GATE Electronics and Communication Engineering

Sample Paper – 7

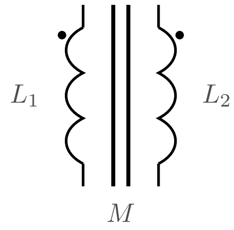
Duration: 128 Minutes **Maximum Marks: 72**

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 magnetically coupled coils have self-inductances $L_1 = 2$ H and $L_2 = 8$ H and a mutual inductance $M = 3$ H, as shown by the dot markings. The coefficient of coupling $k = M/\sqrt{L_1 L_2}$ is: **[1 mark]**



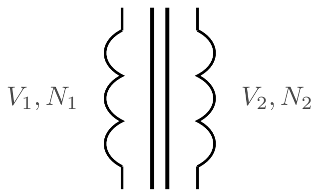
(A) 0.375

(B) 0.5

(C) 0.75

(D) 1.0

Q2. An ideal transformer has primary and secondary turns $N_1 = 200$ and $N_2 = 1000$, as shown. If the primary is driven by $V_1 = 12$ V, the secondary voltage $V_2 = V_1(N_2/N_1)$ is: **[1 mark]**



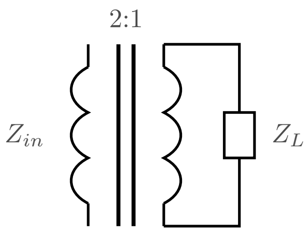
(A) 2.4 V

(B) 12 V

(C) 6 V

(D) 60 V

Q3. An ideal transformer with turns ratio $N_1 : N_2 = 2 : 1$ is terminated in a load $Z_L = 100\ \Omega$ on its secondary, as shown. The impedance Z_{in} seen at the primary, $Z_{in} = (N_1/N_2)^2 Z_L$, is: **[1 mark]**



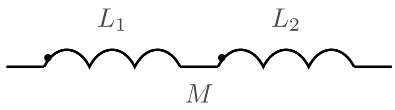
(A) 25 Ω

(B) 100 Ω

(C) $400\ \Omega$

(D) $50\ \Omega$

Q4. Two series-connected coupled coils are wound so that their fluxes aid (dots at the same end), as shown. With $L_1 = 3$ H, $L_2 = 5$ H and $M = 2$ H, the equivalent inductance $L_{eq} = L_1 + L_2 + 2M$ is: **[1 mark]**



(A) 8 H

(B) 12 H

(C) 4 H

(D) 10 H

Q5. The same two coils of the previous type are now connected in series-opposing (one dot reversed). With $L_1 = 6$ H, $L_2 = 4$ H and $M = 3$ H, the equivalent inductance $L_{eq} = L_1 + L_2 - 2M$ is: **[1 mark]**

(A) 16 H

(B) 4 H

(C) 10 H

(D) 7 H

Q6. An ideal transformer is used to match a source of internal resistance $R_s = 50\ \Omega$ to a load $R_L = 8\ \Omega$ for maximum power transfer. The required turns ratio $N_1 : N_2 = \sqrt{R_s/R_L}$ is nearest to: **[1 mark]**

(A) 6.25

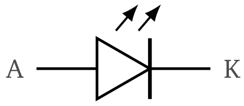
(B) 0.4

(C) 1.25

(D) 2.5

Electronic Devices

Q7. A light-emitting diode (LED) is fabricated from a direct-gap semiconductor of band gap $E_g = 2.0$ eV, as symbolised below. The peak wavelength of the emitted light, $\lambda = 1240/E_g(\text{eV})$ nm, is nearest to: **[1 mark]**



(A) 1240 nm

(B) 248 nm

(C) 310 nm

(D) 620 nm

Q8. A silicon solar cell has open-circuit voltage $V_{oc} = 0.5$ V, short-circuit current $I_{sc} = 35$ mA, and at its maximum-power point $V_{mp} = 0.4$ V, $I_{mp} = 30$ mA. The fill factor $FF = (V_{mp}I_{mp})/(V_{oc}I_{sc})$ is nearest to: **[1 mark]**

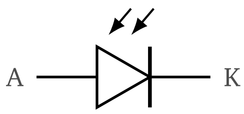
(A) 0.50

(B) 0.686

(C) 0.343

(D) 0.857

Q9. A reverse-biased photodiode (symbol shown) receives an optical power of 2 mW and produces a photocurrent of 0.9 mA. Its responsivity $R = I_{ph}/P_{opt}$ is: **[1 mark]**



(A) 0.9 A/W

(B) 2.22 A/W

(C) 0.45 A/W

(D) 0.18 A/W

Q10. A photodiode has a responsivity of $R = 0.5$ A/W at an operating wavelength of $\lambda = 800$ nm. Using $\eta = R\,(1.24/\lambda_{\mu\text{m}})$ with λ in micrometres, the external quantum efficiency η is nearest to: **[1 mark]**

(A) 0.50

(B) 0.775

(C) 0.62

(D) 1.00

Q11. A silicon photodetector must respond to photons whose energy exceeds the band gap $E_g = 1.1$ eV. The longest wavelength it can detect (the cut-off wavelength), $\lambda_c = 1240/E_g(\text{eV})$ nm, is nearest to: **[1 mark]**

(A) 0.55 μm

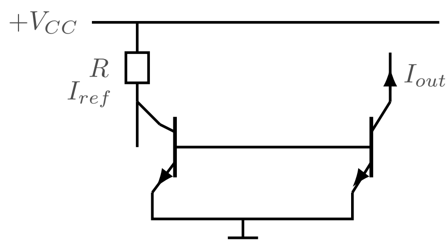
(B) 1.13 μm

(C) 2.26 μm

(D) 0.89 μm

Analog Circuits

Q12. In the basic BJT current mirror shown, the reference resistor $R = 93$ kΩ is tied from $V_{CC} = 10$ V to the diode-connected transistor ($V_{BE} = 0.7$ V). Neglecting base currents, the output (mirrored) current $I_{out} \approx I_{ref} = (V_{CC} - V_{BE})/R$ is: **[1 mark]**



(A) 1 mA

(B) 10 μA

(C) 50 μA

(D) 100 μA

Q13. The output transistor of a current mirror has an Early voltage $V_A = 50$ V and carries a collector current $I_C = 0.5$ mA. Its small-signal output resistance $r_o = V_A/I_C$ (which sets the mirror's output resistance) is: **[1 mark]**

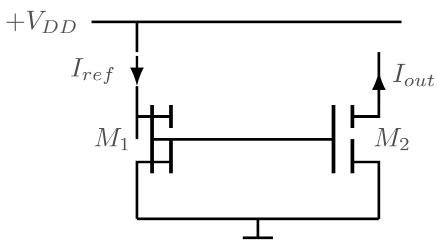
(A) 25 kΩ

(B) 50 kΩ

(C) 100 kΩ

(D) 250 kΩ

Q14. In the MOSFET current mirror shown, both devices share the same V_{GS}, and the output transistor has an aspect ratio four times that of the reference transistor. With $I_{ref} = 100\ \mu$A, the output current $I_{out} = (W/L)_2/(W/L)_1 \times I_{ref}$ is: **[1 mark]**



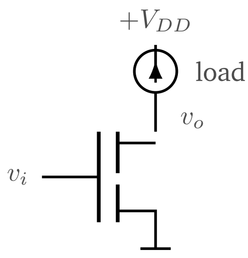
(A) 25 μA

(B) 100 μA

(C) 200 μA

(D) 400 μA

Q15. A common-source amplifier uses an ideal current source as an active load, as shown. The transistor has $g_m = 1$ mA/V and output resistance $r_{on} = 100$ kΩ, and the load presents $r_{op} = 100$ kΩ. The small-signal gain magnitude $|A_v| = g_m(r_{on} \| r_{op})$ is: **[1 mark]**



(A) 50

(B) 100

(C) 25

(D) 10

Q16. A cascode current mirror boosts the output resistance to $R_{out} \approx g_m r_o^2$. Taking $g_m = 2$ mA/V and $r_o = 100$ kΩ for the cascode device, the output resistance is nearest to: **[1 mark]**

(A) 100 kΩ

(B) 20 MΩ

(C) 200 kΩ

(D) 2 MΩ

Q17. In a basic two-transistor BJT current mirror the finite current gain β introduces a base-current error, giving $I_{out}/I_{ref} = 1/(1 + 2/\beta)$. For $\beta = 100$ and $I_{ref} = 1$ mA, the output current is nearest to: **[1 mark]**

(A) 1.00 mA

(B) 1.02 mA

(C) 0.50 mA

(D) 0.98 mA

Q18. A common-source amplifier loaded by a current-source (active) load has a small-signal voltage gain magnitude $|A_v| = g_m r_o$, where r_o is the net output resistance. With $g_m = 5$ mA/V and $r_o = 40$ kΩ, the gain magnitude is: **[1 mark]**

(A) 50

(B) 200

(C) 100

(D) 40

Digital Circuits

Q19. A ring counter is built by connecting flip-flops in a loop so that a single 1 circulates through them. The number of distinct states of a 4-flip-flop ring counter is: **[1 mark]**

(A) 4

(B) 16

(C) 8

(D) 2

Q20. A Johnson (twisted-ring) counter feeds the complemented output of the last flip-flop back to the first. The number of distinct states of a 4-flip-flop Johnson counter, $2n$, is: **[1 mark]**

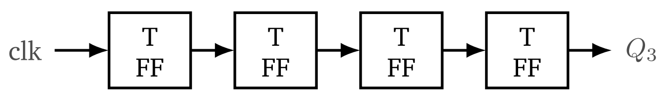
(A) 8

(B) 4

(C) 16

(D) 3

Q21. Four negative-edge-triggered T flip-flops (each with $T = 1$) are cascaded so that each one clocks the next, as shown. If the input clock frequency is 16 kHz, the frequency at the output of the last flip-flop is: **[2 marks]**



each stage divides by 2

(A) 4 kHz

(B) 16 kHz

(C) 1 kHz

(D) 8 kHz

Q22. A finite-state machine (Mealy type) requires 5 distinct internal states. Using binary state encoding, the minimum number of flip-flops needed is $\lceil \log_2 5 \rceil$, which equals: **[2 marks]**

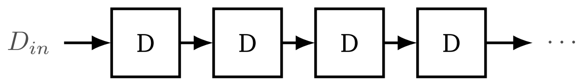
(A) 3

(B) 5

(C) 2

(D) 4

Q23. A serial-in serial-out shift register is made of 8 flip-flops, as shown; a data bit entering the input appears at the output after passing through all stages. If the shift clock runs at 1 MHz, the input-to-output delay is: **[2 marks]**



8 stages, clocked at 1 MHz

(A) 8 μs

(B) 1 μs

(C) 16 μs

(D) 4 μs

Q24. A synchronous counter uses 5 flip-flops. The maximum number of distinct states it can pass through, 2^5, is: **[2 marks]**

(A) 10

(B) 32

(C) 5

(D) 25

Signals and Systems

Q25. Two finite-length discrete sequences of lengths 5 and 4 samples are linearly convolved. The length of the resulting sequence, $N_1 + N_2 - 1$, is: **[2 marks]**

(A) 8

(B) 9

(C) 20

(D) 5

Q26. Two discrete sequences $x[n] = \{1, 2, 3\}$ and $h[n] = \{1, 1\}$ are convolved. The sum of all samples of the output equals the product of the two sample sums, $\left(\sum x\right)\left(\sum h\right)$, which is: **[2 marks]**

(A) 6

(B) 12

(C) 5

(D) 36

Q27. A 4-point DFT is taken of the unit impulse sequence $x[n] = \delta[n] = \{1, 0, 0, 0\}$. The value of the DFT coefficient $X[3]$ is: **[2 marks]**

(A) 0

(B) 4

(C) 1

(D) N

Q28. A 4-point DFT is taken of the constant sequence $x[n] = \{1, 1, 1, 1\}$. The zero-frequency (d.c.) coefficient $X[0] = \sum_{n=0}^{3} x[n]$ is: **[2 marks]**

(A) 4

(B) 0

(C) 1

(D) 16

Q29. The linear convolution of two length-6 sequences is to be computed exactly using an N-point circular convolution (DFT method). The minimum DFT length N that avoids time-domain aliasing, $N \geq N_1 + N_2 - 1$, is: **[2 marks]**

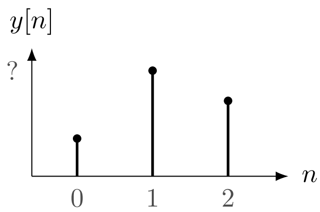
(A) 6

(B) 12

(C) 36

(D) 11

Q30. The sequences $x[n] = \{1, 2\}$ and $h[n] = \{3, 4\}$ (both starting at $n = 0$) are linearly convolved to give $y[n]$. The stem plot form of the result is indicated. The sample $y[1]$ is: **[2 marks]**



(A) 10

(B) 3

(C) 8

(D) 11

Control Systems

Q31. A linear system is described in state-space form with system matrix $A = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix}$. The eigenvalues of A (equal to the system poles) are: **[2 marks]**

(A) $\{+2, +3\}$

(B) $\{-5, -6\}$

(C) $\{0, -5\}$

(D) $\{-2, -3\}$

Q32. A second-order system has state matrix $A = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix}$ and input matrix $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$. From the controllability matrix $Q_c = [\, B \;\; AB \,]$ with $\det Q_c \neq 0$, the system is: **[2 marks]**

(A) unstable

(B) uncontrollable

(C) controllable

(D) marginally stable

Q33. A single-input single-output system has the scalar state-space model $\dot{x} = -2x + u$, $y = 3x$ (so $A = -2$, $B = 1$, $C = 3$, $D = 0$). Its transfer function is $H(s) = C(sI - A)^{-1}B = 3/(s+2)$. The d.c. gain $H(0)$ is: **[2 marks]**

(A) 3

(B) 0.5

(C) 1.5

(D) 2

Q34. A system has state matrix $A = \begin{bmatrix} 0 & 1 \\ -8 & -4 \end{bmatrix}$. Comparing its characteristic equation $s^2 + 4s + 8 = 0$ with $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$, the undamped natural frequency $\omega_n = \sqrt{8}$ is nearest to: **[2 marks]**

(A) 8 rad/s

(B) 4 rad/s

(C) 2 rad/s

(D) 2.83 rad/s

Q35. A system has state matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ and output matrix $C = [1 \;\; 0]$. From the observability matrix $Q_o = \begin{bmatrix} C \\ CA \end{bmatrix}$ with $\det Q_o \neq 0$, the system is: **[2 marks]**

(A) unobservable

(B) unstable

(C) observable

(D) uncontrollable

Communications

Q36. A discrete memoryless source emits three symbols with probabilities $\{0.5,\ 0.25,\ 0.2$
Its entropy $H = -\sum p_i \log_2 p_i$ is: **[2 marks]**

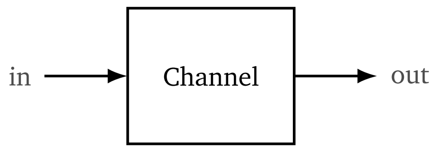
(A) 1.5 bits/symbol

(B) 2.0 bits/symbol

(C) 1.0 bit/symbol

(D) 3.0 bits/symbol

Q37. A channel of bandwidth $B = 4$ kHz has a signal-to-noise ratio of 15 (power ratio). By the Shannon–Hartley law $C = B\log_2(1 + \text{SNR})$, the channel capacity is: **[2 marks]**



$B = 4$ kHz, SNR $= 15$

(A) 4 kbps

(B) 32 kbps

(C) 8 kbps

(D) 16 kbps

Q38. In a message from a discrete source, one particular symbol occurs with probability 0.125. The self-information (information content) it carries, $I = \log_2(1/p)$, is: **[2 marks]**

(A) 3 bits

(B) 8 bits

(C) 0.125 bits

(D) 1 bit

Q39. A discrete memoryless source emits 16 symbols that are all equally likely. The maximum entropy of the source, $\log_2 16$, is: **[2 marks]**

(A) 4 bits/symbol

(B) 16 bits/symbol

(C) 8 bits/symbol

(D) 2 bits/symbol

Q40. A channel of bandwidth $B = 1$ kHz has a signal-to-noise ratio of 3 (power ratio). By the Shannon–Hartley law $C = B\log_2(1 + \text{SNR})$, the channel capacity is: **[2 marks]**

(A) 1 kbps

(B) 2 kbps

(C) 4 kbps

(D) 3 kbps

Q41. A source of entropy $H = 1.5$ bits/symbol is encoded with a code whose average codeword length is $L = 2$ bits/symbol. The coding efficiency $\eta = H/L$ is: **[2 marks]**

(A) 0.50

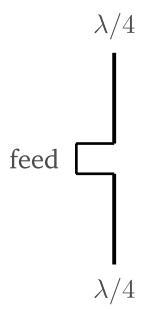
(B) 1.00

(C) 0.75

(D) 0.60

Electromagnetics

Q42. A thin half-wave dipole antenna (length $\lambda/2$), fed at its centre as shown, is a standard reference radiator. Its radiation resistance (input resistance at resonance) is closest to: **[2 marks]**



(A) $73\ \Omega$

(B) $377\ \Omega$

(C) $50\ \Omega$

(D) $36.5\ \Omega$

Q43. An antenna has a directivity $D = 20$ (dimensionless) and a radiation efficiency $\eta = 0.5$. Its power gain $G = \eta D$ is: **[2 marks]**

(A) 20

(B) 40

(C) 10

(D) 0.5

Q44. A half-wave dipole antenna is designed to operate at a frequency of 300 MHz in free space. Its physical length ($\lambda/2$, with $\lambda = c/f$) is: **[2 marks]**

(A) 1 m

(B) 0.5 m

(C) 0.25 m

(D) 2 m

Q45. A short (Hertzian) dipole of length dl radiates with radiation resistance $R_r = 80\pi^2(dl/\lambda)^2$. For a dipole whose length is $dl/\lambda = 0.01$, the radiation resistance is nearest to: **[2 marks]**

(A) $73\ \Omega$

(B) $0.79\ \Omega$

(C) $7.9\ \Omega$

(D) $0.079\ \Omega$

Q46. An antenna has a directivity $D = 4$ (dimensionless). Expressed in decibels relative to an isotropic radiator, $D_{\text{dBi}} = 10\log_{10} D$, its directivity is nearest to: **[2 marks]**

(A) 4 dBi

(B) 6 dBi

(C) 16 dBi

(D) 2 dBi

Detailed Solutions

Q1.

Solution

Concept – coefficient of coupling: The coefficient of coupling links the mutual inductance to the two self-inductances by $k = \dfrac{M}{\sqrt{L_1 L_2}}$, and it always lies between 0 and 1.

Step 1 – list the data: $L_1 = 2$ H, $L_2 = 8$ H, $M = 3$ H.

Step 2 – form the product of the self-inductances: $L_1 L_2 = 2 \times 8 = 16$

Step 3 – take the square root: $\sqrt{L_1 L_2} = \sqrt{16} = 4$

Step 4 – divide the mutual inductance by this root: $k = \dfrac{3}{4}$

$k = 0.75$

Step 5 – sanity check: The value 0.75 lies between 0 and 1, so it is a physically valid coupling.

Final Answer: $k = 0.75 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – ideal transformer voltage ratio: In an ideal transformer voltages scale with the turns, $\dfrac{V_2}{V_1} = \dfrac{N_2}{N_1}$.

Step 1 – list the data: $N_1 = 200$, $N_2 = 1000$, $V_1 = 12$ V.

Step 2 – form the turns ratio: $\dfrac{N_2}{N_1} = \dfrac{1000}{200} = 5$

Step 3 – multiply the primary voltage by this ratio: $V_2 = 12 \times 5$

Step 4 – evaluate: $V_2 = 60$ V

Why the other options are wrong:

- A, 2.4 V: divides instead of multiplies (uses N_1/N_2).
- C, 6 V: halves the primary voltage, unrelated to the turns.

Final Answer: $V_2 = 60 \text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – impedance reflection through an ideal transformer: An impedance on the secondary is seen at the primary scaled by the square of the turns ratio, $Z_{in} = \left(\frac{N_1}{N_2}\right)^2 Z_L$.

Step 1 – list the data: $\frac{N_1}{N_2} = 2$, $Z_L = 100\ \Omega$.

Step 2 – square the turns ratio: $\left(\frac{N_1}{N_2}\right)^2 = 2^2 = 4$

Step 3 – multiply by the load: $Z_{in} = 4 \times 100$

Step 4 – evaluate: $Z_{in} = 400\ \Omega$

Final Answer: $Z_{in} = 400\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept – series-aiding coupled coils: When two coupled coils are in series with their fluxes aiding, the mutual term adds, $L_{eq} = L_1 + L_2 + 2M$.

Step 1 – list the data: $L_1 = 3$ H, $L_2 = 5$ H, $M = 2$ H.

Step 2 – add the self-inductances: $L_1 + L_2 = 3 + 5 = 8$

Step 3 – form the mutual term: $2M = 2 \times 2 = 4$

Step 4 – add for the aiding connection: $L_{eq} = 8 + 4$

$L_{eq} = 12$ H

Final Answer: $L_{eq} = 12\text{ H} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q4

Q5.

Solution

Concept – series-opposing coupled coils: When the two coupled coils are connected so their fluxes oppose, the mutual term subtracts, $L_{eq} = L_1 + L_2 - 2M$.

Step 1 – list the data: $L_1 = 6$ H, $L_2 = 4$ H, $M = 3$ H.

Step 2 – add the self-inductances: $L_1 + L_2 = 6 + 4 = 10$

Step 3 – form the mutual term: $2M = 2 \times 3 = 6$

Step 4 – subtract for the opposing connection: $L_{eq} = 10 - 6$

$L_{eq} = 4$ H

Final Answer: $L_{eq} = 4 \text{ H} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept – impedance matching with an ideal transformer: The transformer reflects the load as $R_s = (N_1/N_2)^2 R_L$, so the matching turns ratio is $\dfrac{N_1}{N_2} = \sqrt{\dfrac{R_s}{R_L}}$.

Step 1 – list the data: $R_s = 50\ \Omega$, $R_L = 8\ \Omega$.

Step 2 – form the resistance ratio: $\dfrac{R_s}{R_L} = \dfrac{50}{8} = 6.25$

Step 3 – take the square root: $\dfrac{N_1}{N_2} = \sqrt{6.25}$

Step 4 – evaluate: $\dfrac{N_1}{N_2} = 2.5$

Why the other options are wrong:

- A, 6.25: is the resistance ratio itself, before taking the square root.
- B, 0.4: is the reciprocal N_2/N_1.

Final Answer: $N_1 : N_2 = 2.5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – photon energy and emission wavelength of an LED: The emitted photon energy equals the band gap, and wavelength and energy are related by $\lambda(\text{nm}) = \dfrac{1240}{E_g(\text{eV})}$.

Step 1 – list the data: $E_g = 2.0$ eV.

Step 2 – substitute into the relation: $\lambda = \dfrac{1240}{2.0}$

Step 3 – evaluate: $\lambda = 620$ nm

Step 4 – interpret: 620 nm lies in the red part of the visible spectrum, consistent with a 2.0 eV LED.

Final Answer: $\lambda = 620 \text{ nm} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – fill factor of a solar cell: The fill factor compares the maximum-power-point product with the product of open-circuit voltage and short-circuit current, $FF = \dfrac{V_{mp}I_{mp}}{V_{oc}I_{sc}}$.

Step 1 – form the maximum-power-point product: $V_{mp}I_{mp} = 0.4 \times 30 \text{ mW} = 12$ mW

Step 2 – form the reference product: $V_{oc}I_{sc} = 0.5 \times 35 \text{ mW} = 17.5 \text{ mW}$

Step 3 – divide: $FF = \dfrac{12}{17.5}$

Step 4 – evaluate: $FF = 0.686$

Final Answer: $FF \approx 0.686 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – responsivity of a photodiode: Responsivity is the photocurrent generated per unit of incident optical power, $R = \dfrac{I_{ph}}{P_{opt}}$.

Step 1 – list the data: $I_{ph} = 0.9 \text{ mA} = 0.9 \times 10^{-3}$ A, $P_{opt} = 2 \text{ mW} = 2 \times 10^{-3}$ W.

Step 2 – form the ratio: $R = \dfrac{0.9 \times 10^{-3}}{2 \times 10^{-3}}$

Step 3 – cancel the powers of ten: $R = \dfrac{0.9}{2}$

Step 4 – evaluate: $R = 0.45$ A/W

Final Answer: $R = 0.45 \text{ A/W} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – quantum efficiency from responsivity: The external quantum efficiency and responsivity are related by $R = \dfrac{\eta\,\lambda_{\mu\text{m}}}{1.24}$, so $\eta = R\,\dfrac{1.24}{\lambda_{\mu\text{m}}}$.

Step 1 – convert the wavelength to micrometres: $\lambda = 800$ nm $= 0.8\ \mu$m

Step 2 – form the factor $1.24/\lambda$: $\dfrac{1.24}{0.8} = 1.55$

Step 3 – multiply by the responsivity: $\eta = 0.5 \times 1.55$

Step 4 – evaluate: $\eta = 0.775$

Step 5 – interpret: $\eta = 0.775$ means about 77.5% of the incident photons produce collected carriers, a valid value below unity.

Final Answer: $\eta \approx 0.775 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept – cut-off wavelength of a photodetector: A photon is absorbed only if its energy exceeds the band gap; the longest detectable wavelength corresponds to $E = E_g$, giving $\lambda_c(\text{nm}) = \dfrac{1240}{E_g(\text{eV})}$.

Step 1 – list the data: $E_g = 1.1$ eV.

Step 2 – substitute: $\lambda_c = \dfrac{1240}{1.1}$

Step 3 – evaluate: $\lambda_c = 1127$ nm

Step 4 – convert to micrometres: $\lambda_c = 1.13\ \mu$m

Final Answer: $\lambda_c \approx 1.13\ \mu\text{m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept – basic BJT current mirror: The diode-connected transistor sets a reference current $I_{ref} = \dfrac{V_{CC} - V_{BE}}{R}$, and the matched output transistor copies it, $I_{out} \approx I_{ref}$.

Step 1 – form the numerator (voltage across R): $V_{CC} - V_{BE} = 10 - 0.7 = 9.3$ V

Step 2 – write the resistance: $R = 93\ \text{k}\Omega = 93 \times 10^3\ \Omega$

Step 3 – divide: $I_{ref} = \dfrac{9.3}{93 \times 10^3}$

Step 4 – evaluate: $I_{ref} = 0.1 \times 10^{-3}$ A $= 100$ μA

Step 5 – copy through the mirror: $I_{out} \approx I_{ref} = 100$ μA

Final Answer: $I_{out} \approx 100$ μA $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q12**

Q13.

Solution

Concept – output resistance of the mirror transistor: The Early effect gives the small-signal output resistance $r_o = \dfrac{V_A}{I_C}$.

Step 1 – list the data: $V_A = 50$ V, $I_C = 0.5$ mA $= 0.5 \times 10^{-3}$ A.

Step 2 – divide: $r_o = \dfrac{50}{0.5 \times 10^{-3}}$

Step 3 – simplify the division: $r_o = \dfrac{50}{0.5} \times 10^3$

$r_o = 100 \times 10^3$ Ω

Step 4 – express in kilo-ohms: $r_o = 100$ kΩ

Final Answer: $r_o = 100$ k$\Omega \Rightarrow \boxed{\text{C}}$

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

Q14.

Solution

Concept – ratioed MOSFET current mirror: Two MOSFETs sharing the same V_{GS} carry currents in proportion to their aspect ratios, $\dfrac{I_{out}}{I_{ref}} = \dfrac{(W/L)_2}{(W/L)_1}$.

Step 1 – read the aspect-ratio scaling: $\dfrac{(W/L)_2}{(W/L)_1} = 4$

Step 2 – write the reference current: $I_{ref} = 100$ μA

Step 3 – multiply: $I_{out} = 4 \times 100$ μA

Step 4 – evaluate: $I_{out} = 400$ μA

Final Answer: $I_{out} = 400$ μA $\Rightarrow \boxed{\text{D}}$

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

Q15.

Solution

Concept – gain of a common-source stage with an active load: The gain magnitude is the transconductance times the total resistance at the output node, $|A_v| = g_m(r_{on}\|r_{op})$.

Step 1 – combine the two output resistances in parallel: $r_{on}\|r_{op} = \dfrac{100 \times 100}{100 + 100}$ kΩ

Step 2 – evaluate the parallel combination: $r_{on}\|r_{op} = \dfrac{10000}{200}$ kΩ $= 50$ kΩ

Step 3 – multiply by the transconductance: $|A_v| = (1 \text{ mA/V}) \times (50 \text{ k}\Omega)$

Step 4 – evaluate (mA times kΩ is dimensionless): $|A_v| = 1 \times 10^{-3} \times 50 \times 10^{3}$

$|A_v| = 50$

Final Answer: $|A_v| = 50 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept – output resistance of a cascode mirror: Cascoding multiplies the plain output resistance by roughly the intrinsic gain, $R_{out} \approx g_m r_o \cdot r_o = g_m r_o^2$.

Step 1 – square the transistor output resistance: $r_o^2 = (100 \times 10^3)^2 = 1 \times 10^{10}\ \Omega^2$

Step 2 – multiply by the transconductance: $R_{out} = (2 \times 10^{-3}) \times (1 \times 10^{10})$

Step 3 – combine the powers of ten: $R_{out} = 2 \times 10^7\ \Omega$

Step 4 – express in mega-ohms: $R_{out} = 20$ MΩ

Step 5 – interpret: This is 200 times the plain $r_o = 100$ kΩ, which is exactly why cascoding is used to make near-ideal current sources.

Final Answer: $R_{out} \approx 20 \text{ M}\Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept – base-current error of a two-transistor mirror: The two base currents are drawn from the reference branch, giving $\dfrac{I_{out}}{I_{ref}} = \dfrac{1}{1 + 2/\beta}$.

Step 1 – form the correction term: $\frac{2}{\beta} = \frac{2}{100} = 0.02$

Step 2 – form the denominator: $1 + 0.02 = 1.02$

Step 3 – take the ratio: $\frac{I_{out}}{I_{ref}} = \frac{1}{1.02} = 0.9804$

Step 4 – multiply by the reference current: $I_{out} = 0.9804 \times 1$ mA

$I_{out} = 0.98$ mA

Final Answer: $I_{out} \approx 0.98$ mA $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q17

Q18.

Solution

Concept – gain of a common-source stage with a current-source load: The intrinsic gain magnitude is $|A_v| = g_m r_o$.

Step 1 – list the data: $g_m = 5$ mA/V $= 5 \times 10^{-3}$ A/V, $r_o = 40$ k$\Omega = 40 \times 10^3\ \Omega$.

Step 2 – multiply: $|A_v| = (5 \times 10^{-3}) \times (40 \times 10^3)$

Step 3 – combine the powers of ten: $|A_v| = 5 \times 40 = 200$

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

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – states of a ring counter: In a ring counter a single 1 (or 0) is circulated through the n flip-flops, so it visits exactly n distinct states before repeating.

Step 1 – read the number of flip-flops: $n = 4$.

Step 2 – apply the ring-counter state count: number of states $= n = 4$

Why the other options are wrong:

- B, 16: is 2^4, the count for a full binary counter, not a ring counter.
- C, 8: is $2n$, the count for a Johnson counter.

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

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – states of a Johnson counter: Feeding back the complement of the last flip-flop makes the pattern fill and then empty, giving $2n$ distinct states for n flip-flops.

Step 1 – read the number of flip-flops: $n = 4$.

Step 2 – apply the Johnson-counter state count: number of states $= 2n = 2 \times 4$

Step 3 – evaluate: number of states $= 8$

Final Answer: 8 states $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – frequency division by cascaded toggle flip-flops: Each T flip-flop with $T = 1$ toggles once per input edge, dividing the frequency by 2. A chain of m such stages divides by 2^m.

Step 1 – read the number of stages: $m = 4$.

Step 2 – form the total division factor: $2^m = 2^4 = 16$

Step 3 – divide the input frequency: $f_{out} = \dfrac{16 \text{ kHz}}{16}$

Step 4 – evaluate: $f_{out} = 1$ kHz

Final Answer: $f_{out} = 1$ kHz $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q21

Q22.

Solution

Concept – minimum flip-flops for a state machine: With binary encoding, k flip-flops give 2^k states, so the minimum number for N states is $k = \lceil \log_2 N \rceil$.

Step 1 – list the data: $N = 5$ states.

Step 2 – take the base-2 logarithm: $\log_2 5 = 2.32$

Step 3 – round up to the next integer: $k = \lceil 2.32 \rceil = 3$

Step 4 – verify: $2^3 = 8 \geq 5$, while $2^2 = 4 < 5$, so 3 is indeed the minimum.

Final Answer: $k = 3$ flip-flops $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept – delay through a shift register: A bit advances one flip-flop per clock period, so passing through m stages takes m clock periods, a delay of $t_d = m\,T_{clk} = m/f_{clk}$.

Step 1 – find the clock period: $T_{clk} = \dfrac{1}{f_{clk}} = \dfrac{1}{1 \times 10^6} = 1\ \mu\text{s}$

Step 2 – read the number of stages: $m = 8$.

Step 3 – multiply: $t_d = 8 \times 1\ \mu\text{s}$

Step 4 – evaluate: $t_d = 8\ \mu\text{s}$

Final Answer: $t_d = 8\ \mu\text{s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept – maximum states of a binary counter: With n flip-flops the counter has 2^n distinct binary combinations, which is the largest possible modulus.

Step 1 – read the number of flip-flops: $n = 5$.

Step 2 – raise two to that power: $2^5 = 32$

Why the other options are wrong:

- A, 10: would be a decade (mod-10) count, not the maximum.
- D, 25: confuses 5^2 with 2^5.

Final Answer: 32 states $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept – length of a linear convolution: The convolution of sequences of lengths N_1 and N_2 has length $N_1 + N_2 - 1$.

Step 1 – list the data: $N_1 = 5$, $N_2 = 4$.

Step 2 – add the lengths: $N_1 + N_2 = 5 + 4 = 9$

Step 3 – subtract one: length $= 9 - 1$

Step 4 – evaluate: length $= 8$

Final Answer: 8 samples $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – sum of a convolution: Summing all samples of $y = x * h$ gives the product of the individual sums, $\sum_n y[n] = \left(\sum_n x[n]\right)\left(\sum_n h[n]\right)$.

Step 1 – sum the first sequence: $\sum x = 1 + 2 + 3 = 6$

Step 2 – sum the second sequence: $\sum h = 1 + 1 = 2$

Step 3 – multiply the two sums: $\sum y = 6 \times 2$

Step 4 – evaluate: $\sum y = 12$

Step 5 – cross-check by direct convolution: $y = \{1, 3, 5, 3\}$, and $1+3+5+3 = 12$, which agrees.

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

Answer: (B) Go Back to Q26

Q27.

Solution

Concept – DFT of a unit impulse: The N-point DFT is $X[k] = \sum_{n=0}^{N-1} x[n]\, e^{-j2\pi kn/N}$. For $x[n] = \delta[n]$ only the $n = 0$ term survives.

Step 1 – write the DFT sum for $k = 3$, $N = 4$: $X[3] = \sum_{n=0}^{3} \delta[n]\, e^{-j2\pi \cdot 3 \cdot n/4}$

Step 2 – keep only the non-zero sample ($n = 0$): $X[3] = \delta[0]\, e^{-j2\pi \cdot 3 \cdot 0/4}$

Step 3 – evaluate the exponential at $n = 0$: $e^0 = 1$

Step 4 – combine: $X[3] = 1 \times 1 = 1$

Step 5 – interpret: The DFT of an impulse is flat (all coefficients equal 1), so every $X[k] = 1$.

Final Answer: $X[3] = 1 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept – d.c. coefficient of the DFT: The zero-frequency coefficient is just the sum of the samples, $X[0] = \sum_{n=0}^{N-1} x[n]$.

Step 1 – write the samples: $x[n] = \{1, 1, 1, 1\}$.

Step 2 – add them: $X[0] = 1 + 1 + 1 + 1$

Step 3 – evaluate: $X[0] = 4$

Step 4 – interpret: A constant sequence has energy only at d.c., so $X[0] = 4$ while $X[1] = X[2] = X[3] = 0$.

Final Answer: $X[0] = 4 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – avoiding aliasing in DFT-based convolution: N-point circular convolution equals the linear convolution only if N is at least the linear-convolution length $N_1 + N_2 - 1$.

Step 1 – list the data: $N_1 = 6$, $N_2 = 6$.

Step 2 – add the lengths: $N_1 + N_2 = 6 + 6 = 12$

Step 3 – subtract one: $N_1 + N_2 - 1 = 12 - 1 = 11$

Step 4 – state the minimum DFT length: $N_{\text{min}} = 11$

Final Answer: $N = 11 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q29

Q30.

Solution

Concept – one output sample of a convolution: The convolution sum is $y[n] = \sum_k x[k]\, h[n-k]$; the sample $y[1]$ takes the overlapping products at shift 1.

Step 1 – list the sequences: $x = \{x[0], x[1]\} = \{1, 2\}$, $h = \{h[0], h[1]\} = \{3, 4\}$.

Step 2 – write the terms that contribute to $y[1]$: $y[1] = x[0]\, h[1] + x[1]\, h[0]$

Step 3 – substitute the values: $y[1] = (1)(4) + (2)(3)$

Step 4 – multiply each product: $y[1] = 4 + 6$

Step 5 – add: $y[1] = 10$

Final Answer: $y[1] = 10 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q30

Q31.

Solution

Concept – eigenvalues of the state matrix: The system poles are the eigenvalues of A, found from $\det(sI - A) = 0$.

Step 1 – form $sI - A$: $sI - A = \begin{bmatrix} s & -1 \\ 6 & s+5 \end{bmatrix}$

Step 2 – take the determinant: $\det(sI - A) = s(s+5) - (-1)(6)$

Step 3 – expand: $\det(sI - A) = s^2 + 5s + 6$

Step 4 – factor the characteristic polynomial: $s^2 + 5s + 6 = (s+2)(s+3)$

Step 5 – read off the roots: $s = -2$ and $s = -3$

Final Answer: eigenvalues $\{-2, -3\} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q31

Q32.

Solution

Concept – controllability test: A second-order system is controllable if its controllability matrix $Q_c = [\,B \quad AB\,]$ is non-singular (its determinant is non-zero).

Step 1 – compute AB: $AB = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$

Step 2 – assemble the controllability matrix: $Q_c = \begin{bmatrix} 0 & 1 \\ 1 & -2 \end{bmatrix}$

Step 3 – take its determinant: $\det Q_c = (0)(-2) - (1)(1) = -1$

Step 4 – apply the test: $\det Q_c = -1 \neq 0$, so Q_c has full rank.

Step 5 – conclude: Full rank means the system is controllable.

Final Answer: controllable $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q32

Q33.

Solution

Concept – d.c. gain from a state-space model: For $H(s) = C(sI - A)^{-1}B + D$, the d.c. gain is the value at $s = 0$.

Step 1 – write the scalar transfer function: $H(s) = \dfrac{C\,B}{s - A} = \dfrac{3}{s+2}$

Step 2 – substitute $s = 0$**:** $H(0) = \dfrac{3}{0+2}$

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

$H(0) = 1.5$

Final Answer: $H(0) = 1.5 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – natural frequency from the state matrix: The characteristic equation $\det(sI - A) = 0$ is compared with the standard form $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$, so $\omega_n = \sqrt{\text{constant term}}$.

Step 1 – form the characteristic equation: $\det(sI - A) = s(s+4) + 8 = s^2 + 4s + 8 = 0$

Step 2 – identify ω_n^2**:** $\omega_n^2 = 8$

Step 3 – take the square root: $\omega_n = \sqrt{8}$

Step 4 – evaluate: $\omega_n = 2.83$ rad/s

Step 5 – interpret: The middle term gives $2\zeta\omega_n = 4$, so $\zeta = 4/(2 \times 2.83) = 0.707$, a well-damped system, but the question asks only for ω_n.

Final Answer: $\omega_n \approx 2.83$ rad/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q34

Q35.

Solution

Concept – observability test: A second-order system is observable if its observability matrix $Q_o = \begin{bmatrix} C \\ CA \end{bmatrix}$ is non-singular.

Step 1 – compute CA: $CA = [1 \;\; 0] \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} = [0 \;\; 1]$

Step 2 – assemble the observability matrix: $Q_o = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

Step 3 – take its determinant: $\det Q_o = (1)(1) - (0)(0) = 1$

Step 4 – apply the test: $\det Q_o = 1 \neq 0$, so Q_o has full rank.

Step 5 – conclude: Full rank means the system is observable.

Final Answer: observable $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q35

Q36.

Solution

Concept – entropy of a discrete source: $H = -\sum_i p_i \log_2 p_i$, with each term measuring the information of a symbol weighted by its probability.

Step 1 – list the probabilities: $p_1 = 0.5$, $p_2 = 0.25$, $p_3 = 0.25$.

Step 2 – evaluate each log term: $\log_2(1/0.5) = 1$, $\log_2(1/0.25) = 2$, $\log_2(1/0.25) = 2$

Step 3 – weight each by its probability: $0.5 \times 1 = 0.5$

$0.25 \times 2 = 0.5$

$0.25 \times 2 = 0.5$

Step 4 – add the contributions: $H = 0.5 + 0.5 + 0.5$

$H = 1.5$ bits/symbol

Final Answer: $H = 1.5$ bits/symbol $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q36

Q37.

Solution

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

Step 1 – list the data: $B = 4$ kHz, $\text{SNR} = 15$.

Step 2 – form $1 + \text{SNR}$**:** $1 + 15 = 16$

Step 3 – take the base-2 logarithm: $\log_2 16 = 4$

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

Step 5 – evaluate: $C = 16$ kbps

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

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – self-information of a symbol: A symbol of probability p carries $I = \log_2(1/p)$ bits; rarer symbols carry more information.

Step 1 – list the data: $p = 0.125$.

Step 2 – form the reciprocal: $\dfrac{1}{0.125} = 8$

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

Step 4 – state the result: $I = 3$ bits

Final Answer: $I = 3$ bits $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q38

Q39.

Solution

Concept – maximum entropy of a source: Entropy is maximised when all M symbols are equally likely, giving $H_{\max} = \log_2 M$.

Step 1 – list the data: $M = 16$ equally likely symbols.

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

Step 3 – state the result: $H_{\max} = 4$ bits/symbol

Why the other options are wrong:

- B, 16: is the number of symbols, not its logarithm.

- C, 8: would correspond to $M = 256$.

Final Answer: $H_{\max} = 4$ bits/symbol $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q39

Q40.

Solution

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

Step 1 – list the data: $B = 1$ kHz, SNR $= 3$.

Step 2 – form $1 +$ **SNR:** $1 + 3 = 4$

Step 3 – take the base-2 logarithm: $\log_2 4 = 2$

Step 4 – multiply by the bandwidth: $C = 1$ kHz $\times 2$

Step 5 – evaluate: $C = 2$ kbps

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

Answer: (B) Go Back to Q40

Q41.

Solution

Concept – coding efficiency: Efficiency compares the source entropy with the average codeword length, $\eta = \dfrac{H}{L}$.

Step 1 – list the data: $H = 1.5$ bits/symbol, $L = 2$ bits/symbol.

Step 2 – form the ratio: $\eta = \dfrac{1.5}{2}$

Step 3 – evaluate: $\eta = 0.75$

Step 4 – interpret: The code uses 2 bits per symbol to carry 1.5 bits of information, so it is 75% efficient with 0.5 bit of redundancy per symbol.

Final Answer: $\eta = 0.75 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q41

Q42.

Solution

Concept – radiation resistance of a half-wave dipole: The centre-fed resonant half-wave dipole is a standard reference antenna with a well-known radiation resistance.

Step 1 – recall the standard result: For an ideal thin half-wave dipole, $R_r \approx 73\,\Omega$.

Step 2 – match to the options: The nearest listed value is $73\,\Omega$.

Why the other options are wrong:

- B, $377\,\Omega$: is the intrinsic impedance of free space, not an antenna's radiation resistance.
- C, $50\,\Omega$: is a common feed-line impedance, chosen for a rough match to (but not equal to) the dipole.
- D, $36.5\,\Omega$: is the radiation resistance of a quarter-wave monopole over a ground plane, half the dipole value.

Final Answer: $R_r \approx 73\,\Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q42

Q43.

Solution

Concept – gain, directivity and efficiency: An antenna's power gain is its directivity reduced by the radiation efficiency, $G = \eta D$.

Step 1 – list the data: $D = 20$, $\eta = 0.5$.

Step 2 – multiply: $G = 0.5 \times 20$

Step 3 – evaluate: $G = 10$

Step 4 – interpret: Half the power is lost, so the gain is half the directivity.

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

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – physical length of a half-wave dipole: The dipole length is half a free-space wavelength, $\ell = \lambda/2$ with $\lambda = c/f$.

Step 1 – find the wavelength: $\lambda = \dfrac{c}{f} = \dfrac{3 \times 10^8}{300 \times 10^6}$

Step 2 – evaluate: $\lambda = 1\ \text{m}$

Step 3 – halve it: $\ell = \dfrac{1}{2} = 0.5\ \text{m}$

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

Answer: (B) Go Back to Q44

Q45.

Solution

Concept – radiation resistance of a short dipole: For a Hertzian (short) dipole, $R_r = 80\pi^2 \left(\dfrac{dl}{\lambda}\right)^2$.

Step 1 – list the data: $\dfrac{dl}{\lambda} = 0.01$.

Step 2 – square the length ratio: $\left(\dfrac{dl}{\lambda}\right)^2 = (0.01)^2 = 1 \times 10^{-4}$

Step 3 – evaluate the constant: $80\pi^2 = 80 \times 9.87 = 789.6$

Step 4 – multiply: $R_r = 789.6 \times 1 \times 10^{-4}$

Step 5 – evaluate: $R_r = 0.079\ \Omega$

Step 6 – interpret: The very small radiation resistance is why electrically short antennas are inefficient radiators.

Final Answer: $R_r \approx 0.079\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q45

Q46.

Solution

Concept – directivity in decibels: A dimensionless directivity is expressed relative to an isotropic source as $D_{\text{dBi}} = 10 \log_{10} D$.

Step 1 – list the data: $D = 4$.

Step 2 – take the base-10 logarithm: $\log_{10} 4 = 0.602$

Step 3 – multiply by ten: $D_{\text{dBi}} = 10 \times 0.602$

Step 4 – evaluate: $D_{\text{dBi}} = 6.02 \approx 6$ dBi

Final Answer: $D_{\text{dBi}} \approx 6 \text{ dBi} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q46

Answer Key

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