# GATE Electronics and Communication Engineering

## Sample Paper – 8

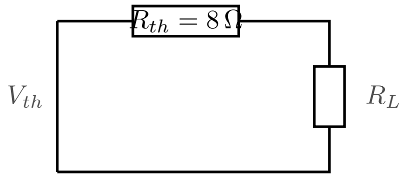
**Duration: 128 Minutes** | **Maximum Marks: 72**

### 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.** A resistive one-port network has been reduced to its Thevenin equivalent with source $V_{th}$ and internal resistance $R_{th} = 8\ \Omega$, feeding a variable load $R_L$ as shown. For **maximum power transfer** to the load, the load resistance must be set to: **[1 mark]**




(A) $16\ \Omega$

(B) $4\ \Omega$

(C) $0\ \Omega$

(D) $8\ \Omega$

**Q2.** A d.c. source of $12$ V is applied across a series combination of a $4\ \Omega$ resistor and an $8\ \Omega$ resistor. Using the voltage-divider rule, the voltage that appears across the $8\ \Omega$ resistor is: **[1 mark]**

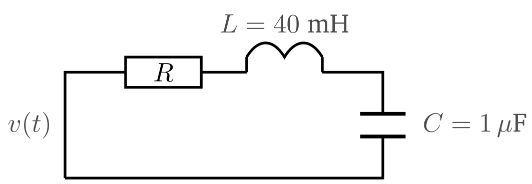
(A) $8$ V

(B) $4$ V

(C) $6$ V

(D) $12$ V

**Q3.** The series $RLC$ circuit shown has $L = 40$ mH and $C = 1\ \mu$F. The undamped natural (resonant) angular frequency $\omega_0 = 1/\sqrt{LC}$ of the circuit is: **[1 mark]**




(A) $5000$ rad/s

(B) $10000$ rad/s

(C) $2500$ rad/s

(D) $1000$ rad/s

**Q4.** 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 $X_C = 1/(\omega C)$ is: **[1 mark]**

(A) $10\ \Omega$

(B) $1000\ \Omega$

(C) $100\ \Omega$

(D) $0.01\ \Omega$

**Q5.** In a linear resistive network a certain branch resistor is analysed by **superposition**. Acting alone, the independent current source drives $6$ A upward through the resistor, while acting alone the independent voltage source drives $2$ A downward through the same resistor. The net branch current is: **[1 mark]**

(A) $8$ A upward

(B) $6$ A upward

(C) $4$ A upward

(D) $2$ A upward

**Q6.** A first-order series $RC$ circuit is formed with $R = 5$ k$\Omega$ and $C = 4\ \mu$F. The time constant $\tau = RC$ of the circuit is: **[1 mark]**

(A) $0.2$ s

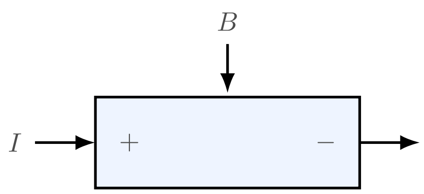
(B) $0.02$ s

(C) $0.01$ s

(D) $2$ s

## Electronic Devices

**Q7.** A rectangular semiconductor bar carries a current $I$ along its length while a magnetic field $B$ is applied normal to its broad face, as sketched (the **Hall effect**). The resulting transverse Hall voltage is measured chiefly to determine: **[1 mark]**




$V_H$ across width

(A) the energy band gap of the material

(B) the minority-carrier lifetime only

(C) the dielectric constant of the material

(D) the type (sign) and concentration of the charge carriers

**Q8.** Electrons in a silicon sample have a mobility $\mu_n = 1400$ cm$^2$/V·s. When a uniform electric field of $E = 5$ V/cm is applied, the electron drift velocity $v_d = \mu_n E$ is: **[1 mark]**

(A) 280 cm/s

(B) 7000 cm/s

(C) 70000 cm/s

(D) 700 cm/s

**Q9.** A bipolar junction transistor operating in the active region has a common-base current gain $\alpha = 0.98$. The corresponding common-emitter current gain $\beta = \alpha/(1-\alpha)$ is: **[1 mark]**

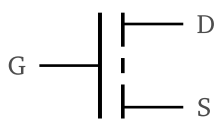
(A) 98

(B) 49

(C) 0.98

(D) 100

**Q10.** An $n$-channel enhancement MOSFET has threshold voltage $V_t = 1$ V and process transconductance parameter $k_n = 0.5$ mA/V$^2$. It is biased in saturation with $V_{GS} = 5$ V, as shown. Using $I_D = \frac{1}{2}k_n(V_{GS} - V_t)^2$, the drain current is: **[1 mark]**




(A) 8 mA

(B) 2 mA

(C) 4 mA

(D) 16 mA

**Q11.** A silicon bar is doped $n$-type with electron concentration $n = 5\times10^{16}$ cm$^{-3}$ and electron mobility $\mu_n = 800$ cm$^2$/V $\cdot$ s. Neglecting the hole contribution, the electrical conductivity $\sigma = q\,n\,\mu_n$ of the bar is (take $q = 1.6 \times 10^{-19}$ C): **[1 mark]**

(A) 64 S/cm

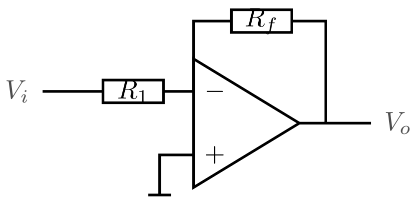
(B) 6.4 S/cm

(C) 0.64 S/cm

(D) 640 S/cm

## Analog Circuits

**Q12.** For the ideal-op-amp inverting amplifier shown, $R_1 = 25$ k$\Omega$ and $R_f = 100$ k$\Omega$. The magnitude of the closed-loop voltage gain $|V_o/V_i| = R_f/R_1$ is: **[1 mark]**



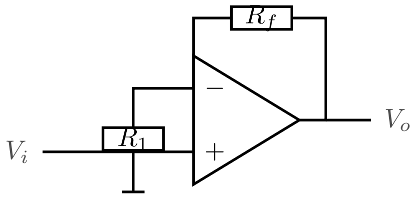

(A) 4

(B) 125

(C) 0.25

(D) 40

**Q13.** For the ideal-op-amp non-inverting amplifier shown, $R_1 = 10$ k$\Omega$ (from the inverting node to ground) and $R_f = 40$ k$\Omega$ (feedback). The closed-loop voltage gain $V_o/V_i = 1 + R_f/R_1$ is: **[1 mark]**




(A) 4

(B) 41

(C) 5

(D) 0.2

**Q14.** A series-fed (direct-coupled) **Class A** power amplifier drives a purely resistive load directly in the collector. The maximum theoretical conversion (collector) efficiency of this configuration is: **[1 mark]**

(A) 50%

(B) 25%

(C) 78.5%

(D) 100%

**Q15.** An idealised **Class B** push-pull power amplifier is driven to the edge of clipping. Its maximum theoretical conversion efficiency, $\eta_{\max} = \pi/4$, is nearest to: **[1 mark]**

(A) 25%

(B) 50%

(C) 100%

(D) 78.5%

**Q16.** 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 (GBW divided by gain) is: **[1 mark]**

(A) 10 MHz

(B) 500 kHz

(C) 200 kHz

(D) 50 kHz

**Q17.** When a two-transistor output stage is biased exactly at cut-off so that each device conducts for only one half-cycle, the output waveform shows a small distortion near the zero crossing. This **crossover distortion** is a characteristic drawback of which amplifier class? **[1 mark]**

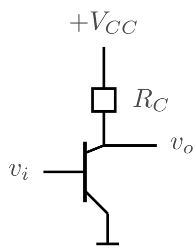
(A) Class A

(B) Class B

(C) Class C

(D) Class AB (in which it is largely removed)

**Q18.** A common-emitter BJT amplifier operates at a quiescent collector current $I_C = 1$ mA with a collector resistor $R_C = 2.5$ k$\Omega$, as shown. Taking $V_T = 25$ mV and neglecting $r_o$, the magnitude of the small-signal voltage gain $|A_v| = g_m R_C$ (with $g_m = I_C/V_T$) is: **[1 mark]**




(A) 250

(B) 40

(C) 25

(D) 100

## Digital Circuits

**Q19.** The unsigned binary number $(10110)_2$ has the decimal (base-10) value: **[1 mark]**

(A) 20

(B) 22

(C) 26

(D) 18

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

(A) $A$

(B) $B$

(C) $AB$

(D) $A + B$

**Q21.** An 8-bit **digital-to-analog converter** (DAC) has a full-scale reference of $V_{ref} = 2.56$ V. Its resolution (the analog step size for one LSB), $V_{ref}/2^n$, is: **[2 marks]**

(A) 10 mV

(B) 2.56 mV

(C) 100 mV

(D) 256 mV

**Q22.** A 12-bit **analog-to-digital converter** (ADC) quantises its input as shown. The total number of distinct output codes (quantisation levels), $2^n$, is: **[2 marks]**


(A) 1024

(B) 4096

(C) 2048

(D) 12

**Q23.** In an ideal uniform quantiser used inside an ADC, the analog input is rounded to the nearest code. The maximum magnitude of the quantisation error, expressed in units of one least-significant bit (LSB) step, is: **[2 marks]**

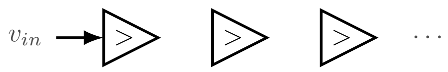
(A) $\pm\frac{1}{2}$ LSB

(B) $\pm 1$ LSB

(C) $\pm 2$ LSB

(D) $0$ (an ideal quantiser is error-free)

**Q24.** A **flash (parallel) ADC** of $n = 3$ bits compares the input against a resistor-string reference using a bank of comparators, as sketched. The number of comparators required, $2^n - 1$, is: **[2 marks]**




7 comparators for 3-bit flash

(A) 8

(B) 3

(C) 7

(D) 15

## Signals and Systems

**Q25.** A continuous-time LTI system has impulse response $h(t)$. The necessary and sufficient condition for the system to be **BIBO stable** is that $h(t)$ be: **[2 marks]**

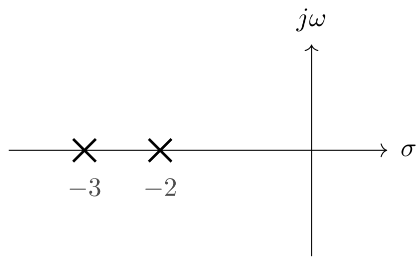
(A) absolutely integrable, i.e. $\int_{-\infty}^{\infty} |h(t)|\, dt < \infty$

(B) periodic with a finite period

(C) of finite duration only

(D) causal, i.e. $h(t) = 0$ for $t < 0$

**Q26.** A stable LTI system has the transfer function $H(s) = \dfrac{6}{(s+2)(s+3)}$, whose pole–zero plot is shown (poles marked $\times$ in the left half-plane). The d.c. gain $H(0)$ of the system is: **[2 marks]**




(A) $1$

(B) $6$

(C) $0.5$

(D) $2$

**Q27.** A discrete-time signal is $x[n] = (0.8)^n\, u[n]$. Because $|0.8| < 1$ the sequence is absolutely summable, so the sum of all its samples, $\sum_{n=-\infty}^{\infty} x[n] = \dfrac{1}{1-0.8}$, is: **[2 marks]**

(A) $0.8$

(B) $1.25$

(C) $4$

(D) $5$

**Q28.** A periodic voltage signal is $x(t) = 6\cos(\omega_0 t)$ volts developed across a $1\,\Omega$ resistor. The average power of the signal, $A^2/2$, is: **[2 marks]**

(A) $18$ W

(B) $36$ W

(C) $9$ W

(D) $6$ W

**Q29.** Two finite-length discrete sequences of lengths $5$ and $8$ samples respectively are linearly convolved. The length (number of samples) of the resulting sequence, $N_1 + N_2 - 1$, is: **[2 marks]**

(A) $13$

(B) $40$

(C) $12$

(D) $8$

**Q30.** A continuous-time signal is band-limited to a maximum frequency of $10$ kHz. According to the sampling theorem, the minimum sampling rate (Nyquist rate) required to reconstruct it without aliasing is: **[2 marks]**

(A) $10$ kHz

(B) $5$ kHz

(C) $20$ kHz

(D) $40$ kHz

## Control Systems

**Q31.** A standard second-order system has the characteristic equation $s^2 + 6s + 9 = 0$. Comparing with $s^2 + 2\zeta\omega_n s + \omega_n^2$, the damping ratio $\zeta$ of the system is: **[2 marks]**

(A) $1$

(B) $0.5$

(C) $2$

(D) $0.25$

**Q32.** The characteristic equation of a feedback system is $s^3 + s^2 + 2s + 8 = 0$. Using the Routh–Hurwitz criterion, the number of closed-loop poles lying in the right half of the $s$-plane (i.e. the system's degree of instability) is: **[2 marks]**

(A) $0$

(B) 3

(C) 1

(D) 2

**Q33.** In a **PID controller** $G_c(s) = K_p + \frac{K_i}{s} + K_d s$, the integral $(K_i/s)$ term is added mainly because it drives its associated error to zero. The quantity it primarily reduces is the: **[2 marks]**

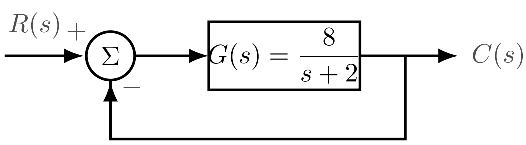
(A) rise time of the transient response

(B) closed-loop bandwidth

(C) steady-state error

(D) gain margin

**Q34.** For the unity-feedback control system shown, the forward-path transfer function is $G(s) = \frac{8}{s+2}$. The d.c. gain of the closed-loop transfer function $\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)}$ (its value at $s = 0$) is nearest to: **[2 marks]**




(A) 8

(B) 0.8

(C) 1

(D) 0.5

**Q35.** A **lag compensator** $G_c(s) = \frac{s+z}{s+p}$ with $z > p$ (its pole nearer the origin) is cascaded into a control loop. Its principal purpose is to improve the system's: **[2 marks]**

(A) steady-state accuracy (it raises the low-frequency gain and lowers steady-state error)

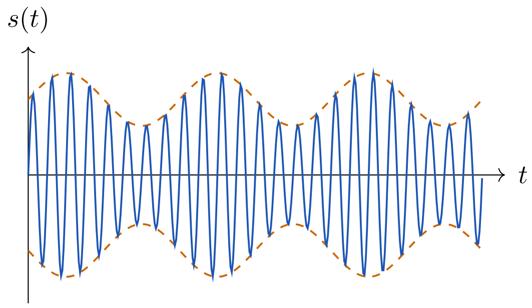
(B) rise time

(C) closed-loop bandwidth

(D) peak time

## Communications

**Q36.** A carrier of power $P_c = 400$ W is amplitude-modulated by a single tone 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]



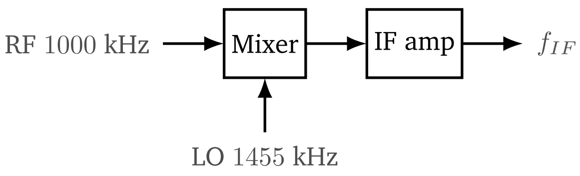

(A) 400 W

(B) 500 W

(C) 450 W

(D) 425 W

**Q37.** A **superheterodyne** AM receiver is tuned to an incoming station at 1000 kHz. Its local oscillator is set above the signal at 1455 kHz, as shown, so the mixer output is down-converted to the fixed intermediate frequency $f_{IF} = |f_{LO} - f_s|$. This intermediate frequency is: [2 marks]




(A) 455 kHz

(B) 1000 kHz

(C) 2455 kHz

(D) 545 kHz

**Q38.** A speech signal band-limited to $5$ kHz is sampled at $10$ kHz and each sample is encoded with $128$ uniform quantisation levels in a PCM system. The output bit rate, (bits per sample) $\times$ (sampling rate), is: **[2 marks]**

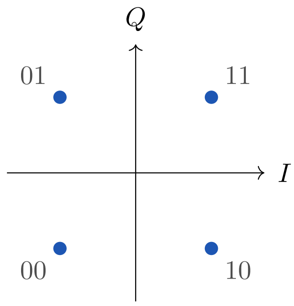
(A) $128$ kbps

(B) $10$ kbps

(C) $7$ kbps

(D) $70$ kbps

**Q39.** A digital link transmits data at a bit rate of $4$ Mbps using QPSK, whose four signal points are shown. Since QPSK carries $2$ bits per symbol, the symbol rate is: **[2 marks]**




(A) $8$ Msym/s

(B) $1$ Msym/s

(C) $4$ Msym/s

(D) $2$ Msym/s

**Q40.** The **superheterodyne** receiver of a station at $f_s = 600$ kHz uses an intermediate frequency of $f_{IF} = 455$ kHz with high-side local-oscillator injection ($f_{LO} = f_s + f_{IF} = 1055$ kHz). The **image frequency**, $f_{im} = f_s + 2f_{IF}$, that the mixer would also translate to the IF is: **[2 marks]**

(A) $600$ kHz

(B) $455$ kHz

(C) $1510$ kHz

(D) $1055$ kHz

**Q41.** A communication channel of bandwidth $B = 4$ kHz has a signal-to-noise ratio of 15 (as a power ratio). By the Shannon–Hartley law $C = B\log_2(1 + \text{SNR})$, the channel capacity is: **[2 marks]**

(A) 4 kbps

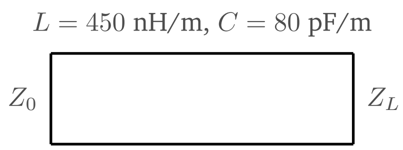
(B) 8 kbps

(C) 64 kbps

(D) 16 kbps

## Electromagnetics

**Q42.** A lossless transmission line has distributed inductance $L = 450$ nH/m and distributed capacitance $C = 80$ pF/m, as indicated. Its characteristic impedance $Z_0 = \sqrt{L/C}$ is: **[2 marks]**




(A) 50 Ω

(B) 75 Ω

(C) 100 Ω

(D) 25 Ω

**Q43.** A transmission line of characteristic impedance $Z_0 = 50\ \Omega$ is terminated in a load $Z_L = 75\ \Omega$. The magnitude of the voltage reflection coefficient, $|\Gamma| = \left|\dfrac{Z_L - Z_0}{Z_L + Z_0}\right|$, at the load is: **[2 marks]**

(A) 0.5

(B) 0.2

(C) 0.333

(D) 1

**Q44.** A quarter-wave transformer is used for **impedance matching** between a 50 Ω feed line and a purely resistive load $Z_L = 200\ \Omega$. The characteristic impedance of the matching section, $Z_1 = \sqrt{Z_0 Z_L}$, must be: **[2 marks]**

(A) $125\ \Omega$

(B) $50\ \Omega$

(C) $200\ \Omega$

(D) $100\ \Omega$

**Q45.** To plot a load on a **Smith chart**, its impedance is first normalised to the line's characteristic impedance. For a load $Z_L = 100 + j50\ \Omega$ on a $50\ \Omega$ line, the normalised load impedance $z_L = Z_L/Z_0$ is: **[2 marks]**

(A) $50 + j25$

(B) $1 + j0.5$

(C) $0.5 + j0.25$

(D) $2 + j1$

**Q46.** A transmission line of characteristic impedance $Z_0 = 50\ \Omega$ is terminated in a matched load $Z_L = 50\ \Omega$. Since the reflection coefficient is $\Gamma = 0$, the voltage standing-wave ratio (VSWR) on the line is: **[2 marks]**

(A) $0$

(B) $1$

(C) $\infty$

(D) $2$

## Detailed Solutions

### Q1.

**Solution**

**Concept – maximum power transfer theorem:** A source with fixed Thevenin resistance delivers the greatest power to its load when the load resistance is made equal to the Thevenin resistance.

**Step 1 – state the matching condition:** The theorem requires $R_L = R_{th}$.

**Step 2 – read the Thevenin resistance from the figure:** $R_{th} = 8\ \Omega$.

**Step 3 – apply the condition:** $R_L = R_{th} = 8\ \Omega$

**Why the other options are wrong:**

- A, $16\ \Omega$ and B, $4\ \Omega$: a mismatched load draws less than the maximum power.
- C, $0\ \Omega$: a short circuit gives maximum current but zero load voltage, so the load power is zero.

**Final Answer:** $R_L = 8\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q1

### Q2.

**Solution**

**Concept – voltage-divider rule:** In a series string the source voltage splits in proportion to the resistances, so the voltage across a resistor is $V_x = V\dfrac{R_x}{R_{total}}$.

**Step 1 – find the total series resistance:** $R_{total} = 4 + 8 = 12\ \Omega$

**Step 2 – form the divider ratio for the $8\ \Omega$ resistor:** $\dfrac{R_x}{R_{total}} = \dfrac{8}{12}$

**Step 3 – multiply by the source voltage:** $V_8 = 12 \times \dfrac{8}{12}$

**Step 4 – evaluate:** $V_8 = 8$ V

**Final Answer:** $V_8 = 8\text{ V} \Rightarrow \boxed{\text{A}}$

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:** $L = 40 \text{ mH} = 40 \times 10^{-3}$ H

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

**Step 2 – form the product $LC$:** $LC = (40 \times 10^{-3}) \times (1 \times 10^{-6})$

$LC = 40 \times 10^{-9} = 4 \times 10^{-8}$

**Step 3 – take the square root:** $\sqrt{LC} = \sqrt{4 \times 10^{-8}} = 2 \times 10^{-4}$

**Step 4 – invert:** $\omega_0 = \dfrac{1}{2 \times 10^{-4}}$

$\omega_0 = 5000$ rad/s

**Final Answer:** $\omega_0 = 5000$ rad/s $\Rightarrow \boxed{\text{A}}$

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

## Q4.

### Solution

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

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

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

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

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

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

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

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

## Q5.

### Solution

**Concept – superposition of source contributions:** In a linear circuit the response due to all sources equals the algebraic sum of the responses due to each source acting alone. Contributions in opposite directions subtract.

**Step 1 – list the two contributions with signs (take upward as positive):** Current source alone: $+6$ A (upward).

Voltage source alone: $-2$ A (downward is negative).

**Step 2 – add algebraically:** $I = (+6) + (-2)$

**Step 3 – evaluate:** $I = +4$ A

**Step 4 – interpret the sign:** A positive result means the net current is $4$ A in the upward direction.

**Final Answer:** $I = 4$ A upward $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** **Go Back to Q5**

## Q6.

### 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:** $R = 5\ \text{k}\Omega = 5 \times 10^3\ \Omega$

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

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

**Step 3 – combine the powers of ten:** $\tau = 20 \times 10^{-3}$

$\tau = 0.02$ s

**Final Answer:** $\tau = 0.02$ s $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** **Go Back to Q6**

## Q7.

### Solution

**Concept – what the Hall effect measures:** When current flows across a magnetic field, the Lorentz force pushes carriers to one side, building a transverse Hall voltage. Its polarity fixes the sign of the carriers and its magnitude fixes their number density.

**Step 1 – relate the Hall voltage to the carriers:** $V_H = \dfrac{IB}{n\,q\,t}$, where $n$ is the carrier concentration and $t$ the sample thickness.

**Step 2 – read off the two pieces of information:** The **sign** of $V_H$ tells whether the carriers are electrons or holes (the carrier type).

The **magnitude** of $V_H$ gives the carrier concentration $n$.

**Step 3 – select the matching option:** Both facts together mean the measurement yields the type and concentration of the charge carriers.

**Why the other options are wrong:**

- A, band gap: comes from optical or thermal measurements, not the Hall voltage.
- B, lifetime: is found from transient photoconductivity, not from a static Hall voltage.
- C, dielectric constant: is a capacitive property unrelated to the Hall voltage.

**Final Answer:** type and concentration of the charge carriers $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

## Q8.

**Solution**

**Concept – drift velocity in an electric field:** In the low-field (ohmic) regime the drift velocity is proportional to the field, $v_d = \mu_n E$.

**Step 1 – list the data:** $\mu_n = 1400 \text{ cm}^2/\text{V}\cdot\text{s}$, $E = 5 \text{ V/cm}$.

**Step 2 – substitute into the formula:** $v_d = 1400 \times 5$

**Step 3 – evaluate:** $v_d = 7000 \text{ cm/s}$

**Step 4 – check the units:** $\dfrac{\text{cm}^2}{\text{V}\cdot\text{s}} \times \dfrac{\text{V}}{\text{cm}} = \dfrac{\text{cm}}{\text{s}}$, which is a velocity. Consistent.

**Final Answer:** $v_d = 7000 \text{ cm/s} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

## Q9.

**Solution**

**Concept – relation between $\alpha$ and $\beta$ of a BJT:** The common-emitter gain is obtained from the common-base gain by $\beta = \dfrac{\alpha}{1-\alpha}$.

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

**Step 2 – divide:** $\beta = \dfrac{0.98}{0.02}$

**Step 3 – evaluate:** $\beta = 49$

**Why the other options are wrong:**

- A, 98: uses $\alpha/(1-\alpha)$ with a wrong factor of 10 in the denominator.

- C, $0.98$: is $\alpha$ itself, not $\beta$.
- D, $100$: is only a rounded guess, not $0.98/0.02$.

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

**Answer: (B)** 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:** $V_{GS} - V_t = 5 - 1 = 4$ V

**Step 2 – square the overdrive:** $(V_{GS} - V_t)^2 = 4^2 = 16$ V$^2$

**Step 3 – substitute into the current equation:** $I_D = \frac{1}{2} \times (0.5\ \text{mA/V}^2) \times 16$

**Step 4 – multiply step by step:** $\frac{1}{2} \times 0.5 = 0.25$

$I_D = 0.25 \times 16$

$I_D = 4$ mA

**Final Answer:** $I_D = 4$ mA $\Rightarrow \boxed{\text{C}}$

**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, $n = 5 \times 10^{16}$ cm$^{-3}$, $\mu_n = 800$ cm$^2$/V $\cdot$ s.

**Step 2 – multiply charge and concentration:** $q\,n = (1.6 \times 10^{-19}) \times (5 \times 10^{16})$

$q\,n = 8 \times 10^{-3}$

**Step 3 – multiply by the mobility:** $\sigma = (8 \times 10^{-3}) \times 800$

**Step 4 – evaluate:** $\sigma = 6.4$ S/cm

**Final Answer:** $\sigma = 6.4$ S/cm $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** 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:** $R_f = 100\ \text{k}\Omega$, $R_1 = 25\ \text{k}\Omega$.

**Step 2 – form the ratio:** $|A_v| = \frac{100\ \text{k}\Omega}{25\ \text{k}\Omega}$

**Step 3 – evaluate:** $|A_v| = 4$

**Why the other options are wrong:**

- B, $125$: adds the resistances instead of dividing them.
- C, $0.25$: inverts the ratio $R_1/R_f$.
- D, $40$: misplaces a factor of ten.

**Final Answer:** $|A_v| = 4 \Rightarrow \boxed{\text{A}}$

**Answer: (A)** 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:** $\frac{R_f}{R_1} = \frac{40\ \text{k}\Omega}{10\ \text{k}\Omega} = 4$

**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.
- B, $41$: wrongly uses $R_f/R_1 = 40$.
- D, $0.2$: inverts the ratio.

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

**Answer: (C)** Go Back to Q13

## Q14.

**Solution**

**Concept – efficiency of a series-fed Class A amplifier:** In a Class A stage the active device conducts for the whole cycle and carries a steady d.c. bias current even with no signal, which caps the a.c.-to-d.c. conversion efficiency.

**Step 1 – write the theoretical maximum:** For a direct (series-fed) Class A stage the best-case efficiency is $\eta_{\max} = 25\%$.

**Step 2 – reason why it is so low:** Even at full drive, half the supply power is lost as constant quiescent dissipation in the device, so no more than a quarter of the d.c. input reaches the load as signal power.

**Why the other options are wrong:**

- A, $50\%$: is the ceiling for a **transformer-coupled** Class A stage, not the series-fed one.
- C, $78.5\%$: is the Class B push-pull maximum.
- D, $100\%$: would need zero device dissipation, which Class A never achieves.

**Final Answer:** $\eta_{\max} = 25\% \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q14

## Q15.

**Solution**

**Concept – efficiency of a Class B push-pull amplifier:** Each transistor conducts for one half-cycle only, so there is no standing quiescent dissipation and the efficiency is much higher than Class A.

**Step 1 – write the theoretical maximum:** $\eta_{\max} = \dfrac{\pi}{4}$

**Step 2 – substitute $\pi \approx 3.1416$:** $\eta_{\max} = \dfrac{3.1416}{4}$

**Step 3 – evaluate:** $\eta_{\max} = 0.785 = 78.5\%$

**Why the other options are wrong:**

- A, $25\%$ and B, $50\%$: are the Class A (series-fed and transformer-coupled) limits.
- C, $100\%$: is unattainable because the transistor drop and residual dissipation remain.

**Final Answer:** $\eta_{\max} = 78.5\% \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

## Q16.

### Solution

**Concept – gain–bandwidth product:** For a single-pole op-amp the product of closed-loop gain and closed-loop bandwidth is constant and equal to the unity-gain frequency: GBW $= A_{CL} \times$ BW.

**Step 1 – list the data:** GBW $= 10$ MHz, $A_{CL} = 50$.

**Step 2 – solve for the bandwidth:** BW $= \dfrac{\text{GBW}}{A_{CL}} = \dfrac{10\text{ MHz}}{50}$

**Step 3 – evaluate:** BW $= 0.2$ MHz

**Step 4 – convert to kHz:** BW $= 200$ kHz

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

Answer: (C) Go Back to Q16

## Q17.

### Solution

**Concept – crossover distortion:** Crossover distortion is the flat spot in the output near the zero crossing that appears when both output devices are momentarily off because neither base–emitter junction has yet reached its turn-on voltage.

**Step 1 – identify the biasing described:** The two transistors are biased right at cut-off, each conducting for only one half-cycle. That is the defining bias of a **Class B** push-pull stage.

**Step 2 – link the bias to the distortion:** Near the zero crossing, for input magnitudes below about $0.7$ V neither transistor conducts, so the output stays at zero and the waveform is distorted there.

**Step 3 – name the class:** This is inherent to **Class B** operation.

**Why the other options are wrong:**

- A, Class A: conducts for the full cycle, so there is no dead zone and no crossover distortion.
- C, Class C: conducts for less than half a cycle and is used for tuned RF, a different distortion picture.
- D, Class AB: adds a small forward bias precisely to **remove** crossover distortion, so it is not the class that exhibits it.

**Final Answer:** Class B $\Rightarrow$ $\boxed{\text{B}}$

**Answer: (B)** Go Back to Q17

## Q18.

### Solution

**Concept – small-signal gain of a CE amplifier:** The magnitude of the voltage gain is $|A_v| = g_m R_C$, with transconductance $g_m = \dfrac{I_C}{V_T}$.

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

$g_m = 0.04 \text{ S} = 40 \text{ mS}$

**Step 2 – list the collector resistance:** $R_C = 2.5 \text{ k}\Omega = 2500 \ \Omega$

**Step 3 – multiply to get the gain:** $|A_v| = 0.04 \times 2500$

**Step 4 – evaluate:** $|A_v| = 100$

**Final Answer:** $|A_v| = 100 \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q18

## Q19.

### Solution

**Concept – binary to decimal conversion:** Each bit weight is a power of two; sum the weights where the bit is 1.

**Step 1 – write the place values for** $(10110)_2$**:** Bits (MSB to LSB): $1, 0, 1, 1, 0$ with weights $16, 8, 4, 2, 1$.

**Step 2 – keep only the weights where the bit is** $1$**:** $16$ (bit $= 1$), $8$ (bit $= 0$, skip), $4$ (bit $= 1$), $2$ (bit $= 1$), $1$ (bit $= 0$, skip).

**Step 3 – add the retained weights:** $16 + 4 + 2$

**Step 4 – evaluate:** $= 22$

**Final Answer:** $(10110)_2 = 22 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q19

## Q20.

**Solution**

**Concept – Boolean simplification by factoring:** Terms that differ in only one variable and cover both its states combine, using $B + \bar{B} = 1$.

**Step 1 – factor out the common variable** $A$**:** $Y = AB + A\bar{B} = A(B + \bar{B})$

**Step 2 – apply the complement law:** $B + \bar{B} = 1$

**Step 3 – substitute:** $Y = A \times 1$

**Step 4 – simplify:** $Y = A$

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

Answer: (A) Go Back to Q20

## Q21.

**Solution**

**Concept – DAC resolution:** The analog step size (resolution) of an $n$-bit converter is the full-scale reference divided by the number of steps, $\frac{V_{ref}}{2^n}$.

**Step 1 – find the number of steps:** $2^n = 2^8 = 256$

**Step 2 – divide the reference by the number of steps:** $\text{resolution} = \frac{2.56 \text{ V}}{256}$

**Step 3 – evaluate:** $\text{resolution} = 0.01 \text{ V}$

**Step 4 – convert to millivolts:** $0.01 \text{ V} = 10 \text{ mV}$

**Final Answer:** $\text{resolution} = 10 \text{ mV} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

## Q22.

**Solution**

**Concept – number of quantisation levels of an ADC:** An $n$-bit converter produces $2^n$ distinct output codes.

**Step 1 – identify the number of bits:** $n = 12$

**Step 2 – raise two to that power:** $2^{12} = 2^{10} \times 2^2 = 1024 \times 4$

**Step 3 – evaluate:** $2^{12} = 4096$

**Why the other options are wrong:**

- A, $1024$: is $2^{10}$ (a $10$-bit converter).

- C, $2048$: is $2^{11}$ (an $11$-bit converter).
- D, $12$: is just the bit count, not the number of levels.

**Final Answer:** $2^{12} = 4096$ levels $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

## Q23.

### Solution

**Concept – quantisation error of an ideal rounding quantiser:** When each input is rounded to the nearest code, the largest distance from any input to its code is half of one step.

**Step 1 – set up one quantisation interval:** A step covers one LSB in width; the decision levels sit at the midpoints between adjacent codes.

**Step 2 – find the worst-case distance:** An input exactly at a midpoint is half a step from the nearest code, so the maximum error magnitude is $\frac{1}{2}$ LSB.

**Step 3 – include the sign:** The error can be positive or negative, giving $\pm\frac{1}{2}$ LSB.

**Why the other options are wrong:**

- B, $\pm1$ LSB and C, $\pm2$ LSB: overstate the worst case; rounding never misses by a full step.
- D, $0$: even an ideal quantiser has finite step size, so it cannot be error-free.

**Final Answer:** $\pm\frac{1}{2}$ LSB $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

## Q24.

### Solution

**Concept – comparators in a flash ADC:** A flash converter compares the input against every internal reference tap at once; an $n$-bit flash needs $2^n - 1$ comparators.

**Step 1 – find the number of levels:** $2^n = 2^3 = 8$

**Step 2 – subtract one:** $2^n - 1 = 8 - 1$

**Step 3 – evaluate:** $= 7$ comparators

**Why the other options are wrong:**

- A, $8$: counts the levels, one too many (the top reference needs no separate comparator).
- B, $3$: is the bit count, not the comparator count.
- D, $15$: is $2^4 - 1$, the count for a $4$-bit flash.

**Final Answer:** $7$ comparators $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q24

## Q25.

### Solution

**Concept – BIBO stability condition:** A bounded input produces a bounded output for every bounded input if and only if the impulse response is absolutely integrable.

**Step 1 – write the output as a convolution:** $y(t) = \displaystyle\int_{-\infty}^{\infty} h(\tau)\, x(t-\tau)\, d\tau$

**Step 2 – bound the output magnitude:** If $|x(t)| \le M$ for all $t$, then $|y(t)| \le M \displaystyle\int_{-\infty}^{\infty} |h(\tau)|\, d\tau$.

**Step 3 – state the requirement:** The output stays bounded for every bounded input exactly when $\displaystyle\int_{-\infty}^{\infty} |h(t)|\, dt < \infty$, i.e. $h(t)$ is absolutely integrable.

**Why the other options are wrong:**

- B, periodic: a periodic impulse response is not integrable and would be unstable.
- C, finite duration: is sufficient but not necessary; many stable systems have infinite-length $h(t)$.
- D, causal: concerns realisability, not stability.

**Final Answer:** $h(t)$ absolutely integrable $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q25

## Q26.

### Solution

**Concept – d.c. gain of a transfer function:** The d.c. (steady-state) gain is the value of $H(s)$ at $s = 0$. Both poles lie in the left half-plane, so the system is stable and $H(0)$ is finite.

**Step 1 – set $s = 0$ in the transfer function:** $H(0) = \dfrac{6}{(0+2)(0+3)}$

**Step 2 – evaluate the denominator factors:** $(0+2) = 2$ and $(0+3) = 3$

**Step 3 – multiply the denominator:** $2 \times 3 = 6$

**Step 4 – divide:** $H(0) = \dfrac{6}{6} = 1$

**Why the other options are wrong:**

- B, 6: uses only the numerator and ignores the denominator product.
- C, 0.5 and D, 2: come from mis-multiplying the pole factors.

**Final Answer:** $H(0) = 1 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q26

## Q27.

**Solution**

**Concept – sum of an infinite geometric series:** For $|r| < 1$, $\displaystyle\sum_{n=0}^{\infty} r^n = \frac{1}{1-r}$.

**Step 1 – identify the ratio:** Here $r = 0.8$, and $u[n]$ restricts the sum to $n \geq 0$.

**Step 2 – write the series:** $\displaystyle\sum_{n=0}^{\infty} (0.8)^n$

**Step 3 – apply the closed form:** $= \dfrac{1}{1-0.8}$

**Step 4 – form the denominator:** $1 - 0.8 = 0.2$

**Step 5 – divide:** $= \dfrac{1}{0.2} = 5$

**Final Answer:** sum $= 5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q27

## Q28.

**Solution**

**Concept – average power of a sinusoid:** For $x(t) = A\cos(\omega_0 t)$ across a $1\ \Omega$ resistor the average power equals the mean-square value, $\dfrac{A^2}{2}$.

**Step 1 – identify the amplitude:** $A = 6$ V

**Step 2 – square the amplitude:** $A^2 = 6^2 = 36$

**Step 3 – halve it:** $P = \dfrac{36}{2}$

**Step 4 – evaluate:** $P = 18$ W

**Why the other options are wrong:**

- B, 36: forgets the factor $\frac{1}{2}$ (that is the peak, not the average, power).
- C, 9: halves twice.
- D, 6: is just the amplitude.

**Final Answer:** $P = 18 \text{ W} \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q28

## Q29.

**Solution**

**Concept – length of a linear convolution:** Convolving sequences of lengths $N_1$ and $N_2$ gives a sequence of length $N_1 + N_2 - 1$.

**Step 1 – list the two lengths:** $N_1 = 5$, $N_2 = 8$.

**Step 2 – add the lengths:** $N_1 + N_2 = 5 + 8 = 13$

**Step 3 – subtract one:** $13 - 1 = 12$

**Why the other options are wrong:**

- A, 13: forgets to subtract the overlap of one sample.
- B, 40: multiplies the lengths instead of adding.
- D, 8: is only the longer input length.

**Final Answer:** length $= 12 \Rightarrow \boxed{\text{C}}$

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

## Q30.

**Solution**

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

**Step 1 – identify the maximum signal frequency:** $f_m = 10$ kHz

**Step 2 – apply the Nyquist rule:** $f_s^{\min} = 2f_m$

**Step 3 – substitute:** $f_s^{\min} = 2 \times 10$ kHz

**Step 4 – evaluate:** $f_s^{\min} = 20$ kHz

**Final Answer:** $f_s^{\min} = 20 \text{ kHz} \Rightarrow \boxed{\text{C}}$

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

## Q31.

**Solution**

**Concept – damping ratio from the characteristic equation:** Compare $s^2+6s+9$ with the standard form $s^2 + 2\zeta\omega_n s + \omega_n^2$.

**Step 1 – match the constant term to $\omega_n^2$:** $\omega_n^2 = 9$, so $\omega_n = 3$ rad/s.

**Step 2 – match the $s$ coefficient to $2\zeta\omega_n$:** $2\zeta\omega_n = 6$

**Step 3 – solve for $\zeta$:** $\zeta = \dfrac{6}{2\omega_n} = \dfrac{6}{2\times 3}$

**Step 4 – evaluate:** $\zeta = \dfrac{6}{6} = 1$

**Step 5 – interpret:** $\zeta = 1$ means the system is critically damped.

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

**Answer: (A)** Go Back to Q31

## Q32.

**Solution**

**Concept – Routh–Hurwitz test for right-half-plane poles:** Build the Routh array; the number of sign changes in the first column equals the number of roots in the right half-plane.

**Step 1 – write the first two rows from $s^3+s^2+2s+8$:** $s^3$ row: 1 2

$s^2$ row: 1 8

**Step 2 – compute the $s^1$ row entry:** $\dfrac{(1)(2)-(1)(8)}{1} = \dfrac{2-8}{1} = -6$

So the $s^1$ row is $-6$.

**Step 3 – compute the $s^0$ row entry:** The last coefficient carries down: $s^0$ row $= 8$.

**Step 4 – list the first column:** $1,\ 1,\ -6,\ 8$

**Step 5 – count the sign changes:** $1 \to 1$: no change. $1 \to -6$: one change. $-6 \to 8$: one change. Total $= 2$.

**Step 6 – conclude:** Two sign changes mean two right-half-plane poles, so the system is unstable.

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

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

## Q33.

### Solution

**Concept – role of the integral term in a PID controller:** The integral action accumulates the error over time and keeps acting until the accumulated error is driven to zero.

**Step 1 – write the integral action:** $u_i(t) = K_i \int_0^t e(\tau)\, d\tau$

**Step 2 – reason about the steady state:** At steady state the controller output settles to a constant only if $e(t) \to 0$; any residual constant error would keep integrating and force further correction.

**Step 3 – identify what is reduced:** The integral term therefore drives the **steady-state error** to zero (it raises the system type by one).

**Why the other options are wrong:**

- A, rise time: is chiefly shortened by the proportional (and to a degree derivative) action.
- B, bandwidth: is not the primary target of the integral term; in fact integral action tends to act at low frequencies.
- D, gain margin: integral action usually **reduces** phase margin/gain margin, so it does not improve them.

**Final Answer:** steady-state error $\Rightarrow$ $\boxed{\text{C}}$

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

## Q34.

### Solution

**Concept – d.c. gain of a closed loop:** For unity feedback, $\dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)}$; evaluate it at $s = 0$.

**Step 1 – find the forward-path d.c. gain:** $G(0) = \dfrac{8}{0+2} = \dfrac{8}{2} = 4$

**Step 2 – form the closed-loop numerator:** Numerator $= G(0) = 4$

**Step 3 – form the closed-loop denominator:** $1 + G(0) = 1 + 4 = 5$

**Step 4 – divide:** $\left.\dfrac{C}{R}\right|_{s=0} = \dfrac{4}{5}$
**Step 5 – evaluate:** $= 0.8$

**Why the other options are wrong:**

- A, $8$: is just the numerator of $G$, not the closed-loop gain.
- C, $1$: would need $G(0) \to \infty$ (an integrator in the loop).
- D, $0.5$: comes from a wrong denominator.

**Final Answer:** d.c. gain $= 0.8 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q34

## Q35.

### Solution

**Concept – purpose of a lag compensator:** A lag network adds gain at low frequencies while leaving the crossover region largely unchanged, so it mainly sharpens steady-state performance.

**Step 1 – describe its low-frequency effect:** With its pole nearer the origin than its zero, the lag compensator has a magnitude greater than one at low frequency, boosting the open-loop d.c. gain.

**Step 2 – link higher d.c. gain to steady-state error:** A larger low-frequency (error-constant) gain reduces the steady-state error for step and ramp inputs, i.e. it improves steady-state accuracy.

**Step 3 – note the transient trade-off:** It is designed to add little phase lag near crossover, so it barely disturbs the transient response while it fixes accuracy.

**Why the other options are wrong:**

- B, rise time and D, peak time: are transient measures better improved by a **lead** compensator.
- C, bandwidth: a lag compensator tends to **lower** the bandwidth, not improve it.

**Final Answer:** improves steady-state accuracy $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q35

## Q36.

### Solution

**Concept – total power in an AM signal:** For tone modulation the total transmitted power is $P_t = P_c(1 + \frac{\mu^2}{2})$, where $P_c$ is the carrier power.

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

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

**Step 3 – add one:** $1 + 0.125 = 1.125$

**Step 4 – multiply by the carrier power:** $P_t = 400 \times 1.125$

**Step 5 – evaluate:** $P_t = 450$ W

**Why the other options are wrong:**

- A, 400: is only the carrier power (ignores the sidebands).
- B, 500: uses $\mu = 1$ instead of 0.5.
- D, 425: forgets to halve $\mu^2$.

**Final Answer:** $P_t = 450 \text{ W} \Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q36

## Q37.

### Solution

**Concept – intermediate frequency of a superheterodyne receiver:** The mixer produces the difference between the local-oscillator and signal frequencies, $f_{IF} = |f_{LO} - f_s|$.

**Step 1 – list the two frequencies:** $f_{LO} = 1455$ kHz, $f_s = 1000$ kHz.

**Step 2 – take the difference:** $f_{IF} = 1455 - 1000$

**Step 3 – evaluate:** $f_{IF} = 455$ kHz

**Step 4 – sanity check:** 455 kHz is the standard AM broadcast IF, confirming the result.

**Why the other options are wrong:**

- B, 1000 kHz: is the signal frequency itself.
- C, 2455 kHz: is the **sum** $f_{LO} + f_s$, which the IF filter rejects.
- D, 545 kHz: is not the difference of the two given values.

**Final Answer:** $f_{IF} = 455 \text{ kHz} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q37

## Q38.

**Solution**

**Concept – PCM bit rate:** The bit rate equals the number of bits per sample times the sampling rate, $R_b = n\,f_s$, with $n = \log_2 L$ for $L$ levels.

**Step 1 – find the bits per sample:** $n = \log_2 128 = 7$ bits

**Step 2 – list the sampling rate:** $f_s = 10$ kHz

**Step 3 – multiply:** $R_b = 7 \times 10$ kHz

**Step 4 – evaluate:** $R_b = 70$ kbps

**Why the other options are wrong:**

- A, 128 kbps: multiplies by the number of levels instead of the bits per sample.
- B, 10 kbps: is only the sampling rate.
- C, 7 kbps: is only the bits per sample.

**Final Answer:** $R_b = 70$ kbps $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q38

## Q39.

**Solution**

**Concept – symbol rate of a QPSK link:** QPSK carries 2 bits per symbol, so the symbol rate is the bit rate divided by two, $R_s = R_b/2$.

**Step 1 – list the bit rate:** $R_b = 4$ Mbps

**Step 2 – divide by the bits per symbol:** $R_s = \dfrac{4\text{ Mbps}}{2}$

**Step 3 – evaluate:** $R_s = 2$ Msym/s

**Why the other options are wrong:**

- A, 8 Msym/s: multiplies instead of dividing.
- B, 1 Msym/s: divides by four (as if 4 bits/symbol).
- C, 4 Msym/s: equals the bit rate, ignoring the 2 bits/symbol.

**Final Answer:** $R_s = 2$ Msym/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q39

## Q40.

**Solution**

**Concept – image frequency in a superheterodyne receiver:** With high-side injection the image lies one full IF above the local oscillator, i.e. $f_{im} = f_{LO} + f_{IF} = f_s + 2f_{IF}$.

**Step 1 – confirm the local-oscillator frequency:** $f_{LO} = f_s + f_{IF} = 600 + 455 = 1055$ kHz

**Step 2 – add one more IF to reach the image:** $f_{im} = f_{LO} + f_{IF} = 1055 + 455$

**Step 3 – evaluate:** $f_{im} = 1510$ kHz

**Step 4 – cross-check with $f_s + 2f_{IF}$:** $600 + 2 \times 455 = 600 + 910 = 1510$ kHz. Consistent.

**Why the other options are wrong:**

- A, 600 kHz: is the wanted signal, not the image.
- B, 455 kHz: is the IF.
- D, 1055 kHz: is the local-oscillator frequency.

**Final Answer:** $f_{im} = 1510$ kHz $\Rightarrow \boxed{\text{C}}$

$\boxed{\text{Answer: (C)}}$ Go Back to Q40

## Q41.

**Solution**

**Concept – Shannon–Hartley channel capacity:** $C = B\log_2(1 + \text{SNR})$, with the SNR taken as a power ratio.

**Step 1 – form the term inside the logarithm:** $1 + \text{SNR} = 1 + 15 = 16$

**Step 2 – take the base-2 logarithm:** $\log_2 16 = 4$

**Step 3 – multiply by the bandwidth:** $C = 4$ kHz $\times 4$

**Step 4 – evaluate:** $C = 16$ kbps

**Why the other options are wrong:**

- A, 4 kbps: uses $\log_2$ of 2 instead of 16.
- B, 8 kbps: uses $\log_2 4 = 2$.
- C, 64 kbps: multiplies $B$ by SNR directly instead of by its logarithm.

**Final Answer:** $C = 16$ kbps $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q41

## Q42.

**Solution**

**Concept – characteristic impedance of a lossless line:** $Z_0 = \sqrt{\dfrac{L}{C}}$, using the per-metre inductance and capacitance.

**Step 1 – convert the values to base units:** $L = 450\ \text{nH/m} = 450 \times 10^{-9}\ \text{H/m}$

$C = 80\ \text{pF/m} = 80 \times 10^{-12}\ \text{F/m}$

**Step 2 – form the ratio $L/C$:** $\dfrac{L}{C} = \dfrac{450 \times 10^{-9}}{80 \times 10^{-12}}$

**Step 3 – simplify the powers of ten:** $\dfrac{450}{80} \times 10^{-9+12} = 5.625 \times 10^{3} = 5625$

**Step 4 – take the square root:** $Z_0 = \sqrt{5625}$

**Step 5 – evaluate:** $Z_0 = 75\ \Omega$

**Final Answer:** $Z_0 = 75\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q42

## Q43.

**Solution**

**Concept – reflection coefficient at a load:** $\Gamma = \dfrac{Z_L - Z_0}{Z_L + Z_0}$; its magnitude measures how much of the incident wave is reflected.

**Step 1 – form the numerator:** $Z_L - Z_0 = 75 - 50 = 25$

**Step 2 – form the denominator:** $Z_L + Z_0 = 75 + 50 = 125$

**Step 3 – divide:** $\Gamma = \dfrac{25}{125}$

**Step 4 – evaluate:** $\Gamma = 0.2$

**Step 5 – take the magnitude:** Both quantities are real and positive, so $|\Gamma| = 0.2$.

**Final Answer:** $|\Gamma| = 0.2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q43

## Q44.

**Solution**

**Concept – quarter-wave impedance transformer:** A $\lambda/4$ section matches a real load to a line when its characteristic impedance is the geometric mean, $Z_1 = \sqrt{Z_0 Z_L}$.

**Step 1 – form the product of the two impedances:** $Z_0 Z_L = 50 \times 200 = 10000$

**Step 2 – take the square root:** $Z_1 = \sqrt{10000}$

**Step 3 – evaluate:** $Z_1 = 100\ \Omega$

**Why the other options are wrong:**

- A, $125\ \Omega$: is the arithmetic mean, not the geometric mean.
- B, $50\ \Omega$ and C, $200\ \Omega$: are the line and load values themselves, which do not match the two ends.

**Final Answer:** $Z_1 = 100\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q44

## Q45.

**Solution**

**Concept – normalising impedance for the Smith chart:** Every impedance is divided by the line's characteristic impedance before it is plotted: $z_L = \dfrac{Z_L}{Z_0}$.

**Step 1 – write the load and reference:** $Z_L = 100 + j50\ \Omega$, $Z_0 = 50\ \Omega$.

**Step 2 – divide the real part:** $\dfrac{100}{50} = 2$

**Step 3 – divide the imaginary part:** $\dfrac{50}{50} = 1$

**Step 4 – recombine:** $z_L = 2 + j1$

**Why the other options are wrong:**

- A, $50 + j25$: multiplies by $Z_0$ instead of dividing.
- B, $1 + j0.5$: divides by $100$, not by $50$.
- C, $0.5 + j0.25$: divides by $200$.

**Final Answer:** $z_L = 2 + j1 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q45

## Q46.

### Solution

**Concept – VSWR of a matched line:** $\text{VSWR} = \dfrac{1+|\Gamma|}{1-|\Gamma|}$. When the load equals the line impedance there is no reflection.

**Step 1 – find the reflection coefficient:** $\Gamma = \dfrac{Z_L - Z_0}{Z_L + Z_0} = \dfrac{50-50}{50+50} = \dfrac{0}{100} = 0$

**Step 2 – substitute into the VSWR formula:** $\text{VSWR} = \dfrac{1+0}{1-0}$

**Step 3 – evaluate:** $\text{VSWR} = \dfrac{1}{1} = 1$

**Step 4 – interpret:** $\text{VSWR} = 1$ is the ideal matched condition, with no standing wave on the line.

**Why the other options are wrong:**

- A, $0$: VSWR can never be less than $1$.
- C, $\infty$: corresponds to a total reflection (open or short), the opposite of a match.
- D, $2$: would require $|\Gamma| = \frac{1}{3}$, i.e. a mismatch.

**Final Answer:** $\text{VSWR} = 1 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q46

# Answer Key

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