Remark

ASSIGNMENT 1: GATE EE 2025
EC: ELECTRONICS AND COMMUNICATION ENGINEERING

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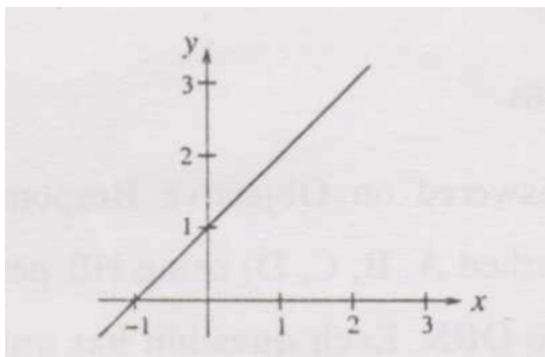
1) If E denotes expectation, the variance of a random variable X is given by: (GATE EE 2025)
   a) $E[X^2] - E^2[X]$
   b) $E[X^2] + E^2[X]$
   c) $E[X^2]$
   d) $E^2[X]$
2) The following plot shows a function y which varies linearly with x. The value of the integral $\int_0^2 y\,dx$ is: (GATE EE 2025)



graph

   a) 1.0 b) 2.5 c) 4.0 d) 5.0

3) For $|x| < 1$, $\coth(x)$ can be approximated as: (GATE EE 2025)

   a) x b) x^2 c) $\frac{1}{x}$ d) $\frac{1}{x^2}$

4) $\lim_{\theta \to 0} \frac{\sin(\theta/2)}{\theta}$ is: (GATE EE 2025)

   a) 0.5 b) 1 c) 2 d) Not defined

5) Which of the following functions is strictly bounded? (GATE EE 2025)

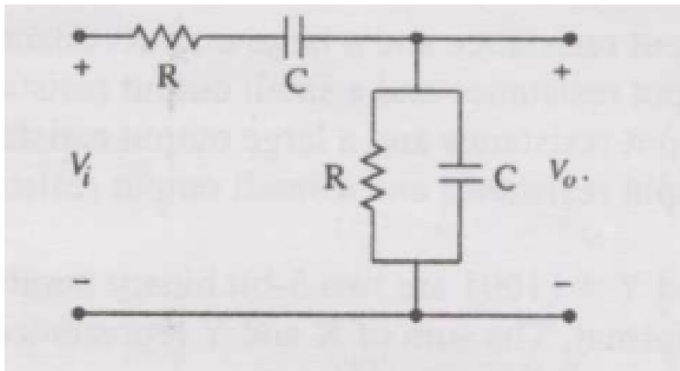
   a) $\sin x$ b) e^x c) $cosx$ d) x^2

6) For the function e^{-x}, the linear approximation around $x = 2$ is: (GATE EE 2025)
   a) $(3 - x)^2$
   b) $1 - x$
   c) $[3 + 2\sqrt{2} - (1 + \sqrt{2})x]e^2$
   d) e^{-2}

7) An independent voltage source in series with $Z_s = R_s + jX_s$ delivers max average power to load Z_L when: (GATE EE 2025)

   a) $Z_L = R_s + jX_s$
   b) $Z_L = R_s$
   c) $Z_L = jX_s$
   d) $Z_L = R_s - jX_s$

8) The RC circuit shown is:



rc circuit

(GATE EE 2025)

   a) Low-pass filter
   b) High-pass filter
   c) Band-pass filter
   d) Band-reject filter

9) The electron and hole concentrations in an intrinsic semiconductor are n_i per cm^3 at 300 K. If acceptor impurities are introduced with concentration N_a, then electron concentration becomes: (GATE EE 2025)

   a) n_i
   b) $n_i + N_a$
   c) $N_a - n_i$
   d) $\frac{n_i^2}{N_a}$

10) In a p^+n junction diode under reverse bias, electric field is maximum at: (GATE EE 2025)

   a) Edge of depletion region on p-side
   b) Edge on n-side
   c) The junction
   d) Centre of depletion on n-side

11) The correct full wave rectifier circuit is: (GATE EE 2025)

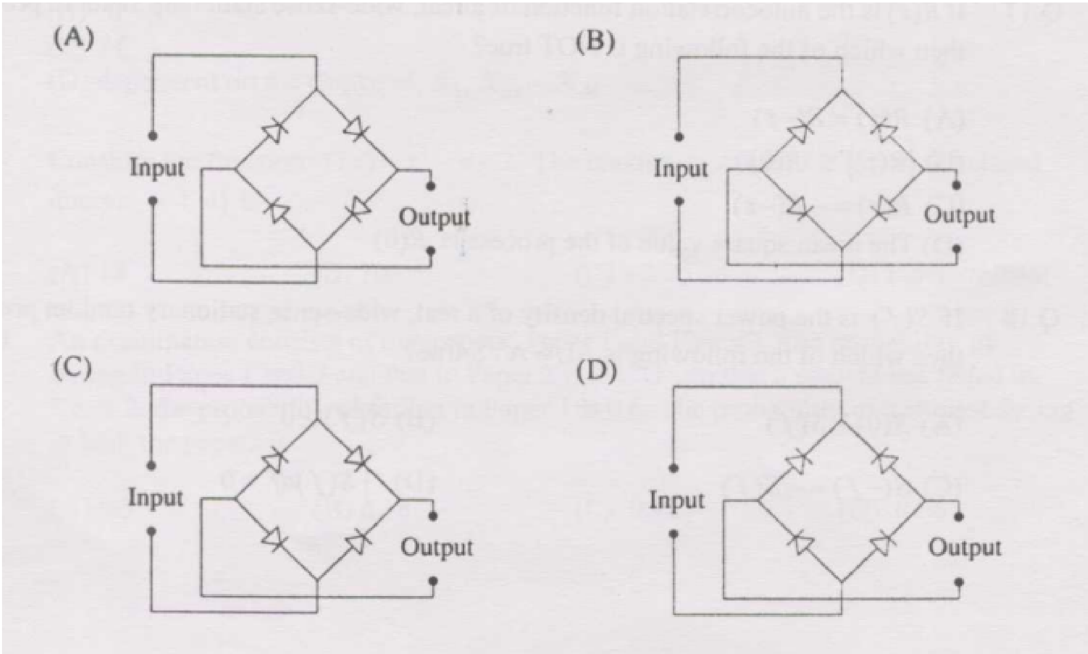


Fig. 11: Full wave rectifier circuit

12) In a transconductance amplifier, it is desirable to have: (GATE EE 2025)
   a) Large input and output resistance
   b) Large input and small output resistance
   c) Small input and large output resistance
   d) Small input and output resistance
13) $X = 01110$, $Y = 11001$ (5-bit numbers in 2's complement). The sum in 6 bits is: (GATE EE 2025)

   a) 100111 b) 001100 c) 000111 d) 101001

14) The Boolean function $Y = AB + CD$ using only 2-input NAND gates requires: (GATE EE 2025)

   a) 2 b) 3 c) 4 d) 5

15) Given closed-loop transfer function $T(s) = \frac{s-5}{(s+2)(s+3)}$, the system is: (GATE EE 2025)
   a) Unstable
   b) Uncontrollable
   c) Minimum phase
   d) Non-minimum phase
16) If Laplace transform of $y(t)$ is $Y(s) = \frac{1}{s(s-1)}$, the final value is: (GATE EE 2025)

   a) -1 b) 0 c) 1 d) Unbounded

17) If $R(\tau)$ is autocorrelation of real, WSS random process, which is NOT true: (GATE EE 2025)
   a) $R(\tau) = R(-\tau)$
   b) $|R(t)| \leq R(0)$
   c) $R(\tau) = -R(-\tau)$
   d) Mean square value is $R(0)$
18) If $S(f)$ is power spectral density of a real WSS random process, which is ALWAYS true: (GATE EE 2025)

a) $S(0) \geq S(f)$ b) $S(f) \geq 0$ c) $S(-f) = -S(f)$ d) $\int S(f)df = 0$

19) A plane wave of wavelength λ is travelling in a direction making an angle 30° with positive x-axis and 90° with positive y-axis. The **E** field of the plane wave can be represented as (E_0 is a constant) (GATE EE 2025)

(A) $\mathbf{E} = -\hat{z},\ E_0 \exp\left(j\left(\omega t - \frac{\sqrt{3}}{2}kx - \frac{1}{2}ky\right)\right)$

(B) $\mathbf{E} = -\hat{z},\ E_0 \exp\left(j\left(\omega t - \frac{\sqrt{3}}{2}ky\right)\right)$

(C) $\mathbf{E} = -\hat{z},\ E_0 \exp\left(j\left(\omega t + \frac{\sqrt{3}}{2}kx + \frac{1}{2}ky\right)\right)$

(D) $\mathbf{E} = -\hat{z},\ E_0 \exp\left(j\left(\omega t - \frac{\sqrt{3}}{2}kx + \frac{1}{2}ky\right)\right)$

20) If C is a closed curve enclosing a surface S, then the magnetic field intensity **H**, the current density **J** and the electric flux density **D** are related by (GATE EE 2025)

(A) $\int_S \mathbf{H} \cdot d\mathbf{s} = \int_S \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right) \cdot d\mathbf{s}$

(B) $\oint_C \mathbf{H} \cdot d\mathbf{l} = \int_S \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right) \cdot d\mathbf{s}$

(C) $\int_S \mathbf{H} \cdot d\mathbf{s} = \oint_C \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right) \cdot d\mathbf{l}$

(D) $\oint_C \mathbf{H} \cdot d\mathbf{l} = \oint_C \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}\right) \cdot d\mathbf{l}$

21) It is given that $X_1, X_2, \ldots, X_M$ are M non-zero, orthogonal vectors. The dimension of the vector space spanned by the $2M$ vectors $X_1, X_2, \ldots, X_M, -X_1$ $, -X_2, \ldots, -X_M$ is: (GATE EE 2025)

(A) $2M$
(B) $M + 1$
(C) M
(D) Dependent on choice of X_i

22) Consider the function $f(x) = x^2 - x - 2$. The maximum value of $f(x)$ in the closed interval $[-4, 4]$ is: (GATE EE 2025)

a) 18 b) 10 c) −2.25 d) Indeterminate

23) An examination consists of two papers, Paper I and Paper II. The probability of failing in Paper I is 0.3 and that in Paper II is 0.2. Given that a student has failed in Paper II, the probability of failing in Paper I is 0.6. The probability of a student failing in both the papers is: (GATE EE 2025)

a) 0.5 b) 0.18 c) 0.12 d) 0.06

24) The solution of the differential equation $k^2\frac{d^2y}{dx^2} = y$, under the boundary conditions (i) $y = y_1$ at $x = 0$ and (ii) $y = y_2$ at $x = \infty$, where k, y_1, y_2 are constants, is: (GATE EE 2025)

(A) $y = (y_1 - y_2)\exp(-x/k) + y_2$
(B) $y = (y_1 - y_2)\exp(-x/k) + y_1$
(C) $y = (y_1 - y_2)\sinh(x/k) + y_2$
(D) $y = (y_1 - y_2)\exp(-x/k) + y_1$

25) The equation $x^2 + x^4 - 4x - 4 = 0$ is to be solved using Newton-Raphson. If $x = 2$ is the initial approximation, then the next approximation using this method will be: (GATE EE 2025)

a) $\frac{2}{3}$ b) $\frac{4}{3}$ c) 1 d) $\frac{3}{2}$

26) Three functions $f_1(t), f_2(t)$ and $f_3(t)$, which are zero outside the interval $[0, 7]$, are shown in the figure. Which of the following statements is correct?

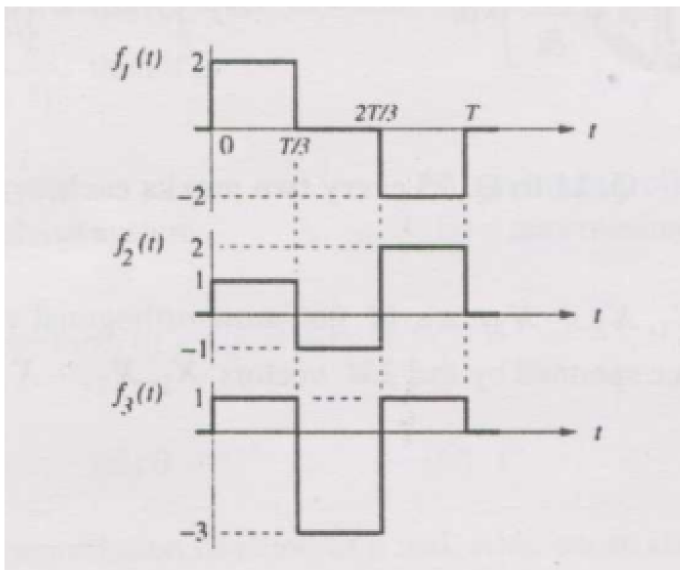


Fig. 26: Functions

(GATE EE 2025)

(A) $f_1(t)$ and $f_2(t)$ are orthogonal
(B) $f_1(t)$ and $f_3(t)$ are orthogonal
(C) $f_2(t)$ and $f_3(t)$ are orthogonal
(D) $f_1(t)$ and $f_2(t)$ are orthonormal

27) If the semi-circular contour D of radius 2 is as shown in the figure, then the value of the integral $\oint_D \frac{1}{(s^2 - 1)} ds$ is:

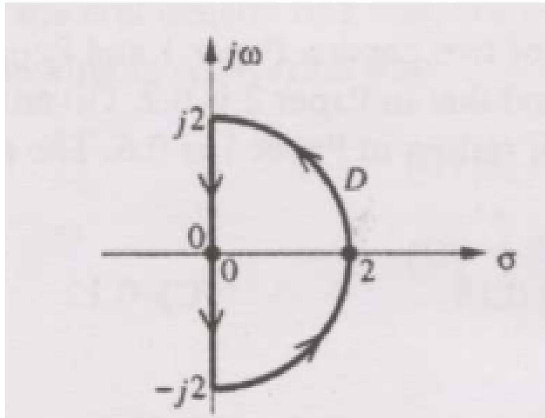


Fig. 27: contour

(GATE EE 2025)

(A) $j\pi$ (B) $-j\pi$ (C) $-\pi$ (D) π

28) Two series resonant filters are as shown in the figure. Let the 3-dB bandwidth of Filter 1 be B_1 and that of Filter 2 be B_2. The value of $\frac{B_1}{B_2}$ is:

(GATE EE 2025)

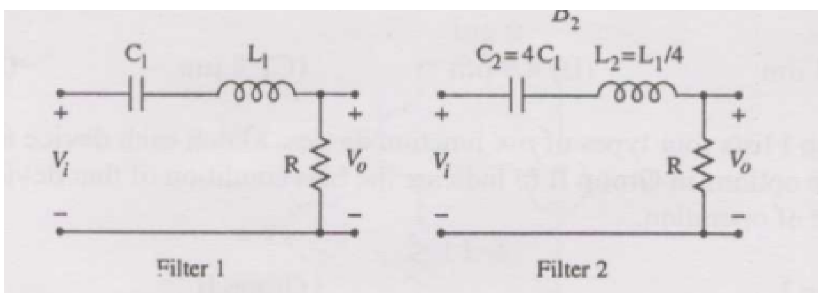


Fig. 28: Ffilters

(A) 4 (B) 1 (C) $\frac{1}{2}$ (D) $\frac{1}{4}$

29) For the circuit shown in the figure, the Thevenin voltage and resistance looking into XY are: (GATE EE 2025)

a) $\frac{4}{3}$ V, $2\,\Omega$ b) 4 V, $\frac{2}{3}\,\Omega$ c) $\frac{4}{3}$ V, $\frac{2}{3}\,\Omega$ d) 4 V, $2\,\Omega$

30) In the circuit shown, V_C is 0 volts at $t = 0$ sec. For $t > 0$, the capacitor current $i_c(t)$, where t is in seconds, is given by: (GATE EE 2025)

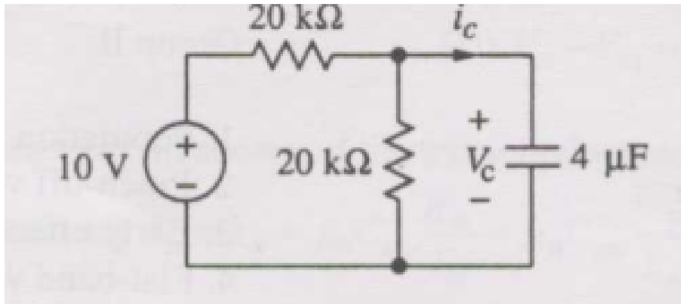


Fig. 30: circuit

a) $0.50\exp(-25t)$ mA
b) $0.25\exp(-25t)$ mA
c) $0.50\exp(-12.5t)$ mA
d) $0.25\exp(-6.25t)$ mA

31) In the AC network shown in the figure, the phasor voltage V_{AB} (in Volts) is:

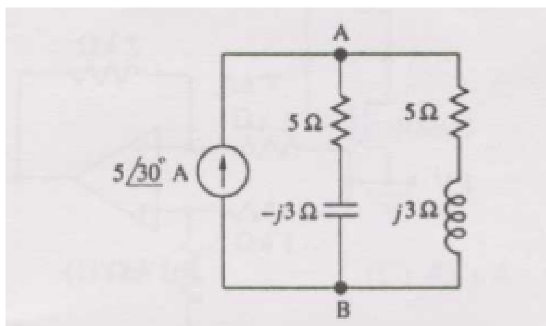


Fig. 31: AC network

(GATE EE 2025)

a) 0
b) $5\angle 20°$
c) $12.5\angle 30°$
d) $17\angle 30°$

32) A p^+n junction has a built-in potential of 0.8 V. The depletion layer width at a reverse bias of 1.2 V is 2 μm. For a reverse bias of 7.2 V, the depletion layer width will be: (GATE EE 2025)

a) 4 μm
b) 4.9 μm
c) 8 μm
d) 12 μm

33) Group I lists four types of pn junction diodes. Match each device in Group I with one of the options in Group II to indicate the bias condition of that device in its normal mode of operation.

Group I	Device	Group II	Bias Condition
P	Zener Diode	1	Forward bias
Q	Solar cell	2	Reverse bias
R	LASER diode		
S	Avalanche Photodiode		

(GATE EE 2025)

a) P-1, Q-2, R-1, S-2
b) P-2, Q-1, R-1, S-2
c) P-2, Q-2, R-1, S-1
d) P-2, Q-1, R-2, S-2

34) The DC current gain (β) of a BJT is 50. Assuming that the emitter injection efficiency is 0.995, the base transport factor is: (GATE EE 2025)

a) 0.980 b) 0.985 c) 0.990 d) 0.995

35) Group I lists four different semiconductor devices. Match each device in Group I with its characteristic property in Group II.

Group I	Device	Group II	Property
P	BJT	1	Population inversion
Q	MOS capacitor	2	Pinch-off voltage
R	LASER diode	3	Early effect
S	JFET	4	Flat-band voltage
Â			

(GATE EE 2025)

a) P-3, Q-1, R-4, S-2
b) P-1, Q-4, R-3, S-2
c) P-3, Q-4, R-1, S-2
d) P-3, Q-2, R-1, S-4

36) For the Op-Amp circuit shown in the figure, V_o is:

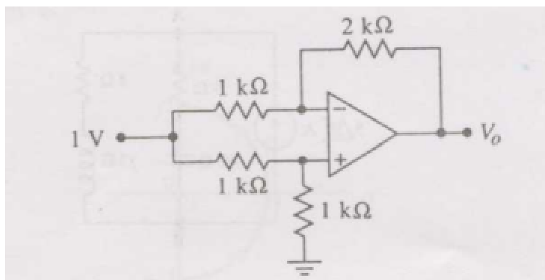


Fig. 36: circuit

(GATE EE 2025)

a) −2 V b) −1 V c) −0.5 V d) 0.5 V

37) For the BJT circuit shown, assume that the β of the transistor is very large and $V_{BE} = 0.7$ V. The mode of operation of the BJT is:

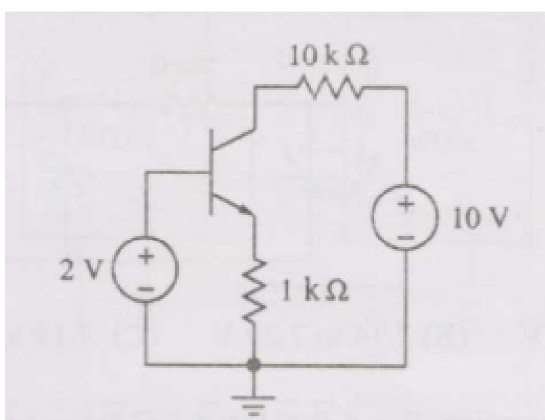


Fig. 37: circuit

(GATE EE 2025)

a) cut-off b) saturation c) normal active d) reverse active

38) In the op-amp circuit shown, assume that the diode current follows the equation $I = I_S \exp(V/V_T)$. For $V_i = 2$ V, $V_o = V_{o1}$, and for $V_i = 4$ V, $V_o = V_{o2}$. The relationship between V_{o1} and V_{o2} is:

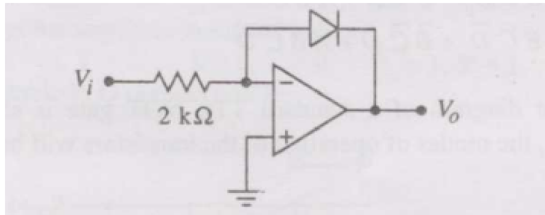


Fig. 38: circuit

(GATE EE 2025)

a) $V_{o2} = \sqrt{2}\, V_{o1}$
b) $V_{o2} = e^2 V_{o1}$
c) $V_{o2} = V_{o1} \ln 2$
d) $V_{o1} - V_{o2} = V_T \ln 2$

39) In the CMOS inverter circuit shown, if the transconductance parameters of the NMOS and PMOS transistors are $k_n = k_p = \mu C_{ox} \frac{W_n}{L_n} = \mu C_{ox} \frac{W_p}{L_p} = 40\ \mu\text{A/V}^2$ and their threshold voltages are $V_{THn} = |V_{THp}| = 1$ V, the current I is:

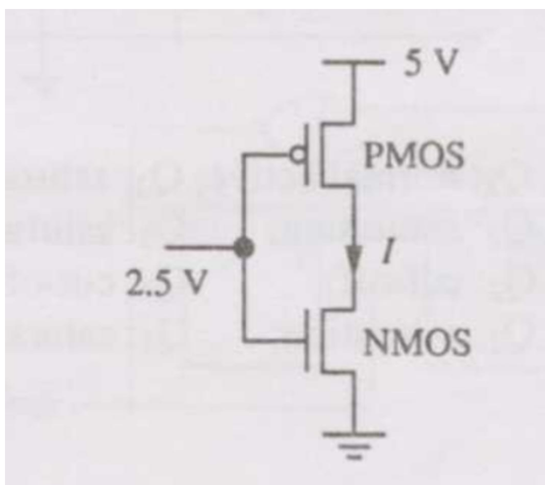


Fig. 39: circuit

(GATE EE 2025)

(A) 0 A (B) 25 μA (C) 45 μA (D) 90 μA

40) For the Zener diode shown in the figure, the Zener voltage at knee is 7 V, the knee current is negligible and the Zener dynamic resistance is 10 Ω. If the input voltage (V_i) range is from 10 to 16 V, the output voltage (V_o) ranges from:

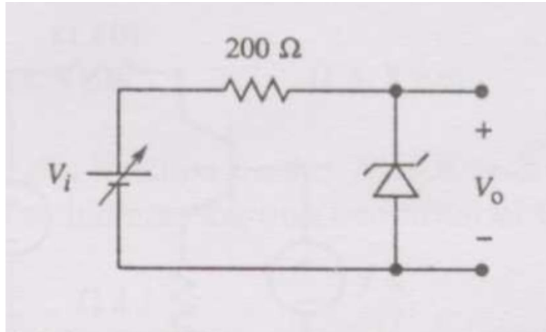


Fig. 40: Zener Diode

(GATE EE 2025)

(A) 7.00 to 7.29 V
(B) 7.14 to 7.29 V
(C) 7.14 to 7.43 V
(D) 7.29 to 7.43 V

41) The Boolean expression $Y = \overline{A}\,\overline{B}\,\overline{C}D + \overline{A}BC\overline{D} + A\overline{B}C\overline{D} + AB\overline{CD}$ can be minimized to: (GATE EE 2025)
   a) $\overline{A}\,\overline{B}C\overline{D} + \overline{A}B\overline{C} + A\overline{CD}$
   b) $\overline{A}\,\overline{B}C\overline{D} + B\overline{CD} + A\overline{BC}D$
   c) $\overline{A}BC\overline{D} + \overline{B}C\overline{D} + AB\overline{C}D$
   d) $\overline{A}B\overline{C}D + \overline{BC}D + AB\overline{CD}$

42) The circuit diagram of a standard TTL NOT gate is shown. When $V_i = 2.5$ V, the modes of operation of the transistors will be:

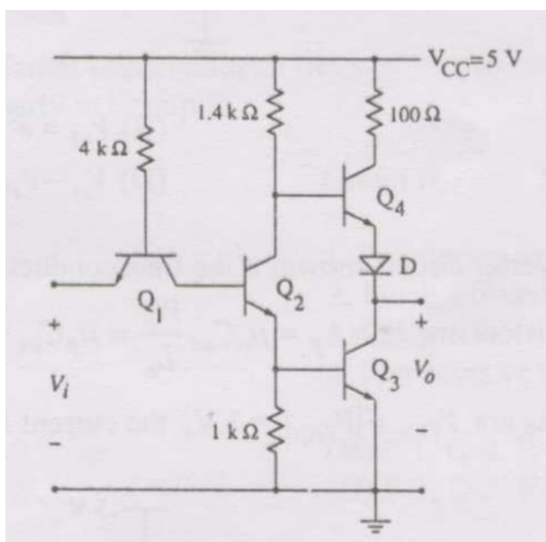


Fig. 42: circuit

(GATE EE 2025)

   a) Q_1: reverse active; Q_2: normal active; Q_3: saturation; Q_4: cut-off
   b) Q_1: reverse active; Q_2: saturation; Q_3: saturation; Q_4: cut-off
   c) Q_1: normal active; Q_2: cut-off; Q_3: cut-off; Q_4: saturation
   d) Q_1: saturation; Q_2: saturation; Q_3: saturation; Q_4: normal active

43) In the following circuit, X is given by:

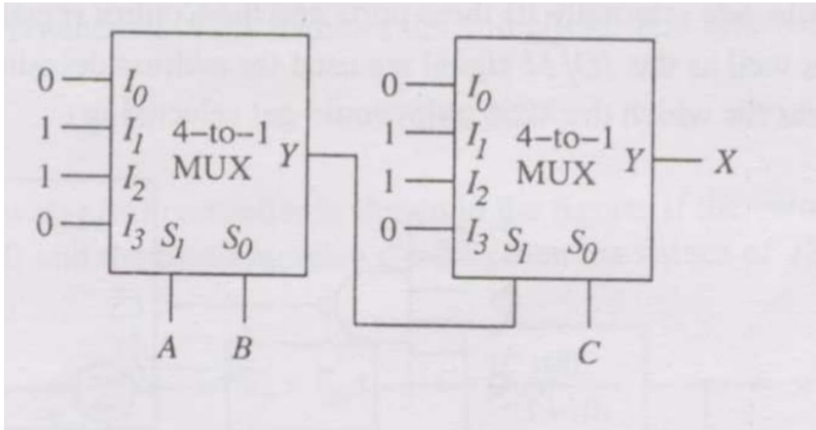


Fig. 43: circuit

(GATE EE 2025)

a) $X = \overline{A}\,\overline{B}C + \overline{A}B\overline{C} + \overline{A}BC + ABC$
b) $X = \overline{A}BC + \overline{A}B\overline{C} + AB\overline{C} + \overline{AB}C$
c) $X = AB + BC + AC$
d) $X = \overline{A}B + \overline{BC} + A\overline{C}$

44) The following binary values were applied to the X and Y inputs of the NAND latch shown. The corresponding stable P, Q outputs will be:

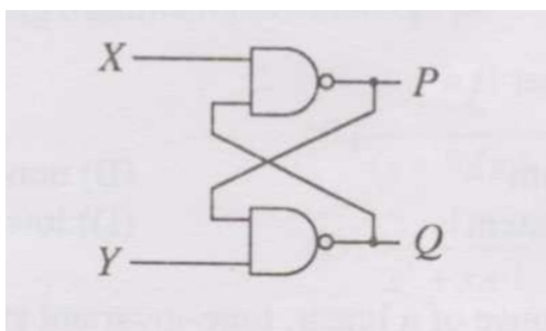


Fig. 44: Figure

Applied sequence: $X = 0, Y = 1$; then $X = 0, Y = 0$; then $X = 1, Y = 1$. (GATE EE 2025)

a) $P = 1,\ Q = 0;\quad P = 1,\ Q = 0;\quad P = 1,\ Q = 0$
b) $P = 1,\ Q = 0;\quad P = 0,\ Q = 1$ or $P = 0,\ Q = 1;\quad P = 0,\ Q = 1$
c) $P = 1,\ Q = 0;\quad P = 1,\ Q = 1;\quad P = 1,\ Q = 0$ or $P = 0,\ Q = 1$
d) $P = 1,\ Q = 0;\quad P = 1,\ Q = 1;\quad P = 1,\ Q = 1$

45) For the circuit shown, the counter state (Q_1Q_0) follows the sequence:

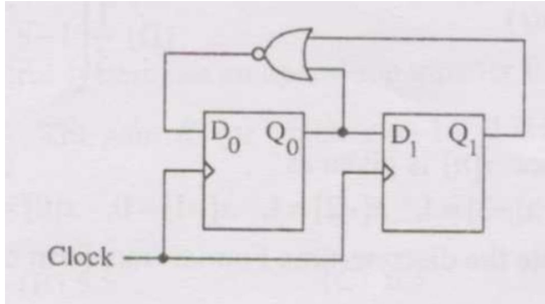


Fig. 45: circuit

(GATE EE 2025)

a) 00, 01, 10, 11, 00, ...
b) 00, 01, 10, 00, 01, ...
c) 00, 01, 11, 00, 01, ...
d) 00, 10, 11, 00, 10, ...

46) An 8255 chip is interfaced to an 8085 microprocessor system as an I/O mapped I/Os as shown. The address lines A_0 and A_1 of the 8085 are used by the 8255 chip to decode internally its three ports and the Control register. The address lines A_3 to A_7 as well as the IO/M signal are used for address decoding. The range of addresses for which the 8255 chip would get selected is:

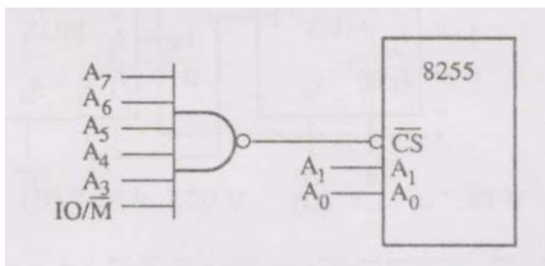


Fig. 46: chip

(GATE EE 2025)

a) F8H – FBH
b) F8H – FCH
c) F8H – FFH
d) F0H – F7H

47) The 3-dB bandwidth of the low-pass signal $e^{-t}u(t)$ is: (GATE EE 2025)

a) $\frac{1}{2\pi}$ Hz b) $\frac{1}{2\pi}\sqrt{2}-1$ Hz c) ∞ d) 1 Hz

48) A Hilbert transformer is a: (GATE EE 2025)

a) Non-linear system
b) Non-causal system
c) Time-varying system
d) Low-pass system

49) The frequency response of a linear time-invariant system is given by $H(f) = \frac{5}{1+j10\pi f}$. The step response of the system is: (GATE EE 2025)

a) $5\left(1-e^{-5t}\right)u(t)$
b) $5\left(1-e^{-t/5}\right)u(t)$
c) $\frac{1}{5}\left(1-e^{-5t}\right)u(t)$
d) $\frac{1}{5}\left(1-e^{-t/5}\right)u(t)$

50) A 5-point sequence $x[n]$ is given as $x[-3]=1$, $x[-2]=1$, $x[-1]=0$, $x[0]=5$, $x[1]=15$. Let $X\left(e^{j\omega}\right)$ denote the discrete-time Fourier transform of $x[n]$. The value of $\int_{-\pi}^{\pi} X\left(e^{4j\omega 3}\right) d\omega$ (GATE EE 2025)

a) 5 b) 10π c) 16π d) $5+j10\pi$

51) The z-transform $X[z]$ of a sequence $x[n]$ is given by $X[z]=\frac{0.5}{1-2z^{-1}}$.
It is given that the region of convergence of $X[z]$ includes the unit circle. The value of $x[0]$ is: (GATE EE 2025)

a) -0.5 b) 0 c) 0.25 d) 0.5

52) A control system with a PD controller is shown. If the velocity error constant $K_v = 1000$ and the damping ratio $\zeta = 0.5$, then the values of K_P and K_D are:

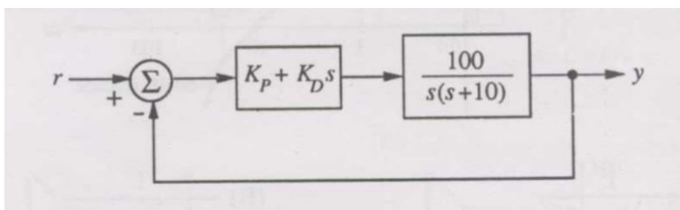


Fig. 52: control system

(GATE EE 2025)

a) $K_P = 100,\ K_D = 0.09$
b) $K_P = 100,\ K_D = 0.9$
c) $K_P = 10,\ K_D = 0.09$
d) $K_P = 10,\ K_D = 0.9$

53) The transfer function of a plant is $T(s)=\frac{5}{(s+5)(s^2+s+1)}$. The second-order approximation of $T(s)$ using the dominant pole concept is: (GATE EE 2025)

(A) $\frac{1}{(s+5)(s+1)}$ (B) $\frac{5}{(s+5)(s+1)}$ (C) $\frac{5}{s^2+s+1}$ (D) $\frac{1}{s^2+s+1}$

54) The open-loop transfer function of a plant is given as $G(s)=\frac{1}{s^2-1}$. If the plant is operated in unity feedback, then the lead compensator that can stabilize the system is: (GATE EE 2025)

a) $\frac{10(s-1)}{s+2}$ b) $\frac{10(s+4)}{s+2}$ c) $\frac{10(s+2)}{s+10}$ d) $\frac{2(s+2)}{s+10}$

55) A unity feedback control system has an open-loop transfer function $G(s)=\frac{K}{s(s^2+7s+12)}$. The gain K for which $s=-1+j1$ will lie on the root locus of this system is: (GATE EE 2025)

a) 4 b) 5.5 c) 6.5 d) 10

56) The asymptotic Bode magnitude plot of a transfer function is as shown: starts at 60 dB, slopes -20 dB/decade until 1 rad/s (at 40 dB), then -40 dB/decade crossing 0 dB near 10, then -60 dB/decade. The transfer function $G(s)$ corresponding to this plot is: (GATE EE 2025)

a) $\frac{1}{(s+1)(s+20)}$ b) $\frac{1}{s(s+1)(s+20)}$ c) $\frac{100}{s(s+1)(s+20)}$ d) $\frac{100}{s(s+1)(1+0.05s)}$

57) The state-space representation of a separately excited DC servo motor dynamics is given as $\frac{d}{dt}\begin{pmatrix}\omega \\ i_a\end{pmatrix} = \begin{pmatrix}-1 & 1 \\ -1 & -10\end{pmatrix}\begin{pmatrix}\omega \\ i_a\end{pmatrix} + \begin{pmatrix}0 \\ 10\end{pmatrix}u$ where ω is the speed, i_a is the armature current, and u is the armature voltage.
The transfer function $\dfrac{\omega(s)}{u(s)}$ is: (GATE EE 2025)
a) $\dfrac{10}{s^2 + 11s + 11}$ b) $\dfrac{1}{s^2 + 11s + 11}$ c) $\dfrac{10s + 10}{s^2 + 11s + 11}$ d) $\dfrac{1}{s^2 + s + 1}$

58) In delta modulation, the slope overload distortion can be reduced by: (GATE EE 2025)
a) decreasing the step size
b) decreasing the granular noise
c) decreasing the sampling rate
d) increasing the step size

59) The raised cosine pulse $p(t)$ used for zero ISI with unity roll-off factor is $p(t) = \frac{\sin 4\pi Wt}{4\pi Wt(1-16W^2t^2)}$. The value of $p(t)$ at $t = \dfrac{1}{4W}$ is: (GATE EE 2025)
a) -0.5 b) 0 c) 0.5 d) ∞

60) In the following scheme, if the spectrum $M(f)$ of $m(t)$ is as shown, then the spectrum $Y(f)$ of $y(t)$ will be: (GATE EE 2025)

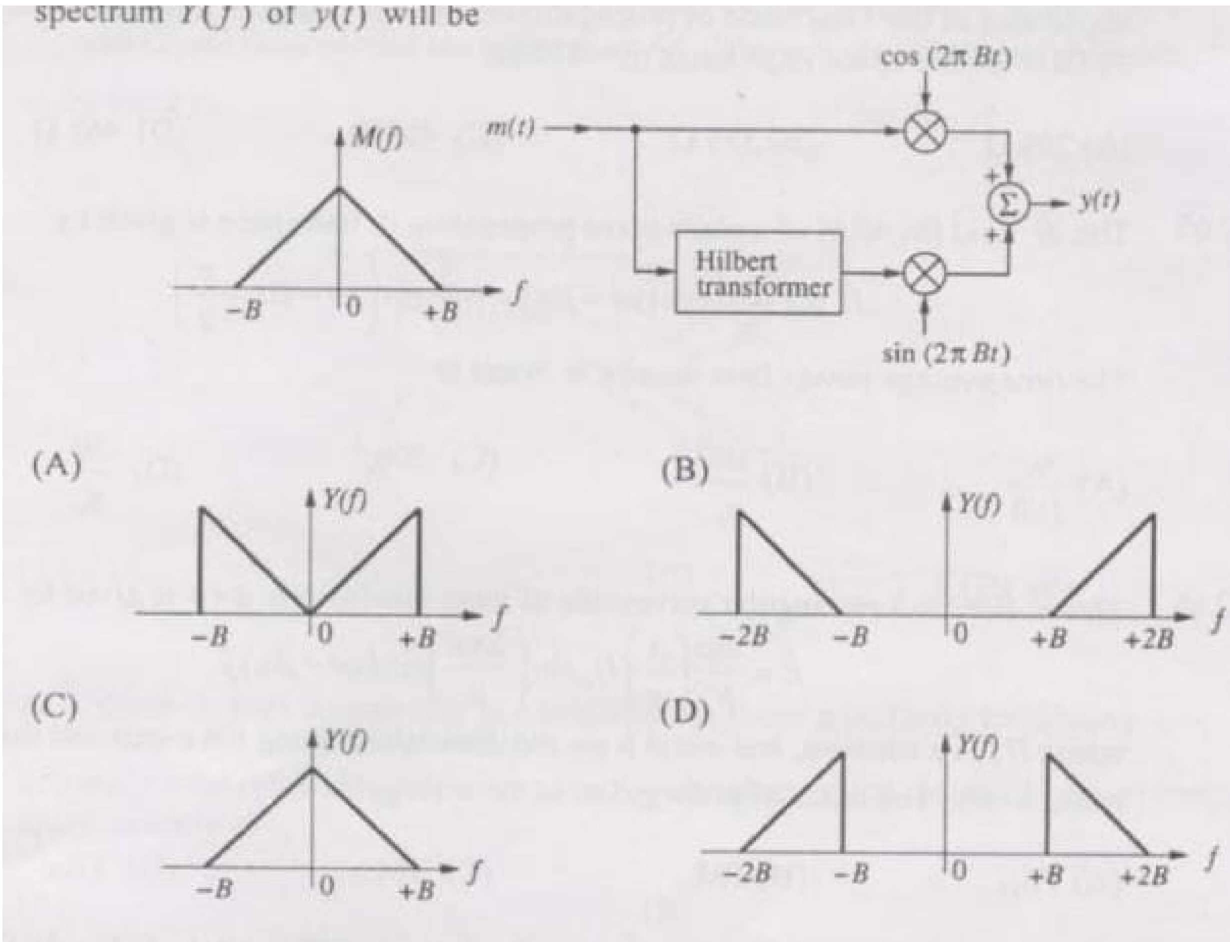


Fig. 60: spectrums

61) During transmission over a binary channel, bit errors occur independently with probability p. The probability of at most one bit in error in a block of n bits is: (GATE EE 2025)
   (A) p^n
   (B) $1 - p^n$
   (C) $np(1-p)^{n-1} + (1-p)^n$
   (D) $1 - (1-p)^n$

62) In a GSM system, 8 channels coexist in 200 kHz using TDMA. A GSM operator is allocated 5 MHz. Assuming frequency reuse factor of 1/5 (five-cell repeat), the maximum number of simultaneous channels in one cell is: (GATE EE 2025)

   a) 200
   b) 40
   c) 25
   d) 5

63) In a Direct Sequence CDMA system the chip rate is 1.2288×10^6 chips/sec. If the processing gain is desired to be **at least** 100, the data rate: (GATE EE 2025)
   a) must be $\leq 12.288 \times 10^3$ bits/sec
   b) must be $> 12.288 \times 10^3$ bits/sec
   c) must be exactly 12.288×10^3 bits/sec
   d) can take any value less than 122.88×10^3 bits/sec

64) An air-filled rectangular waveguide has inner dimensions 3 cm $\times$ 2 cm. The wave impedance of the TE_{20} mode at frequency 30 GHz is (free-space impedance $\eta_0 = 377\ \Omega$): (GATE EE 2025)

a) 308 Ω b) 355 Ω c) 400 Ω d) 461 Ω

65) The magnetic field of a plane wave in free space is $\mathbf{H} = \hat{x}\frac{5\sqrt{3}}{\eta_0}\cos(\omega t - \beta z) + \hat{y}\frac{5}{\eta_0}\left(-\sin(\omega t - \beta z + \frac{\pi}{2})\right)$. The time-average power flow density in Watts is: (GATE EE 2025)

a) $\frac{\eta_0}{100}$ b) $\frac{100}{\eta_0}$ c) $50\eta_0^2$ d) $\frac{50}{\eta_0}$

66) The electric field in a rectangular waveguide of inner dimensions $a \times b$ is given by $\mathbf{E} = \frac{\omega\mu}{k^2}\left(\frac{\pi}{a}\right)H_0 \sin\left(\frac{2\pi x}{a}\right)\sin(\omega t - \beta z)\,\hat{y}$. The mode of propagation is: (GATE EE 2025)

a) TE_{20} b) TM_{11} c) TM_{20} d) TE_{10}

67) A load of 50 Ω is connected in shunt in a 2-wire transmission line of characteristic impedance $Z_0 = 50\ \Omega$ as shown. The 2-port scattering parameter matrix (S-matrix) of the shunt element is:

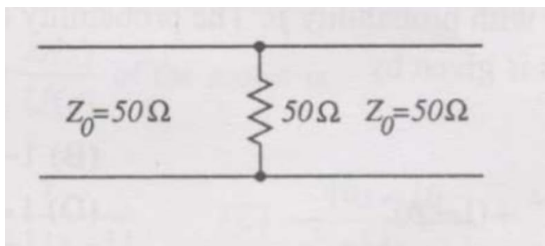


Fig. 67: circuit

(GATE EE 2025)

a) $\begin{pmatrix}\frac{1}{2} & \frac{1}{2}\\ \frac{1}{2} & \frac{1}{2}\end{pmatrix}$ b) $\begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix}$ c) $\begin{pmatrix}\frac{1}{3} & \frac{2}{3}\\ \frac{2}{3} & \frac{1}{3}\end{pmatrix}$ d) $\begin{pmatrix}\frac{1}{4} & \frac{3}{4}\\ \frac{3}{4} & \frac{1}{4}\end{pmatrix}$

68) The parallel branches of a 2-wire transmission line are terminated in 100 Ω and 200 Ω resistors as shown. The characteristic impedance of the line is $Z_0 = 50\ \Omega$ and each section has length $\lambda/4$. The voltage reflection coefficient Γ at the input is:

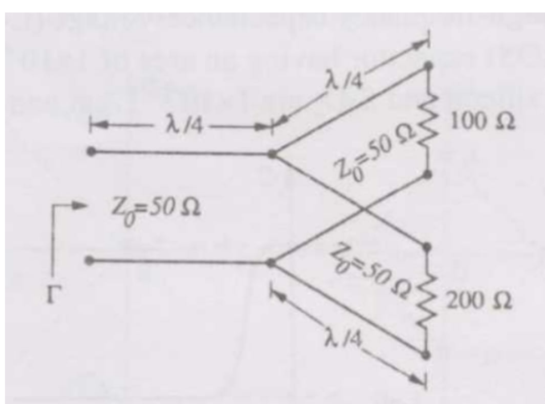


Fig. 68: circuit

(GATE EE 2025)

a) $-j\frac{7}{5}$ b) $-\frac{5}{7}$ c) $j\frac{5}{7}$ d) $\frac{5}{7}$

69) A $\lambda/2$ dipole is kept horizontally at a height of $\lambda_0/2$ above a perfectly conducting ground plane. The radiation pattern in the plane of the dipole (**E**-plane) looks approximately as:

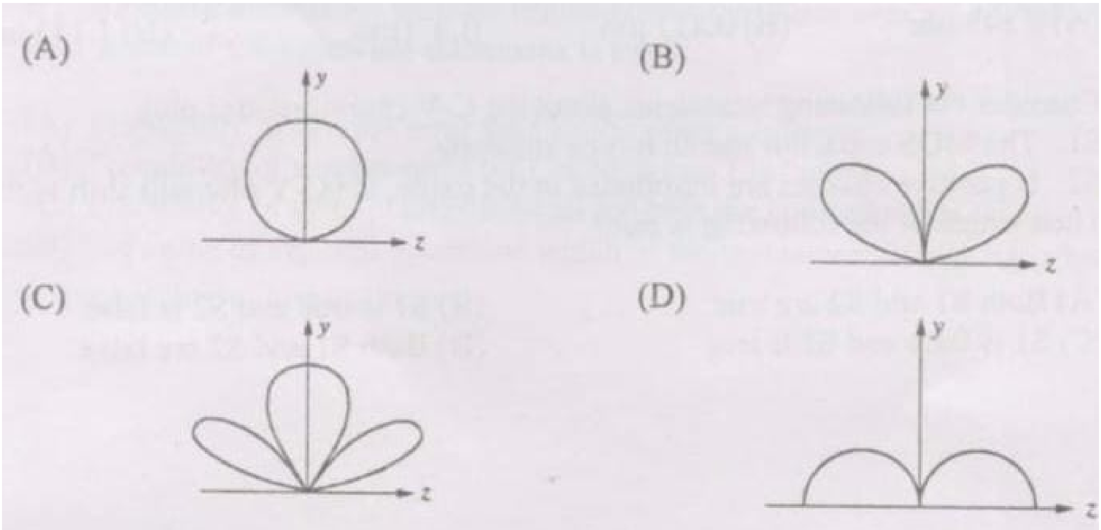


Fig. 69: patterns

(GATE EE 2025)

a) A b) B c) C d) D

70) A right circularly polarized (RCP) plane wave is incident at a dielectric interface. If the reflection coefficient $r_l = 1$, the relative dielectric constant ε_{r2} is:

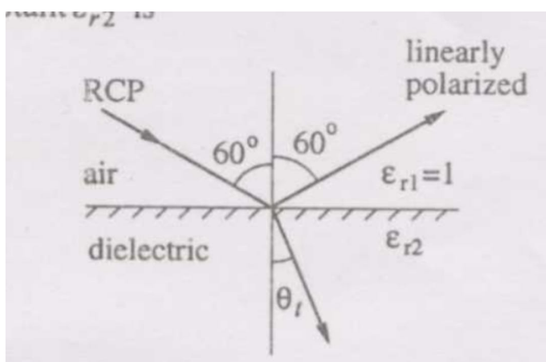


Fig. 70: wave

(GATE EE 2025)

a) $\sqrt{2}$ b) $\sqrt{3}$ c) 2 d) 3

Common Data for Questions 71, 72, 73: The figure shows high-frequency capacitance-voltage (CV) characteristics of a Metal/SiO2/silicon (MOS) capacitor having area $1 \times 10^{-4}\,\text{cm}^2$. Assume permittivities ε_0, εr of silicon and SiO2 as 1×10^{-12} F/cm and 3.5×10^{-13} F/cm respectively. The measured capacitance transitions from Sacc (accumulation) to S_{dep} (depletion/weak inversion) as gate voltage sweeps.Â AÂ sketch:

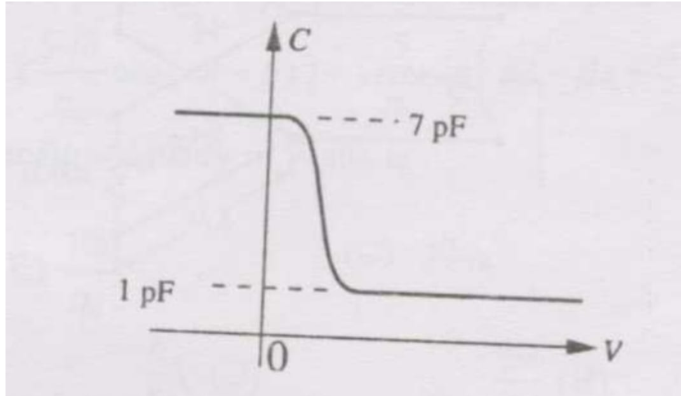


Fig. 70: figure

71) The gate oxide thickness in the MOS capacitor is: (GATE EE 2025)

a) 50 nm
b) 143 nm
c) 350 nm
d) 1 μm

72) The maximum depletion layer width in silicon is: (GATE EE 2025)

a) 0.143 μm
b) 0.857 μm
c) 1 μm
d) 1.143 μm

73) Consider the following statements about the CV characteristics plot:
S1: The MOS capacitor has an n-type substrate.
S2: If positive charges are introduced in the oxide, the CV plot will shift to the left.
Then which of the following is true? (GATE EE 2025)

a) Both S1 and S2 are true
b) S1 is true and S2 is false
c) S1 is false and S2 is true
d) Both S1 and S2 are false

Common Data for Q.74 and Q.75: Two 4-ary signal constellations are shown. It is given that ϕ_1 and ϕ_2 constitute an orthonormal basis and four symbols in each are equiprobable. Let $N_0/2$ denote the power spectral density of white Gaussian noise.

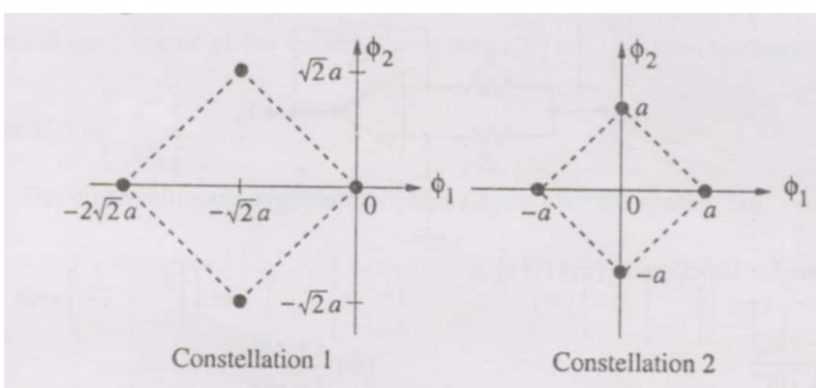


Fig. 73: constellations

74) The ratio of the average energy of Constellation 1 to that of Constellation 2 is: (GATE EE 2025)

a) $4a^2$ b) 4 c) 2 d) 8

75) If these constellations are used over an AWGN channel, then: (GATE EE 2025)
  a) Probability of symbol error for Constellation 1 is lower
  b) Probability of symbol error for Constellation 1 is higher
  c) Probability of symbol error is equal for both
  d) Value of N_0 will determine which has lower error

Statement for Linked Answer Questions 76 & 77: Consider the op-amp circuit shown.

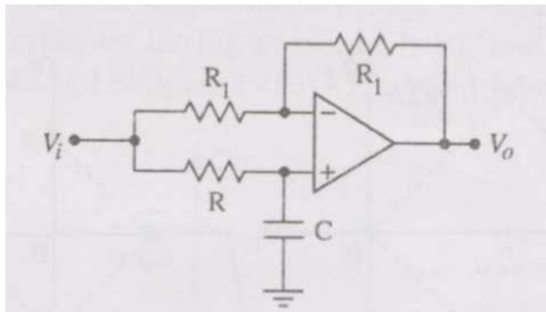


Fig. 75: circuit

76) The transfer function $V_o(s)/V_i(s)$ is: (GATE EE 2025)

a) $\dfrac{1 - sRC}{1 + sRC}$ b) $\dfrac{1 + sRC}{1 - sRC}$ c) $\dfrac{1}{1 - sRC}$ d) $\dfrac{1}{1 + sRC}$

77) If $V_i = V_i \sin(\omega t)$ and $V_o = V_o \sin(\omega t + \phi)$, the minimum and maximum values of ϕ (in radians) are respectively: (GATE EE 2025)

a) $-\pi/2$ and $\pi/2$ b) 0 and $\pi/2$ c) $-\pi$ and 0 d) $-\pi/2$ and 0

Statement for Linked Answer Questions 78 & 79: An 8085 assembly language program is:

```
1: MVI A, B5H
2: MVI B, 0EH
3: XRI 69H
4: ADD B
5: ANI 9BH
6: CPI 9FH
7: STA 3010H
8: HLT
```

78) The contents of the accumulator just after execution of the `ADD` in line 4 will be: (GATE EE 2025)

a) `C3H` b) `EAH` c) `DCH` d) `69H`

79) After execution of line 7, the status of CY and Z flags will be: (GATE EE 2025)
  a) CY = 0, Z = 0
  b) CY = 0, Z = 1
  c) CY = 1, Z = 0
  d) CY = 1, Z = 1

Statement for Linked Answer Questions 80 & 81:
Consider a linear system whose state space representation is $\dot{x}(t) = Ax(t)$.
If the initial state vector of the system is $\mathbf{x}(0) = \begin{pmatrix} 1 & -2 \end{pmatrix}$, then the system response is

$\mathbf{x}(t) = \left(e^{-2t} - 2e^{-2t}\right)$.

If the initial state vector of the system changes to $\mathbf{x}(0) = \left(1 - 1\right)$,

then the system response becomes $\mathbf{x}(t) = \left(e^{-t} - e^{-t}\right)$. [6pt]

80) The eigenvalue and eigenvector pairs (λ, v) for the system are: (GATE EE 2025)

a) $\left(-1, \begin{pmatrix} 1 \\ -1 \end{pmatrix}\right)$ and $\left(-2, \begin{pmatrix} 1 \\ -2 \end{pmatrix}\right)$

b) $\left(-2, \begin{pmatrix} 1 \\ -1 \end{pmatrix}\right)$ and $\left(-1, \begin{pmatrix} 1 \\ -2 \end{pmatrix}\right)$

c) $\left(-1, \begin{pmatrix} 1 \\ -1 \end{pmatrix}\right)$ and $\left(2, \begin{pmatrix} 1 \\ -2 \end{pmatrix}\right)$

d) $\left(-2, \begin{pmatrix} 1 \\ -1 \end{pmatrix}\right)$ and $\left(1, \begin{pmatrix} 1 \\ -2 \end{pmatrix}\right)$

81) The system matrix A is: (GATE EE 2025)

a) $\begin{pmatrix} 0 & 1 \\ -1 & 1 \end{pmatrix}$ b) $\begin{pmatrix} 1 & 1 \\ -1 & -2 \end{pmatrix}$ c) $\begin{pmatrix} 2 & 1 \\ -1 & -1 \end{pmatrix}$ d) $\begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix}$

Statement for Linked Answer Questions 82 & 83:

An input to a 6-level quantizer has PDF $f(x)$ as shown: it is piecewise-constant with three decision boundaries at -1, 0, and 1, chosen to maximize output entropy. The central plateau height is a, the outer flat region height is b.

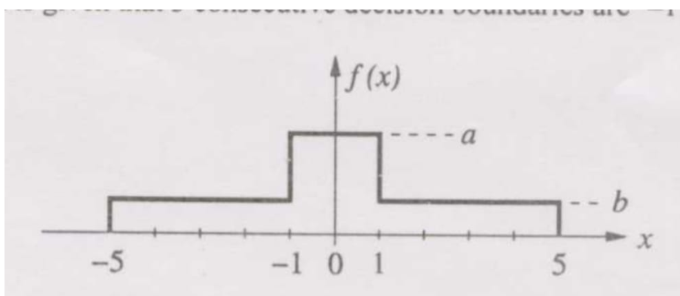


Fig. 81: boundaries

82) The values of a and b are: (GATE EE 2025)

a) $a = \frac{1}{6},\ b = \frac{1}{12}$ b) $a = \frac{1}{5},\ b = \frac{3}{40}$ c) $a = \frac{1}{4},\ b = \frac{1}{16}$ d) $a = \frac{1}{3},\ b = \frac{1}{24}$

83) Assuming reconstruction levels are midpoints of decision intervals, the ratio of signal power to quantization noise power is: (GATE EE 2025)

(A) $\dfrac{152}{9}$ (B) $\dfrac{64}{3}$ (C) $\dfrac{76}{3}$ (D) 28

Statement for Linked Questions 84 & 85: In the DAC circuit shown, $V_R = 10$ V and $R = 10$ kΩ. The ladder consists of series R sections with shunt $2R$ to ground, feeding an inverting op-amp with feedback resistor R.

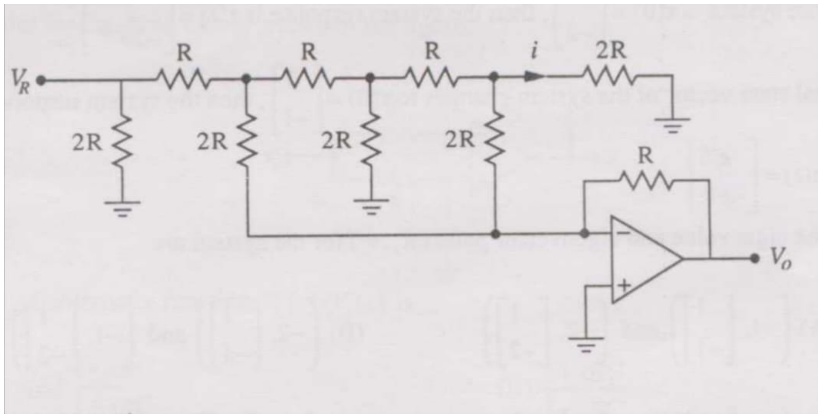


Fig. 83: circuit

84) The current i is: (GATE EE 2025)

(A) 31.25 μA
(B) 62.5 μA
(C) 125 μA
(D) 250 μA

85) The output voltage V_o is: (GATE EE 2025)

(A) -0.781 V
(B) -1.562 V
(C) -3.125 V
(D) -6.250 V