

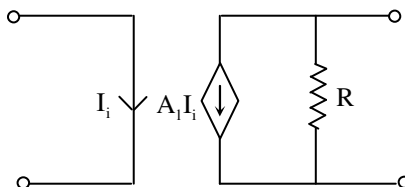
10. A five digit number is formed using the digits 1,3,5,7 and 9 without repeating any of them. What is the sum of all such possible five digit numbers?  
 (A) 6666660      (B) 6666600      (C) 6666666      (D) 6666606

Electronics and Communication Engineering

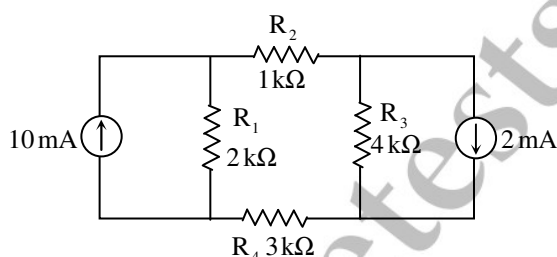
**Q.No. 1 – 25 Carry One Mark Each**

1. The series  $\sum_{n=0}^{\infty} \frac{1}{n!}$  converges to  
 (A)  $2 \ln 2$       (B)  $\sqrt{2}$       (C) 2      (D)  $e$
2. The magnitude of the gradient for the function  $f(x, y, z) = x^2 + 3y^2 + z^3$  at the point (1,1,1) is \_\_\_\_\_.
3. Let  $X$  be a zero mean unit variance Gaussian random variable.  $E[|X|]$  is equal to \_\_\_\_\_
4. If  $a$  and  $b$  are constants, the most general solution of the differential equation  $\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + x = 0$  is  
 (A)  $ae^{-t}$       (B)  $ae^{-t} + bte^{-t}$       (C)  $ae^t + bte^{-t}$       (D)  $ae^{-2t}$
5. The directional derivative of  $f(x, y) = \frac{xy}{\sqrt{2}}(x + y)$  at (1,1) in the direction of the unit vector at an angle of  $\frac{\pi}{4}$  with y-axis, is given by \_\_\_\_\_.

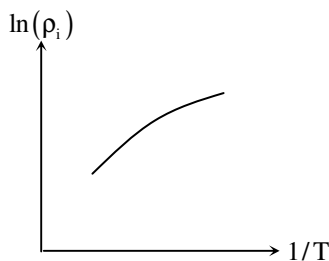
6. The circuit shown in the figure represents a



- (A) Voltage controlled voltage source      (B) Voltage controlled current source  
 (C) Current controlled current source      (D) Current controlled voltage source
7. The magnitude of current (in mA) through the resistor  $R_2$  in the figure shown is \_\_\_\_\_.



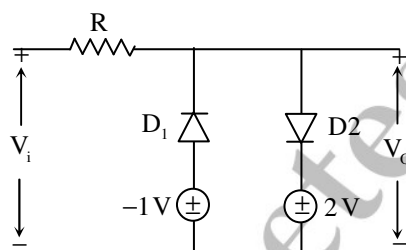
8. At  $T = 300$  K, the band gap and the intrinsic carrier concentration of GaAs are  $1.42$  eV and  $10^6$   $\text{cm}^{-3}$ , respectively. In order to generate electron hole pairs in GaAs, which one of the wavelength ( $\lambda_c$ ) ranges of incident radiation, is most suitable? (Given that: Plank's constant is  $6.62 \times 10^{-34}$  J-s, velocity of light is  $3 \times 10^{10}$  cm/s and charge of electron is  $1.6 \times 10^{-19}$  C)
- (A)  $0.42 \mu\text{m} < \lambda_c < 0.87 \mu\text{m}$       (B)  $0.87 \mu\text{m} < \lambda_c < 1.42 \mu\text{m}$   
 (C)  $1.42 \mu\text{m} < \lambda_c < 1.62 \mu\text{m}$       (D)  $1.62 \mu\text{m} < \lambda_c < 6.62 \mu\text{m}$
9. In the figure  $\ln(\rho_i)$  is plotted as a function of  $1/T$ , where  $\rho_i$  the intrinsic resistivity of silicon,  $T$  is the temperature, and the plot is almost linear.



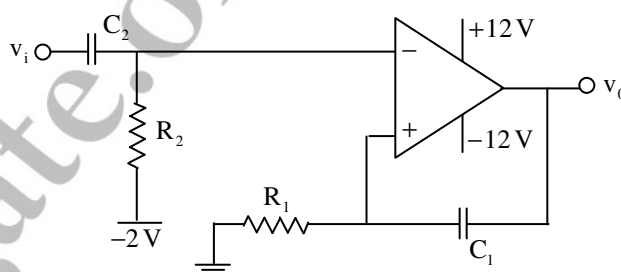
The slope of the line can be used to estimate

- (A) Band gap energy of silicon ( $E_g$ )  
 (B) Sum of electron and hole mobility in silicon ( $\mu_n + \mu_p$ )  
 (C) Reciprocal of the sum of electron and hole mobility in silicon ( $(\mu_n + \mu_p)^{-1}$ )  
 (D) Intrinsic carrier concentration of silicon ( $n_i$ )

10. The cut-off wavelength (in  $\mu\text{m}$ ) of light that can be used for intrinsic excitation of a semiconductor material of bandgap  $E_g = 1.1 \text{ eV}$  is \_\_\_\_\_
11. If the emitter resistance in a common-emitter voltage amplifier is not bypassed, it will
- Reduce both the voltage gain and the input impedance
  - Reduce the voltage gain and increase the input impedance
  - Increase the voltage gain and reduce the input impedance
  - Increase both the voltage gain and the input impedance
12. Two silicon diodes, with a forward voltage drop of  $0.7 \text{ V}$ , are used in the circuit shown in the figure. The range of input voltage  $V_i$  for which the output voltage  $V_o = V_i$ , is

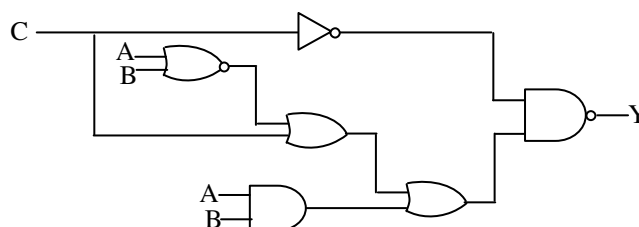


- $-0.3 \text{ V} < V_i < 1.3 \text{ V}$
  - $-0.3 \text{ V} < V_i < 2 \text{ V}$
  - $-1.0 \text{ V} < V_i < 2.0 \text{ V}$
  - $-1.7 \text{ V} < V_i < 2.7 \text{ V}$
13. The circuit shown represents:



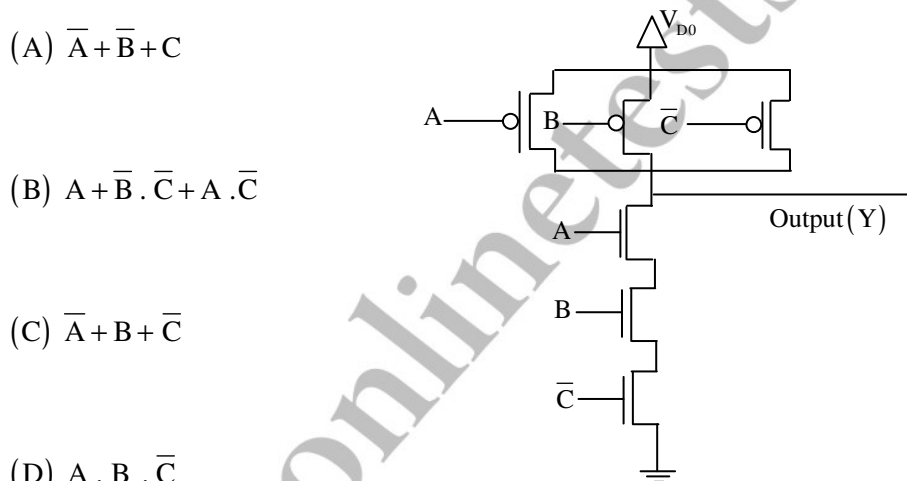
- A bandpass filter
  - A voltage controlled oscillator
  - An amplitude modulator
  - A monostable multivibrator
14. For a given sample-and-hold circuit, if the value of the hold capacitor is increased, then
- Droop rate decreases and acquisition time decreases
  - Droop rate decreases and acquisition time increases
  - Droop rate increases and acquisition time decreases
  - Droop rate increases and acquisition time increases

15. In the circuit shown in the figure, if  $C=0$ , the expression for  $Y$  is



- (A)  $Y = A\bar{B} + \bar{A}B$                       (B)  $Y = A + B$   
 (C)  $Y = \bar{A} + \bar{B}$                               (D)  $Y = AB$

16. The output ( $Y$ ) of the circuit shown in the figure is



- (A)  $\bar{A} + \bar{B} + C$   
 (B)  $A + \bar{B} \cdot \bar{C} + A \cdot \bar{C}$   
 (C)  $\bar{A} + B + \bar{C}$   
 (D)  $A \cdot B \cdot \bar{C}$

17. A Fourier transform pair is given by

$$\left(\frac{2}{3}\right)^n u[n+3] \stackrel{FT}{\leftrightarrow} \frac{A e^{-j6\pi f}}{1 - \left(\frac{2}{3}\right) e^{-j2\pi f}}$$

where  $u[n]$  denotes the unit step sequence. The value of  $A$  is \_\_\_\_\_.

18. A real-valued signal  $x(t)$  limited to the frequency band  $|f| \leq \frac{W}{2}$  is passed through a linear time invariant system whose frequency response is

$$H(f) = \begin{cases} e^{-j4\pi f}, & |f| \leq \frac{W}{2} \\ 0, & |f| > \frac{W}{2} \end{cases}$$

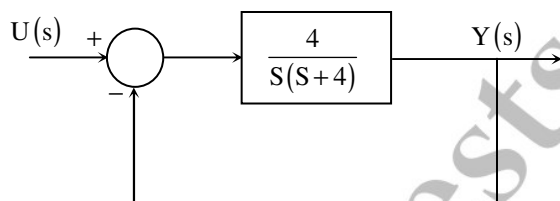
The output of the system is

- (A)  $x(t+4)$               (B)  $x(t-4)$               (C)  $x(t+2)$               (D)  $x(t-2)$

19. The sequence  $x[n] = 0.5^n u[n]$ , where  $u[n]$  is the unit step sequence, is convolved with itself to obtain  $y[n]$ . Then  $\sum_{n=-\infty}^{\infty} y(n)$  \_\_\_\_\_.

20. In a Bode magnitude plot, which one of the following slopes would be exhibited at high frequencies by a 4<sup>th</sup> order all-pole system?  
 (A) - 80 dB/decade (B) - 40 dB/decade  
 (C) +40 dB/decade (D) +80 dB/decade

21. For the second order closed-loop system shown in the figure, the natural frequency (in rad/s) is



(A) 16 (B) 4 (C) 2 (D) 1

22. If calls arrive at a telephone exchange such that the time of arrival of any call is independent of the time of arrival of earlier or future calls, the probability distribution function of the total number of calls in a fixed time interval will be  
 (A) Poisson (B) Gaussian (C) Exponential (D) Gamma

23. In a double side-band (DSB) full carrier AM transmission system, if the modulation index is doubled, then the ratio of total sideband power to the carrier power increases by a factor of \_\_\_\_\_.

24. For an antenna radiating in free space, the electric field at a distance of 1 km is found to be 12 mV/m. Given that intrinsic impedance of the free space is  $120\pi \Omega$ , the magnitude of average power density due to this antenna at a distance of 2 km from the antenna (in nW/m<sup>2</sup>) is \_\_\_\_\_.

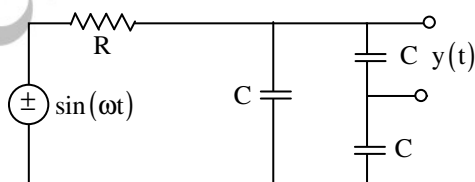
25. Match column A with column B.

Column A	Column B
(1) Point electromagnetic source	(P) Highly directional
(2) Dish antenna	(Q) End free
(3) Yagi-Uda antenna	(R) Isotropic

1 → P                      1 → R                      1 → Q                      1 → R  
 (A) 2 → Q                (B) 2 → P                (C) 2 → P                (D) 2 → Q  
 3 → R                      3 → Q                      3 → R                      3 → P

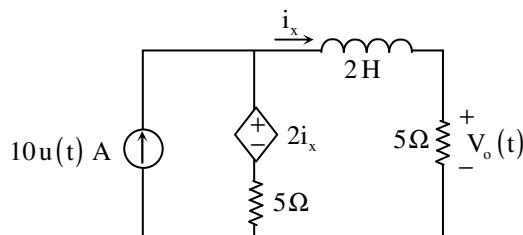
**Q. No. 26 – 55 Carry Two Marks Each**

26. With initial values  $y(0) = y'(0)=1$  the solution of the differential equation  $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = 0$  at  $x = 1$  is \_\_\_\_\_
27. Parcels from sender S to receiver R pass sequentially through two post-offices. Each post-office has a probability  $\frac{1}{5}$  of losing an incoming parcel, independently of all other parcels. Given that a parcel is lost, the probability that it was lost by the second post-office is \_\_\_\_\_.
28. The unilateral Laplace transform of  $f(t)$  is  $\frac{1}{s^2 + s + 1}$ . Which one of the following is the unilateral Laplace transform of  $g(t) = t.f(t)$ ?
- (A)  $\frac{-s}{(s^2 + s + 1)^2}$       (B)  $\frac{-(2s+1)}{(s^2 + s + 1)^2}$       (C)  $\frac{S}{(s^2 + s + 1)^2}$       (D)  $\frac{2S+1}{(s^2 + s + 1)^2}$
29. For a right angled triangle, if the sum of the lengths of the hypotenuse and a side is kept constant, in order to have maximum area of the triangle, the angle between the hypotenuse and the side is
- (A)  $12^\circ$       (B)  $36^\circ$       (C)  $60^\circ$       (D)  $45^\circ$
30. The steady state output of the circuit shown in the figure is given by  $y(t) = A(\omega) \sin(\omega t + \phi(\omega))$ . If the amplitude  $|A(\omega)| = 0.25$ , then the frequency  $\omega$  is

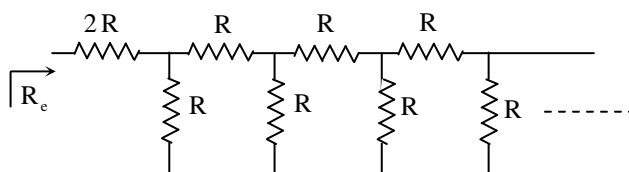


- (A)  $\frac{1}{\sqrt{3} R C}$       (B)  $\frac{2}{\sqrt{3} R C}$       (C)  $\frac{1}{R C}$       (D)  $\frac{2}{R C}$

31. In the circuit shown in the figure, the value of  $V_0(t)$  (in Volts) for  $t \rightarrow \infty$  is \_\_\_\_\_.

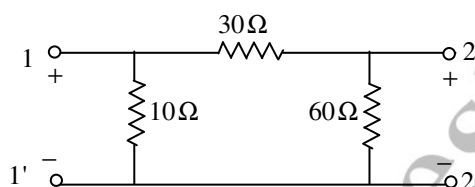


32. The equivalent resistance in the infinite ladder network shown in the figure is  $R_e$ .



The value of  $R_e/R$  is \_\_\_\_\_

33. For the two-port network shown in the figure, the impedance ( $Z$ ) matrix (in  $\Omega$ ) is

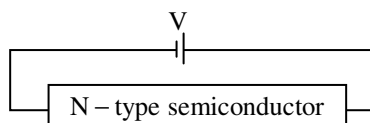


- (A)  $\begin{bmatrix} 6 & 24 \\ 42 & 9 \end{bmatrix}$       (B)  $\begin{bmatrix} 9 & 8 \\ 8 & 24 \end{bmatrix}$       (C)  $\begin{bmatrix} 9 & 6 \\ 6 & 24 \end{bmatrix}$       (D)  $\begin{bmatrix} 42 & 6 \\ 6 & 60 \end{bmatrix}$

34. Consider a silicon sample doped with  $N_D = 1 \times 10^{15}/\text{cm}^3$  donor atoms. Assume that the intrinsic carrier concentration  $n_i = 1.5 \times 10^{10}/\text{cm}^3$ . If the sample is additionally doped with  $N_A = 1 \times 10^{18}/\text{cm}^3$  acceptor atoms, the approximate number of electrons/ $\text{cm}^3$  in the sample, at  $T=300$  K, will be \_\_\_\_\_.

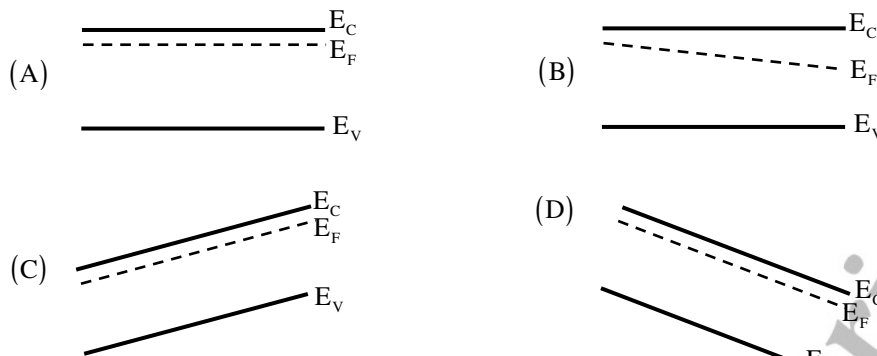
35. Consider two BJTs biased at the same collector current with area  $A_1 = 0.2\mu\text{m} \times 0.2\mu\text{m}$  and  $A_2 = 300\mu\text{m} \times 300\mu\text{m}$ . Assuming that all other device parameters are identical,  $kT/q = 26$  mV, the intrinsic carrier concentration is  $1 \times 10^{10} \text{ cm}^{-3}$ , and  $q = 1.6 \times 10^{-19} \text{ C}$ , the difference between the base-emitter voltages (in mV) of the two BJTs (i.e.,  $V_{BE1} - V_{BE2}$ ) is \_\_\_\_\_.

36. An N-type semiconductor having uniform doping is biased as shown in the figure.

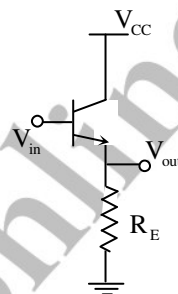


If  $E_C$  is the lowest energy level of the conduction band,  $E_V$  is the highest energy level of the valance band and  $E_F$  is the Fermi level, which one of the following represents the energy band diagram for the biased N-type semiconductor?





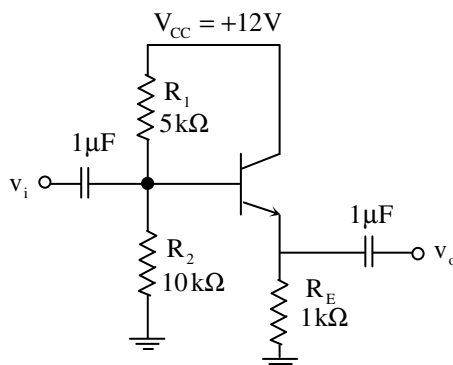
37. Consider the common-collector amplifier in the figure (bias circuitry ensures that the transistor operates in forward active region, but has been omitted for simplicity). Let  $I_C$  be the collector current,  $V_{BE}$  be the base-emitter voltage and  $V_T$  be the thermal voltage. Also,  $g_m$  and  $r_o$  are the small-signal transconductance and output resistance of the transistor, respectively. Which one of the following conditions ensures a nearly constant small signal voltage gain for a wide range of values of  $R_E$ ?



- (A)  $g_m R_E \ll 1$       (B)  $I_C R_E \gg V_T$       (C)  $g_m r_o \gg 1$       (D)  $V_{BE} \gg V_T$

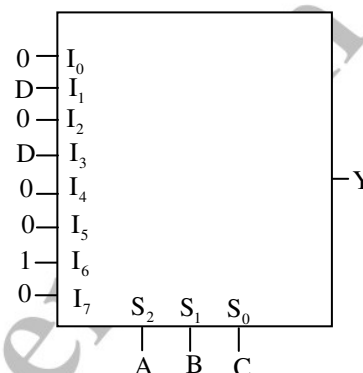
38. A BJT in a common-base configuration is used to amplify a signal received by a  $50\Omega$  antenna. Assume  $kT/q = 25$  mV. The value of the collector bias current (in mA) required to match the input impedance of the amplifier to the impedance of the antenna is \_\_\_\_\_.

39. For the common collector amplifier shown in the figure, the BJT has high  $\beta$ , negligible  $V_{CE(sat)}$ , and  $V_{BE} = 0.7$  V. The maximum undistorted peak-to-peak output voltage  $v_o$  (in Volts) is \_\_\_\_\_.

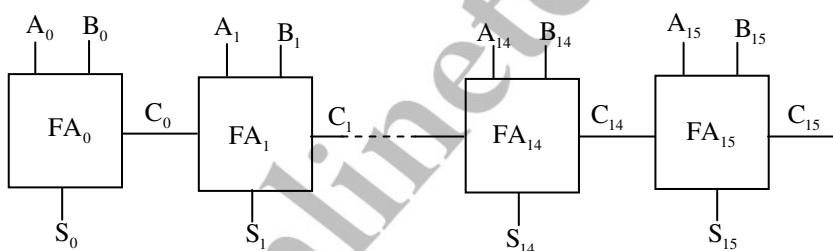


40. An 8-to-1 multiplexer is used to implement a logical function  $Y$  as shown in the figure. The output  $Y$  is given by

- (A)  $Y = A \bar{B} C + A \bar{C} D$
- (B)  $Y = \bar{A} B C + A \bar{B} D$
- (C)  $Y = A B \bar{C} + \bar{A} C D$
- (D)  $Y = \bar{A} \bar{B} D + A \bar{B} C$



41. A 16-bit ripple carry adder is realized using 16 identical full adders (FA) as shown in the figure. The carry-propagation delay of each FA is 12 ns and the sum-propagation delay of each FA is 15 ns. The worst case delay (in ns) of this 16-bit adder will be \_\_\_\_\_.



42. An 8085 microprocessor executes "STA 1234H" with starting address location 1FFEh (STA copies the contents of the Accumulator to the 16-bit address location). While the instruction is fetched and executed, the sequence of values written at the address pins  $A_{15}-A_8$  is
- (A) 1FH, 1FH, 20H, 12H                      (B) 1FH, FEH, 1FH, FFH, 12H
- (C) 1FH, 1FH, 12H, 12H                      (D) 1FH, 1FH, 12H, 20H, 12H
43. A stable linear time invariant (LTI) system has a transfer function  $H(s) = \frac{1}{s^2 + s - 6}$ . To make this system causal it needs to be cascaded with another LTI system having a transfer function  $H_1(s)$ . A correct choice for  $H_1(s)$  among the following options is
- (A)  $s + 3$                       (B)  $s - 2$                       (C)  $s - 6$                       (D)  $s + 1$
44. A causal LTI system has zero initial conditions and impulses response  $h(t)$ . Its input  $x(t)$  and output  $y(t)$  are related through the linear constant-coefficient differential equation

$$\frac{d^2y(t)}{dt^2} + a \frac{dy(t)}{dt} + a^2y(t) = x(t)$$

Let another signal  $g(t)$  be defined as

$$g(t) = a^2 \int_0^t h(\tau) d\tau + \frac{dh(t)}{dt} + ah(t)$$

If  $G(s)$  is the Laplace transform of  $g(t)$ , then the number of poles of  $G(s)$  is \_\_\_\_\_.

45. The N-point DFT X of a sequence  $x[n], 0 \leq n \leq N-1$  is given by

$$X[k] = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{N}nk}, \quad 0 \leq k \leq N-1$$

Denote this relation as  $X = \text{DFT}(x)$ . For  $N = 4$ , which one of the following sequences satisfies  $\text{DFT}(\text{DFT}(x)) = x$  ?

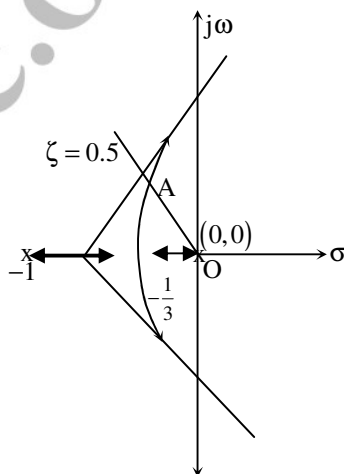
- (A)  $x = [1 \ 2 \ 3 \ 4]$                       (B)  $x = [1 \ 2 \ 3 \ 2]$   
(C)  $x = [1 \ 3 \ 2 \ 2]$                       (D)  $x = [1 \ 2 \ 2 \ 3]$

46. The state transition matrix  $\phi(t)$  of a system  $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

- (A)  $\begin{bmatrix} t & 1 \\ 1 & 0 \end{bmatrix}$                       (B)  $\begin{bmatrix} 1 & 0 \\ t & 1 \end{bmatrix}$                       (C)  $\begin{bmatrix} 0 & 1 \\ 1 & t \end{bmatrix}$                       (D)  $\begin{bmatrix} 1 & t \\ 0 & 1 \end{bmatrix}$

47. Consider a transfer function  $G_p(s) = \frac{ps^2 + 3ps - 2}{s^2 + (3+p)s + (2-p)}$  with  $p$  a positive real parameter. The maximum value of  $p$  until which  $G_p$  remains stable is \_\_\_\_\_.

48. The characteristic equation of a unity negative feedback system  $1 + KG(s) = 0$ . The open loop transfer function  $G(s)$  has one pole at 0 and two poles at -1. The root locus of the system for varying  $K$  is shown in the figure.



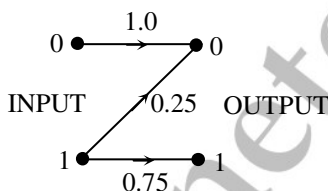
The constant damping ratio line, for  $\zeta = 0.5$ , intersects the root locus at point A. The distance from the origin to point A is given as 0.5. The value of  $K$  at point A is \_\_\_\_\_.

49. Consider a communication scheme where the binary valued signal  $X$  satisfies  $P\{X = +1\} = 0.75$  and  $P\{X = -1\} = 0.25$ . The received signal  $Y = X + Z$ , where  $Z$  is a Gaussian random variable with zero mean and variance  $\sigma^2$ . The received signal  $Y$  is fed to the threshold detector. The output of the threshold detector  $\hat{X}$  is:

$$\hat{X} = \begin{cases} +1, & Y > \tau \\ -1, & Y \leq \tau. \end{cases}$$

To achieve a minimum probability of error  $P\{\hat{X} \neq X\}$ , the threshold  $\tau$  should be

- (A) Strictly positive  
(B) Zero  
(C) Strictly negative  
(D) Strictly positive, zero, or strictly negative depending on the nonzero value of  $\sigma^2$
50. Consider the Z-channel given in the figure. The input is 0 or 1 with equal probability.



If the output is 0, the probability that the input is also 0 equals \_\_\_\_\_

51. An M-level PSK modulation scheme is used to transmit independent binary digits over a band-pass channel with bandwidth 100 kHz. The bit rate is 200 kbps and the system characteristic is a raised-cosine spectrum with 100% excess bandwidth. The minimum value of M is \_\_\_\_\_.
52. Consider a discrete-time channel  $Y = -X + Z$ , where the additive noise  $z$  is signal-dependent. In particular, given the transmitted symbol  $X \in \{-a, +a\}$ . at any instant, the noise sample  $Z$  is chosen independently from a Gaussian distribution with mean  $\beta X$  and unit variance. Assume a threshold detector with zero threshold at the receiver.

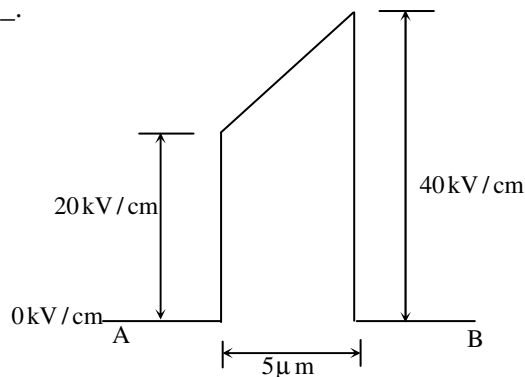
When  $\beta = 0$ , the BER was found to be  $Q(a) = 1 \times 10^{-8}$

$$\left( Q(v) = \frac{1}{\sqrt{2\pi}} \int_v^{\infty} e^{-u^2/2} du, \text{ and for } v > 1, \text{ use } Q(v) \approx e^{-v^2/2} \right)$$

When  $\beta = -0.3$ , the BER is closest to

- (A)  $10^{-7}$                       (B)  $10^{-6}$                       (C)  $10^{-4}$                       (D)  $10^{-2}$

53. The electric field (assumed to be one-dimensional) between two points A and B is shown. Let  $\psi_A$  and  $\psi_B$  be the electrostatic potentials at A and B, respectively. The value of  $\psi_B - \psi_A$  in Volts is \_\_\_\_\_.



54. Given  $\vec{F} = z\hat{x} + x\hat{y} + y\hat{z}$ . If  $S$  represents the portion of the sphere  $x^2 + y^2 + z^2 = 1$  for  $z \geq 0$ , then  $\int \nabla \times \vec{F} \cdot \vec{ds}$  is \_\_\_\_\_.
55. If  $E = -(2y^3 - 3yz^2)\hat{x} - (6xy^2 - 3xz^2)\hat{y} + (6xyz)\hat{z}$  is the electric field in a source free region, a valid expression for the electrostatic potential is  
 (A)  $xy^3 - yz^2$       (B)  $2xy^3 - xyz^2$       (C)  $y^3 + xyz^2$       (D)  $2xy^3 - 3xyz^2$