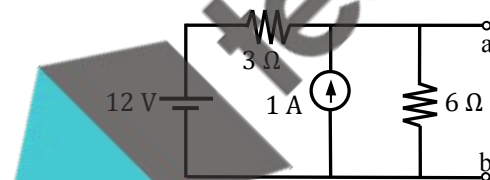
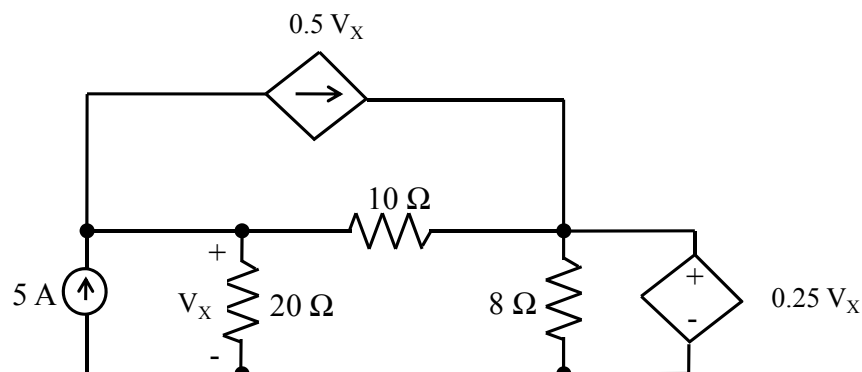


Q. 1 – Q. 25 carry one mark each.

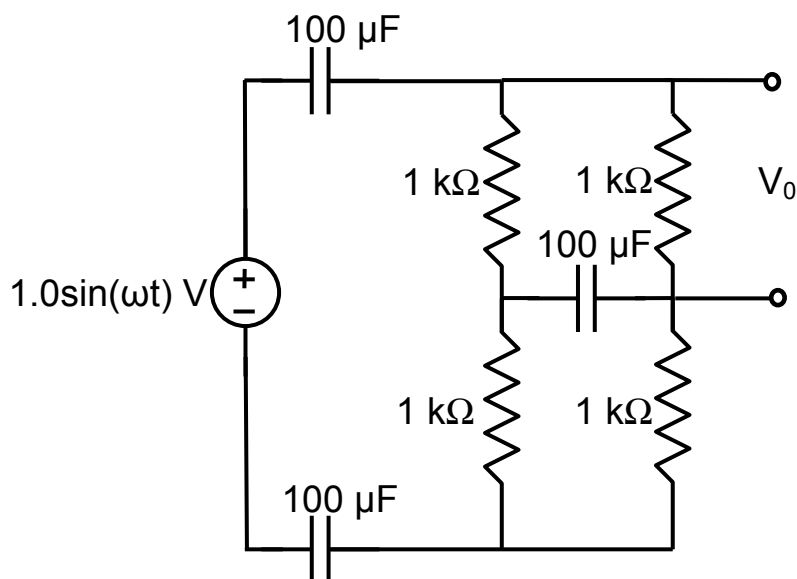
- Q.1 For $A = \begin{bmatrix} 1 & \tan x \\ -\tan x & 1 \end{bmatrix}$, the determinant of $A^T A^{-1}$ is
 (A) $\sec^2 x$ (B) $\cos 4x$ (C) 1 (D) 0
- Q.2 The contour on the x - y plane, where the partial derivative of $x^2 + y^2$ with respect to y is equal to the partial derivative of $6y + 4x$ with respect to x , is
 (A) $y = 2$ (B) $x = 2$ (C) $x + y = 4$ (D) $x - y = 0$
- Q.3 If C is a circle of radius r with centre z_0 , in the complex z -plane and if n is a non-zero integer, then $\oint_C \frac{dz}{(z-z_0)^{n+1}}$ equals
 (A) $2\pi nj$ (B) 0 (C) $\frac{nj}{2\pi}$ (D) $2\pi n$
- Q.4 Consider the function $g(t) = e^{-t} \sin(2\pi t) u(t)$ where $u(t)$ is the unit step function. The area under $g(t)$ is _____.
- Q.5 The value of $\sum_{n=0}^{\infty} n \left(\frac{1}{2}\right)^n$ is _____.
- Q.6 For the circuit shown in the figure, the Thevenin equivalent voltage (in Volts) across terminals a-b is _____.



- Q.7 In the circuit shown, the voltage V_X (in Volts) is _____.



Q.8 At very high frequencies, the peak output voltage V_0 (in Volts) is _____.



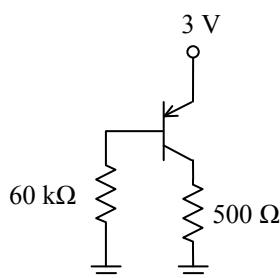
Q.9 Which one of the following processes is preferred to form the gate dielectric (SiO_2) of MOSFETs ?

- (A) Sputtering (B) Molecular beam epitaxy
(C) Wet oxidation (D) Dry oxidation

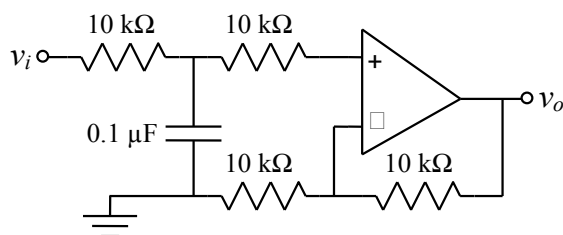
Q.10 If the base width in a bipolar junction transistor is doubled, which one of the following statements will be TRUE?

- (A) Current gain will increase.
(B) Unity gain frequency will increase.
(C) Emitter-base junction capacitance will increase.
(D) Early Voltage will increase.

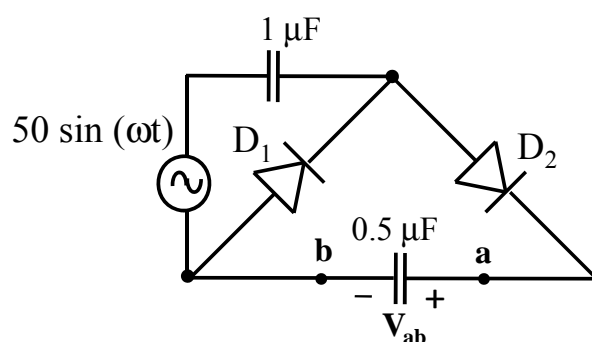
Q.11 In the circuit shown in the figure, the BJT has a current gain (β) of 50. For an emitter-base voltage $V_{EB} = 600 \text{ mV}$, the emitter-collector voltage V_{EC} (in Volts) is _____.



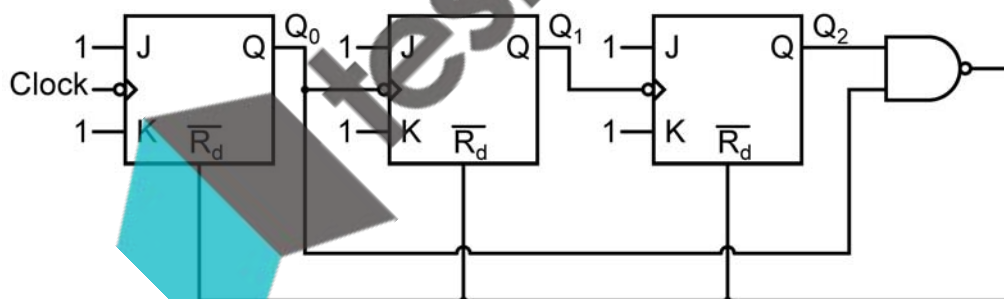
Q.12 In the circuit shown using an ideal opamp, the 3-dB cut-off frequency (in Hz) is _____.



Q.13 In the circuit shown, assume that diodes D_1 and D_2 are ideal. In the steady state condition, the average voltage V_{ab} (in Volts) across the $0.5\text{ }\mu\text{F}$ capacitor is _____.



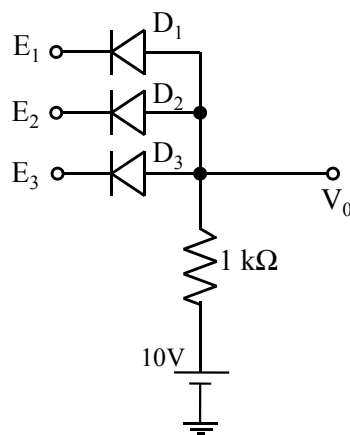
Q.14 The circuit shown consists of J-K flip-flops, each with an active low asynchronous reset ($\overline{R_d}$ input). The counter corresponding to this circuit is



(A) a modulo-5 binary up counter
(C) a modulo-5 binary down counter

(B) a modulo-6 binary down counter
(D) a modulo-6 binary up counter

- Q.15 In the circuit shown, diodes D_1 , D_2 and D_3 are ideal, and the inputs E_1 , E_2 and E_3 are 0 V for logic 0 and 10 V for logic 1 . What logic gate does the circuit represent?



- (A) 3-input OR gate
 (B) 3-input NOR gate
 (C) 3-input AND gate
 (D) 3-input XOR gate
- Q.16 Which one of the following 8085 microprocessor programs correctly calculates the product of two 8-bit numbers stored in registers B and C?

- | | | | |
|-----|--|-----|--|
| (A) | MVI A, 00H
JNZ LOOP
CMP C
LOOP DCR B
HLT | (B) | MVI A, 00H
CMP C
LOOP DCR B
JNZ LOOP
HLT |
| (C) | MVI A, 00H
LOOP ADD C
DCR B
JNZ LOOP
HLT | (D) | MVI A, 00H
ADD C
JNZ LOOP
LOOP INR B
HLT |

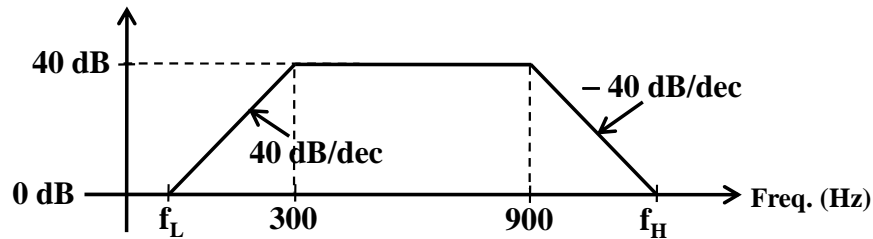
- Q.17 The impulse response of an LTI system can be obtained by

- (A) differentiating the unit ramp response
 (B) differentiating the unit step response
 (C) integrating the unit ramp response
 (D) integrating the unit step response

- Q.18 Consider a four-point moving average filter defined by the equation $y[n] = \sum_{i=0}^3 \alpha_i x[n-i]$. The condition on the filter coefficients that results in a null at zero frequency is

- | | |
|--|--|
| (A) $\alpha_1 = \alpha_2 = 0$; $\alpha_0 = -\alpha_3$ | (B) $\alpha_1 = \alpha_2 = 1$; $\alpha_0 = -\alpha_3$ |
| (C) $\alpha_0 = \alpha_3 = 0$; $\alpha_1 = \alpha_2$ | (D) $\alpha_1 = \alpha_2 = 0$; $\alpha_0 = \alpha_3$ |

Q.19 Consider the Bode plot shown in the figure. Assume that all the poles and zeros are real-valued.



The value of $f_H - f_L$ (in Hz) is _____.

Q.20 The phase margin (in degrees) of the system $G(s) = \frac{10}{s(s+10)}$ is _____.

Q.21 The transfer function of a first-order controller is given as

$$G_c(s) = \frac{K(s+a)}{s+b}$$

where K, a and b are positive real numbers. The condition for this controller to act as a phase lead compensator is

- (A) $a < b$ (B) $a > b$ (C) $K < ab$ (D) $K > ab$

Q.22 The modulation scheme commonly used for transmission from GSM mobile terminals is

- (A) 4-QAM
(B) 16-PSK
(C) Walsh-Hadamard orthogonal codes
(D) Gaussian Minimum Shift Keying (GMSK)

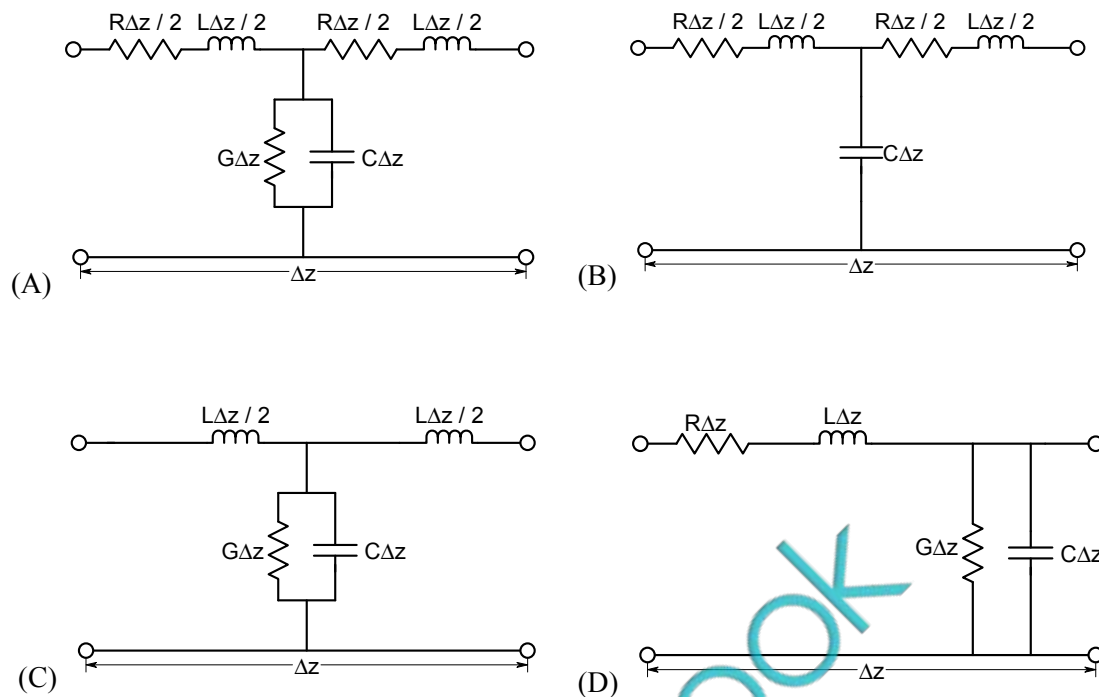
Q.23 A message signal $m(t) = A_m \sin(2\pi f_m t)$ is used to modulate the phase of a carrier $A_c \cos(2\pi f_c t)$ to get the modulated signal $y(t) = A_c \cos(2\pi f_c t + m(t))$. The bandwidth of $y(t)$

- (A) depends on A_m but not on f_m
(B) depends on f_m but not on A_m
(C) depends on both A_m and f_m
(D) does not depend on A_m or f_m

Q.24 The directivity of an antenna array can be increased by adding more antenna elements, as a larger number of elements

- (A) improves the radiation efficiency
(B) increases the effective area of the antenna
(C) results in a better impedance matching
(D) allows more power to be transmitted by the antenna

- Q.25 A coaxial cable is made of two brass conductors. The spacing between the conductors is filled with Teflon ($\epsilon_r' = 2.1$, $\tan \delta = 0$). Which one of the following circuits can represent the lumped element model of a small piece of this cable having length Δz ?



Q. 26 – Q. 55 carry two marks each.

- Q.26 The Newton-Raphson method is used to solve the equation $f(x) = x^3 - 5x^2 + 6x - 8 = 0$. Taking the initial guess as $x = 5$, the solution obtained at the end of the first iteration is _____.
- Q.27 A fair die with faces $\{1, 2, 3, 4, 5, 6\}$ is thrown repeatedly till 3 is observed for the first time. Let X denote the number of times the die is thrown. The expected value of X is _____.

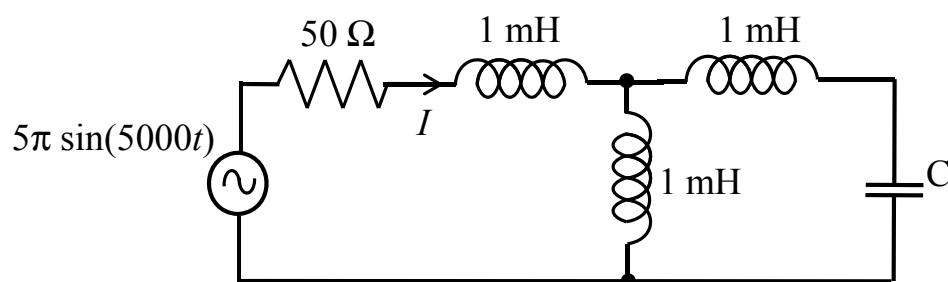
- Q.28 Consider the differential equation

$$\frac{d^2x(t)}{dt^2} + 3\frac{dx(t)}{dt} + 2x(t) = 0.$$

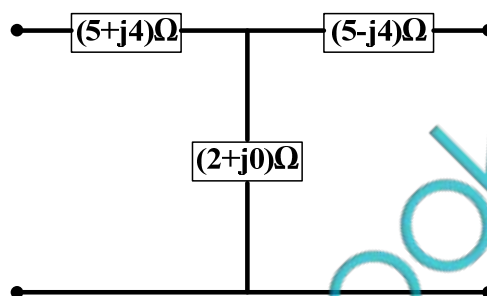
Given $x(0) = 20$ and $x(1) = 10/e$, where $e = 2.718$, the value of $x(2)$ is _____.

- Q.29 A vector field $\mathbf{D} = 2\rho^2 \mathbf{a}_\rho + z \mathbf{a}_z$ exists inside a cylindrical region enclosed by the surfaces $\rho = 1$, $z = 0$ and $z = 5$. Let S be the surface bounding this cylindrical region. The surface integral of this field on S ($\oint_S \mathbf{D} \cdot d\mathbf{s}$) is _____.

- Q.30 In the circuit shown, the current I flowing through the $50\ \Omega$ resistor will be zero if the value of capacitor C (in μF) is _____.



- Q.31 The ABCD parameters of the following 2-port network are



- (A) $\begin{bmatrix} 3.5 + j2 & 20.5 \\ 20.5 & 3.5 - j2 \end{bmatrix}$ (B) $\begin{bmatrix} 3.5 + j2 & 30.5 \\ 0.5 & 3.5 - j2 \end{bmatrix}$
 (C) $\begin{bmatrix} 10 & 2 + j0 \\ 2 + j0 & 10 \end{bmatrix}$ (D) $\begin{bmatrix} 7 + j4 & 0.5 \\ 30.5 & 7 - j4 \end{bmatrix}$

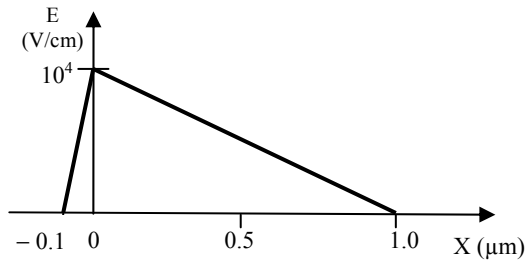
- Q.32 A network is described by the state model as

$$\begin{aligned}\dot{x}_1 &= 2x_1 - x_2 + 3u \\ \dot{x}_2 &= -4x_2 - u \\ y &= 3x_1 - 2x_2\end{aligned}$$

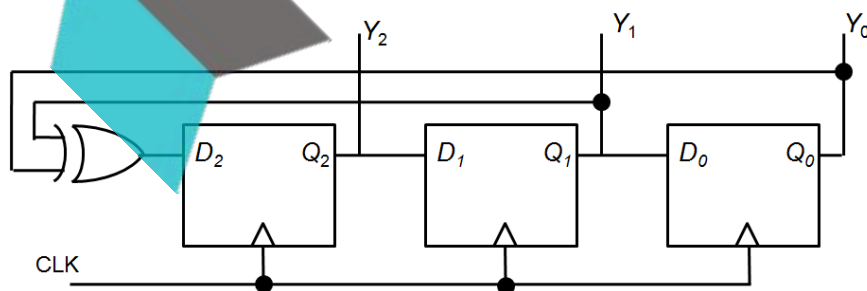
The transfer function $H(s)$ ($= \frac{Y(s)}{U(s)}$) is

- (A) $\frac{11s+35}{(s-2)(s+4)}$ (B) $\frac{11s-35}{(s-2)(s+4)}$
 (C) $\frac{11s+38}{(s-2)(s+4)}$ (D) $\frac{11s-38}{(s-2)(s+4)}$

Q.33 The electric field profile in the depletion region of a p-n junction in equilibrium is shown in the figure. Which one of the following statements is **NOT TRUE**?

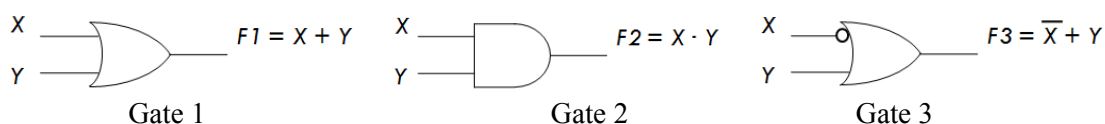


- (A) The left side of the junction is n-type and the right side is p-type
- (B) Both the n-type and p-type depletion regions are uniformly doped
- (C) The potential difference across the depletion region is 700 mV
- (D) If the p-type region has a doping concentration of 10^{15} cm^{-3} , then the doping concentration in the n-type region will be 10^{16} cm^{-3}
- Q.34 The current in an enhancement mode NMOS transistor biased in saturation mode was measured to be 1 mA at a drain-source voltage of 5 V. When the drain-source voltage was increased to 6 V while keeping gate-source voltage same, the drain current increased to 1.02 mA. Assume that drain to source saturation voltage is much smaller than the applied drain-source voltage. The channel length modulation parameter λ (in V^{-1}) is _____.
- Q.35 An npn BJT having reverse saturation current $I_s = 10^{-15} \text{ A}$ is biased in the forward active region with $V_{BE} = 700 \text{ mV}$. The thermal voltage (V_T) is 25 mV and the current gain (β) may vary from 50 to 150 due to manufacturing variations. The maximum emitter current (in μA) is _____.
- Q.36 A three bit pseudo random number generator is shown. Initially the value of output $Y \equiv Y_2 Y_1 Y_0$ is set to 111. The value of output Y after three clock cycles is



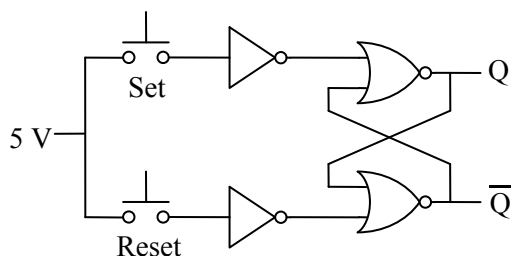
- (A) 000 (B) 001 (C) 010 (D) 100

- Q.37 A universal logic gate can implement any Boolean function by connecting sufficient number of them appropriately. Three gates are shown.

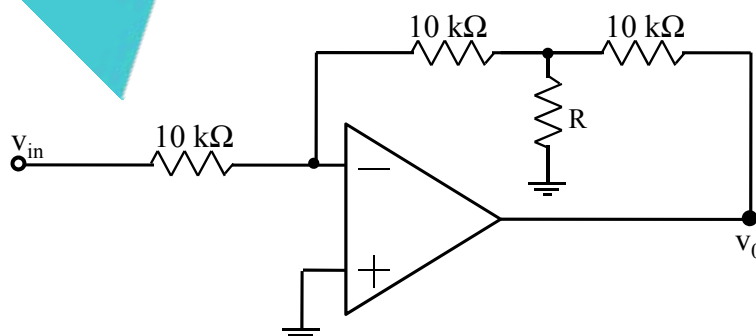


Which one of the following statements is TRUE?

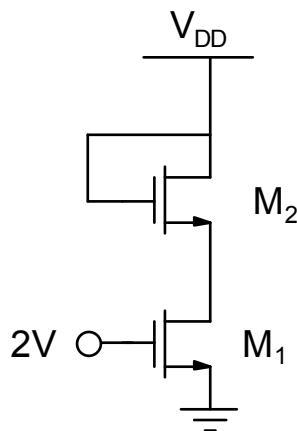
- (A) Gate 1 is a universal gate.
 (B) Gate 2 is a universal gate.
 (C) Gate 3 is a universal gate.
 (D) None of the gates shown is a universal gate.
- Q.38 An SR latch is implemented using TTL gates as shown in the figure. The set and reset pulse inputs are provided using the push-button switches. It is observed that the circuit fails to work as desired. The SR latch can be made functional by changing



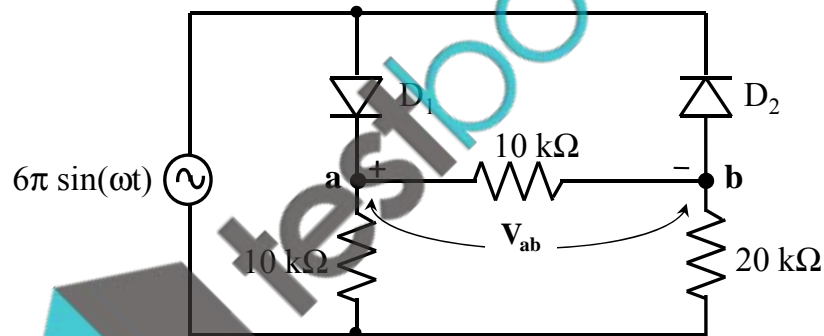
- (A) NOR gates to NAND gates
 (B) inverters to buffers
 (C) NOR gates to NAND gates and inverters to buffers
 (D) 5 V to ground
- Q.39 In the circuit shown, assume that the opamp is ideal. If the gain (v_o / v_{in}) is $\frac{1}{2}$, the value of R (in $k\Omega$) is ____.



- Q.40 In the circuit shown, both the enhancement mode NMOS transistors have the following characteristics: $k_n = \mu_n C_{ox}(W/L) = 1 \text{ mA/V}^2$; $V_{TN} = 1 \text{ V}$. Assume that the channel length modulation parameter λ is zero and body is shorted to source. The minimum supply voltage V_{DD} (in volts) needed to ensure that transistor M_1 operates in saturation mode of operation is _____.



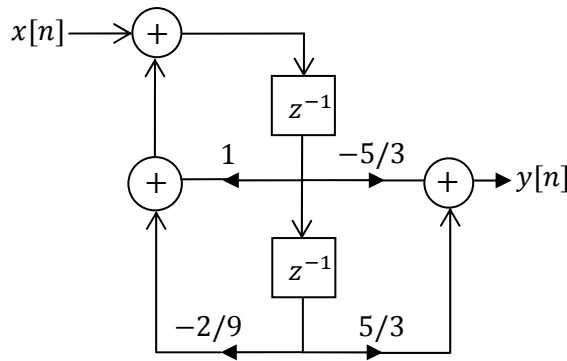
- Q.41 In the circuit shown, assume that the diodes D_1 and D_2 are ideal. The average value of voltage V_{ab} (in Volts), across terminals **a** and **b** is _____.



- Q.42 Suppose $x[n]$ is an absolutely summable discrete-time signal. Its z-transform is a rational function with two poles and two zeroes. The poles are at $z = \pm 2j$. Which one of the following statements is TRUE for the signal $x[n]$?

- (A) It is a finite duration signal.
- (B) It is a causal signal.
- (C) It is a non-causal signal.
- (D) It is a periodic signal.

- Q.43 A realization of a stable discrete time system is shown in the figure. If the system is excited by a unit step sequence input $x[n]$, the response $y[n]$ is

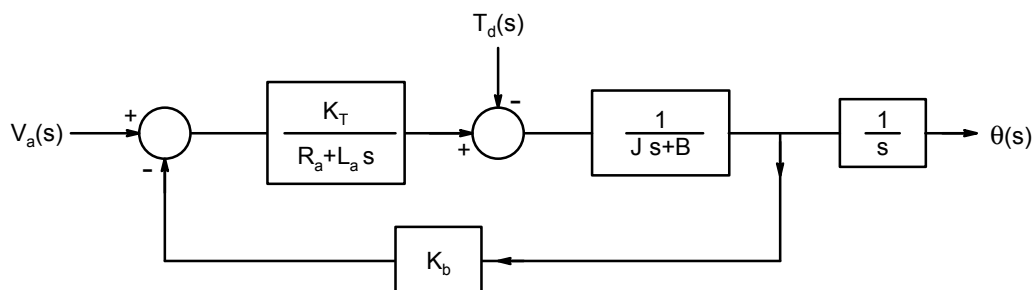


- (A) $4\left(-\frac{1}{3}\right)^n u[n] - 5\left(-\frac{2}{3}\right)^n u[n]$ (B) $5\left(-\frac{2}{3}\right)^n u[n] - 3\left(-\frac{1}{3}\right)^n u[n]$
 (C) $5\left(\frac{1}{3}\right)^n u[n] - 5\left(\frac{2}{3}\right)^n u[n]$ (D) $5\left(\frac{2}{3}\right)^n u[n] - 5\left(\frac{1}{3}\right)^n u[n]$
- Q.44 Let $\tilde{x}[n] = 1 + \cos\left(\frac{\pi n}{8}\right)$ be a periodic signal with period 16. Its DFS coefficients are defined by $a_k = \frac{1}{16} \sum_{n=0}^{15} \tilde{x}[n] \exp(-j\frac{\pi}{8}kn)$ for all k . The value of the coefficient a_{31} is _____.
- Q.45 Consider a continuous-time signal defined as

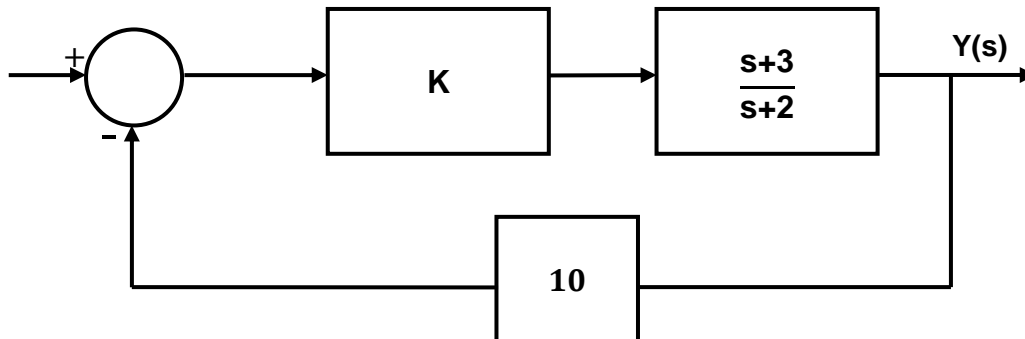
$$x(t) = \left(\frac{\sin(\pi t/2)}{(\pi t/2)} \right) * \sum_{n=-\infty}^{\infty} \delta(t - 10n)$$

where $*$ denotes the convolution operation and t is in seconds. The Nyquist sampling rate (in samples/sec) for $x(t)$ is _____.

- Q.46 The position control of a DC servo-motor is given in the figure. The values of the parameters are $K_T = 1$ N-m/A, $R_a = 1\Omega$, $L_a = 0.1$ H, $J = 5$ kg-m², $B = 1$ N-m/(rad/sec) and $K_b = 1$ V/(rad/sec). The steady-state position response (in radians) due to unit impulse disturbance torque T_d is _____.



Q.47 For the system shown in the figure, $s = -2.75$ lies on the root locus if K is _____.



Q.48 The characteristic equation of an LTI system is given by $F(s) = s^5 + 2s^4 + 3s^3 + 6s^2 - 4s - 8 = 0$. The number of roots that lie strictly in the left half s -plane is _____.

Q.49 Two sequences $x_1[n]$ and $x_2[n]$ have the same energy. Suppose $x_1[n] = \alpha 0.5^n u[n]$, where α is a positive real number and $u[n]$ is the unit step sequence. Assume

$$x_2[n] = \begin{cases} \sqrt{1.5} & \text{for } n = 0, 1 \\ 0 & \text{otherwise.} \end{cases}$$

Then the value of α is _____.

Q.50 The variance of the random variable X with probability density function $f(x) = \frac{1}{2}|x|e^{-|x|}$ is _____.

Q.51 The complex envelope of the bandpass signal $x(t) = -\sqrt{2} \left(\frac{\sin(\pi t / 5)}{\pi t / 5} \right) \sin(\pi t - \frac{\pi}{4})$, centered about $f = \frac{1}{2}$ Hz, is

(A) $\left(\frac{\sin(\pi t / 5)}{\pi t / 5} \right) e^{j\frac{\pi}{4}}$

(B) $\left(\frac{\sin(\pi t / 5)}{\pi t / 5} \right) e^{-j\frac{\pi}{4}}$

(C) $\sqrt{2} \left(\frac{\sin(\pi t / 5)}{\pi t / 5} \right) e^{j\frac{\pi}{4}}$

(D) $\sqrt{2} \left(\frac{\sin(\pi t / 5)}{\pi t / 5} \right) e^{-j\frac{\pi}{4}}$

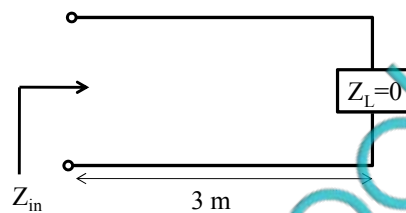
Q.52 A random binary wave $y(t)$ is given by

$$y(t) = \sum_{n=-\infty}^{\infty} X_n p(t - nT - \phi)$$

where $p(t) = u(t) - u(t - T)$, $u(t)$ is the unit step function and ϕ is an independent random variable with uniform distribution in $[0, T]$. The sequence $\{X_n\}$ consists of independent and identically distributed binary valued random variables with $P\{X_n = +1\} = P\{X_n = -1\} = 0.5$ for each n .

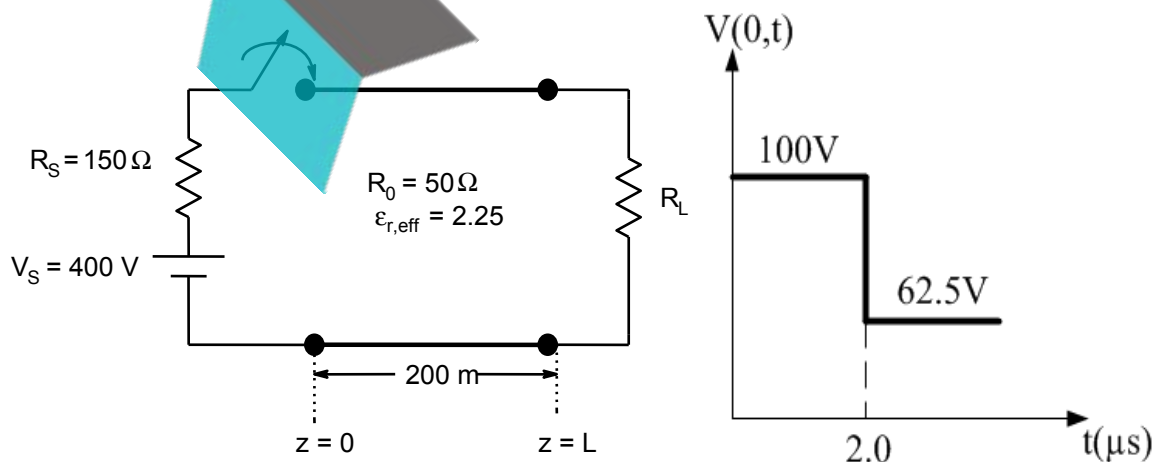
The value of the autocorrelation $R_{yy}\left(\frac{3T}{4}\right) \triangleq E\left[y(t)y\left(t - \frac{3T}{4}\right)\right]$ equals _____.

Q.53 Consider the 3 m long lossless air-filled transmission line shown in the figure. It has a characteristic impedance of $120\pi \Omega$, is terminated by a short circuit, and is excited with a frequency of 37.5 MHz. What is the nature of the input impedance (Z_{in})?



- (A) Open (B) Short (C) Inductive (D) Capacitive

Q.54 A 200 m long transmission line having parameters shown in the figure is terminated into a load R_L . The line is connected to a 400 V source having source resistance R_S through a switch, which is closed at $t = 0$. The transient response of the circuit at the input of the line ($z = 0$) is also drawn in the figure. The value of R_L (in Ω) is _____.



Q.55 A coaxial capacitor of inner radius 1 mm and outer radius 5 mm has a capacitance per unit length of 172 pF/m. If the ratio of outer radius to inner radius is doubled, the capacitance per unit length (in pF/m) is _____.

END OF THE QUESTION PAPER

