.

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

Answer: (A) 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-12 counter: $2^n \geq 12$

Step 2 – test $n = 3$: $2^3 = 8$, and $8 < 12$, so 3 flip-flops are not enough.

Step 3 – test $n = 4$: $2^4 = 16$, and $16 \geq 12$, so 4 flip-flops suffice.

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

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

Answer: (B) Go Back to Q22

Q23.

Solution

Concept – inputs of a multiplexer: A multiplexer with n select lines can choose from 2^n data inputs.

Step 1 – write the relation for 5 select lines: number of inputs $= 2^n = 2^5$

Step 2 – evaluate the power of two: $2^5 = 32$

Step 3 – conclude: The multiplexer can select from 32 data inputs.

Why the other options are wrong:

- C, 25: is 5^2, not 2^5.
- B, 10: is 2×5, not 2^5.

Final Answer: 32 inputs $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q23

Q24.

Solution

Concept – size of the AND array of a PLA: Every product term can tap the true and complemented form of each input, so the number of connection points in the AND array is (product terms) $\times$ ($2\times$ inputs).

Step 1 – count the input lines feeding the AND array: Each of the 4 inputs appears in true and complement form, giving $2 \times 4 = 8$ lines.

Step 2 – multiply by the number of product terms: 8 lines $\times$ 8 product terms

Step 3 – evaluate: $= 64$ connection points

Why the other options are wrong:

- A, 32: uses 4 input lines (forgets the complements) $\times 8 = 32$.
- D, 48: would come from mixing the OR array (8×3) into the AND-array count.

Final Answer: 64 links $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept – energy of a signal: The energy of $x(t)$ is $E = \int_{-\infty}^{\infty} x^2(t)\,dt$. For a constant-amplitude pulse this is (amplitude)$^2 \times$ (duration).

Step 1 – read the pulse parameters: amplitude $A = 3$ V, duration $T = 3 - 1 = 2$ s.

Step 2 – square the amplitude: $A^2 = 3^2 = 9$

Step 3 – multiply by the duration: $E = 9 \times 2$

Step 4 – evaluate: $E = 18$ J

Final Answer: $E = 18$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q25

Q26.

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: $A = 5$ 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

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

$\boxed{\text{Answer: (D)}}$ Go Back to Q26

Q27.

Solution

Concept – autocorrelation at zero lag: For a power signal the autocorrelation at zero lag equals the average power, $R_{xx}(0) = P = \dfrac{A^2}{2}$ for a sinusoid.

Step 1 – identify the amplitude: $A = 2$ V.

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

Step 3 – divide by two: $R_{xx}(0) = \dfrac{4}{2}$

Step 4 – evaluate: $R_{xx}(0) = 2$ W

Final Answer: $R_{xx}(0) = 2 \text{ W} \Rightarrow \boxed{\text{B}}$

$\boxed{\text{Answer: (B)}}$ Go Back to Q27

Q28.

Solution

Concept – energy of a discrete-time signal: $E = \sum_n |x[n]|^2$, the sum of the squares of the samples.

Step 1 – square each sample of $\{1, 2, 2, 1\}$: $1^2 = 1$

$2^2 = 4$

$2^2 = 4$

$1^2 = 1$

Step 2 – add the squares: $1 + 4 + 4 + 1$

Step 3 – evaluate: $E = 10$

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

$\boxed{\text{Answer: (A)}}$ Go Back to Q28

Q29.

Solution

Concept – autocorrelation at zero lag of a sequence: $R_{xx}[0] = \sum_n x[n]\, x[n]$, which equals the sum of the squares of the samples.

Step 1 – square each sample of $\{1, 2, 1\}$: $1^2 = 1$

$2^2 = 4$

$1^2 = 1$

Step 2 – add the squares: $1 + 4 + 1$

Step 3 – evaluate: $R_{xx}[0] = 6$

Step 4 – note: The autocorrelation always peaks at zero lag, so $R_{xx}[0]$ is the largest value of the autocorrelation sequence.

Final Answer: $R_{xx}[0] = 6 \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q29**

Q30.

Solution

Concept – average power of the unit step: $u(t)$ equals 1 for $t > 0$ and 0 for $t < 0$, so its squared value is 1 over half of all time.

Step 1 – write the power integral: $P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} u^2(t)\, dt$

Step 2 – note $u^2(t) = u(t)$, non-zero only for $0 < t < T$: $\int_{-T}^{T} u^2(t)\, dt = \int_0^T 1\, dt = T$

Step 3 – substitute into the power expression: $P = \lim_{T\to\infty} \frac{T}{2T}$

Step 4 – simplify: $P = \frac{1}{2} = 0.5$

Step 5 – interpret: Because the energy grows without bound but the power is finite and non-zero, $u(t)$ is a power signal.

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

Answer: (B) **Go Back to Q30**

Q31.

Solution

Concept – standard second-order form: The closed-loop characteristic equation is compared with $s^2 + 2\zeta\omega_n s + \omega_n^2$.

Step 1 – form the closed-loop characteristic equation: With $G(s) = \frac{25}{s(s+6)}$ and unity feedback, the denominator is $s(s + 6) + 25 = s^2 + 6s + 25$.

Step 2 – match the constant term: $\omega_n^2 = 25 \Rightarrow \omega_n = 5$ rad/s

Step 3 – match the middle term: $2\zeta\omega_n = 6$

Step 4 – substitute $\omega_n = 5$**:** $2\zeta(5) = 6$

$10\zeta = 6$

Step 5 – solve for ζ**:** $\zeta = \frac{6}{10} = 0.6$

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

Answer: (B) Go Back to Q31

Q32.

Solution

Concept – damped natural frequency: $\omega_d = \omega_n\sqrt{1-\zeta^2}$.

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

Step 2 – compute $1-\zeta^2$**:** $1-(0.6)^2 = 1-0.36 = 0.64$

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

Step 4 – multiply by ω_n**:** $\omega_d = 5 \times 0.8$

Step 5 – evaluate: $\omega_d = 4$ rad/s

Final Answer: $\omega_d = 4$ rad/s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – peak time of a second-order step response: $t_p = \frac{\pi}{\omega_d}$.

Step 1 – list the data: $\omega_d = 4$ rad/s.

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

Step 3 – put in $\pi = 3.1416$**:** $t_p = \frac{3.1416}{4}$

Step 4 – evaluate: $t_p = 0.785$ s

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

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – settling time (2% criterion): $t_s = \dfrac{4}{\zeta\omega_n}$.

Step 1 – form the product $\zeta\omega_n$: $\zeta\omega_n = 0.6 \times 5 = 3$

Step 2 – substitute into the settling-time formula: $t_s = \dfrac{4}{3}$

Step 3 – evaluate: $t_s = 1.33$ s

Final Answer: $t_s = 1.33 \text{ s} \Rightarrow \boxed{\text{C}}$

Answer: (C) 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 $1-\zeta^2$: $1-(0.6)^2 = 1-0.36 = 0.64$

Step 2 – take its square root: $\sqrt{0.64} = 0.8$

Step 3 – 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 4 – take the exponential: $e^{-2.356} = 0.0948$

Step 5 – convert to a percentage: $M_p = 0.0948 \times 100\% = 9.48\% \approx 9.5\%$

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

Answer: (D) Go Back to Q35

Q36.

Solution

Concept – aggregate bit rate of a TDM link: Each channel contributes (bits per sample) $\times$ (sampling rate) bits/s, and the TDM aggregate is the number of channels times that.

Step 1 – find the bit rate of one channel: $8 \text{ bits} \times 8000 \text{ samples/s} = 64000 \text{ bps}$

Step 2 – multiply by the number of channels: $R = 24 \times 64000$

Step 3 – evaluate: $R = 1536000 \text{ bps} = 1.536 \text{ Mbps}$

Why the other options are wrong:

- B, 64 kbps: is a single channel, not the multiplexed total.
- D, 1.544 Mbps: is the T1 rate that includes 8 kbps of framing overhead, which we were told to neglect.

Final Answer: $R = 1.536$ Mbps $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q36

Q37.

Solution

Concept – bandwidth of an FDM group: With no guard bands the total bandwidth is (number of channels) $\times$ (per-channel bandwidth).

Step 1 – list the data: number of channels $= 5$, per-channel bandwidth $= 4$ kHz.

Step 2 – multiply: $B = 5 \times 4$

Step 3 – evaluate: $B = 20$ kHz

Why the other options are wrong:

- B, 25 kHz: would need a 1 kHz guard band per channel, which the question excludes.
- A, 4 kHz: is a single channel, not the whole group.

Final Answer: $B = 20$ kHz $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q37

Q38.

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 – form the bracket: $1 + 0.125 = 1.125$

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

Step 5 – evaluate: $P_t = 225$ W

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

Answer: (A) Go Back to Q38

Q39.

Solution

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

Step 1 – list the data: $\Delta f = 75$ kHz, $f_m = 10$ kHz.

Step 2 – form the ratio: $\beta = \dfrac{75}{10}$

Step 3 – evaluate: $\beta = 7.5$

Final Answer: $\beta = 7.5 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – processing gain of a spread-spectrum system: $G_p = \dfrac{W}{R}$ (spread bandwidth over data rate); in decibels $G_p(\text{dB}) = 10\log_{10}(W/R)$.

Step 1 – form the ratio W/R: $\dfrac{W}{R} = \dfrac{1\times10^6}{10\times10^3}$

Step 2 – evaluate the ratio: $= 100$

Step 3 – express as a power of ten: $100 = 10^2$

Step 4 – take the logarithm and multiply by 10: $10\log_{10}(10^2) = 10\times 2$

Step 5 – evaluate: $G_p = 20$ dB

Final Answer: $G_p = 20$ dB $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q40

Q41.

Solution

Concept – chip rate of a direct-sequence system: Each data bit is multiplied by a PN code of a fixed number of chips, so $R_c = (\text{chips per bit}) \times R_b$.

Step 1 – list the data: chips per bit $= 127$, $R_b = 10$ kbps $= 10\times10^3$ bps.

Step 2 – multiply: $R_c = 127 \times (10\times10^3)$

Step 3 – evaluate: $R_c = 1270\times10^3$ cps $= 1.27\times10^6$ cps

Step 4 – state in engineering units: $R_c = 1.27$ Mcps

Final Answer: $R_c = 1.27$ Mcps $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q41

Q42.

Solution

Concept – reflection coefficient at a normal-incidence boundary: $\Gamma = \dfrac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$.

Step 1 – write the two impedances in terms of η_0: $\eta_1 = \eta_0$, $\eta_2 = \dfrac{\eta_0}{2} = 0.5\,\eta_0$.

Step 2 – form the numerator: $\eta_2 - \eta_1 = 0.5\,\eta_0 - \eta_0 = -0.5\,\eta_0$

Step 3 – form the denominator: $\eta_2 + \eta_1 = 0.5\,\eta_0 + \eta_0 = 1.5\,\eta_0$

Step 4 – form the ratio: $\Gamma = \dfrac{-0.5\,\eta_0}{1.5\,\eta_0} = -\dfrac{0.5}{1.5}$

Step 5 – take the magnitude: $|\Gamma| = \dfrac{0.5}{1.5} = 0.333$

Final Answer: $|\Gamma| = 0.333 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – Snell's law of refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$, so $\sin\theta_2 = \dfrac{n_1 \sin\theta_1}{n_2}$.

Step 1 – list the data: $n_1 = 1$, $\theta_1 = 30°$, $n_2 = 1.5$.

Step 2 – evaluate $\sin\theta_1$: $\sin 30° = 0.5$

Step 3 – form $\sin\theta_2$: $\sin\theta_2 = \dfrac{1 \times 0.5}{1.5} = \dfrac{0.5}{1.5}$

Step 4 – evaluate: $\sin\theta_2 = 0.333$

Step 5 – take the inverse sine: $\theta_2 = \sin^{-1}(0.333) = 19.5°$

Step 6 – sanity check: The ray bends towards the normal on entering the denser medium ($\theta_2 < \theta_1$), as expected.

Final Answer: $\theta_2 \approx 19.5° \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q43

Q44.

Solution

Concept – critical angle for total internal reflection: $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$, valid when the ray travels from the denser to the rarer medium.

Step 1 – list the data: $n_1 = 1.5$ (glass), $n_2 = 1$ (air).

Step 2 – form the ratio: $\frac{n_2}{n_1} = \frac{1}{1.5} = 0.667$

Step 3 – take the inverse sine: $\theta_c = \sin^{-1}(0.667)$

Step 4 – evaluate: $\theta_c = 41.8^\circ$

Step 5 – interpret: For incidence angles greater than 41.8° the ray is totally internally reflected and none is transmitted.

Final Answer: $\theta_c \approx 41.8^\circ \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – wavelength in a dielectric: The phase velocity slows by $\sqrt{\varepsilon_r}$, so $\lambda = \frac{c}{f\sqrt{\varepsilon_r}}$.

Step 1 – list the data: $c = 3 \times 10^8$ m/s, $f = 3$ GHz $= 3 \times 10^9$ Hz, $\varepsilon_r = 4$.

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

Step 3 – form the denominator $f\sqrt{\varepsilon_r}$: $f\sqrt{\varepsilon_r} = (3 \times 10^9) \times 2 = 6 \times 10^9$

Step 4 – divide: $\lambda = \frac{3 \times 10^8}{6 \times 10^9}$

Step 5 – simplify: $\lambda = 0.5 \times 10^{-1}\ \text{m} = 0.05\ \text{m}$

Step 6 – convert to centimetres: $\lambda = 5$ cm

Final Answer: $\lambda = 5\ \text{cm} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q45

Q46.

Solution

Concept – intrinsic impedance of a dielectric: For a non-magnetic dielectric ($\mu_r = 1$) the intrinsic impedance is $\eta = \frac{\eta_0}{\sqrt{\varepsilon_r}}$.

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

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

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

Why the other options are wrong:

- A, $377\ \Omega$: is the free-space value, ignoring the dielectric.
- D, $754\ \Omega$: multiplies by $\sqrt{\varepsilon_r}$ instead of dividing.

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

Answer: (B) Go Back to Q46

Answer Key

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