IES MASTER

Institute for Engineers (IES/GATE/PSUs)

GATE 2017

Detailed Solution

ELECTRONICS & COMMUNICATION ENGINEERING

SESSION - 1

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GATE—2017

Electronics & Communication Engineering

Questions and Detailed Solution

Session-1

1. Three fair cubical dice are thrown simultaneously. The probability that all three dice have the same number on the faces showing up is (up to third decimal place)

Sol. (0.0278)

The total no. of outcomes, n(s) = 6×6×6 = 216

The favourable outcomes, n(E) are (1, 1, 1), (2, 2, 2), ... (6, 6, 6)

So, n(E) = 6

$\therefore$ required probability= $\frac{n(E)}{n(s)} = \frac{6}{216}$

= 0.0278

2. Consider the following statements about the linear dependence of the real valued functions $y_1 = 1, y_2 = x$ and $y_3 = x^2$, over the field of real numbers.

I. y_1, y_2 and y_3 are linearly independent on $-1 \le x \le 0$

II. y_1, y_2 and y_3 are linearly dependent on $0 \le x \le 1$

III. y_1, y_2 and y_3 are linearly dependent on $0 \le x \le 1$

IV. y_1, y_2 and y_3 are linearly independent on $-1 \le x \le 1$

Which on among the following is correct?

(a) Both I and II are true

(b) Both I and III are true

(c) Both II and IV are true

(d) Both III and IV are true

Sol. (a)

$y_1 = 1, y_2 = x, y_3 = x^2$

Linear combination is given by

$ay_1 + by_2 + cy_3 = 0, \ a,b,c \in R$

$\Rightarrow \ a + bx + cx^2 = 0, \ a,b,c, \in R$

Case : 1

If $x \in [0,1]$

$a + bx + cx^2 = 0$

At $x = 0 \Rightarrow a = 0$ ....(1)

At $x = \frac{1}{2}; \frac{b}{2} + \frac{c}{4} = 0$ ...(2)

At x = 1, b + c = 0

From equation (1) and (2), we get

b = c = 0

$\therefore$ a = b = c = 0

$\Rightarrow$ y_1, y_2 and y_3 are linearly independent for $0 \le x \le 1$.

Case II :

If $x \in [-1, 0]$

a + bx + cx^2 = 0

At $x = 0 \Rightarrow a = 0$

At $x = -1 \ \Rightarrow - b + c = 0$ ...(4)

At $x = -\frac{1}{2} \Rightarrow -\frac{b}{2} + \frac{c}{4} = 0$ ...(5)

From equation (4) and (5), we get

b = c = 0

$\therefore$ a = b = c = 0

$\Rightarrow$ y_1, y_2 and y_3 are linearly independent for $-1 \le x \le 0$.

3. Consider a wireless communication link between a transmitter and a receiver located in free space with finite and stricitly positive capacity. If the effective areas of the transmitter and the receiver antenna and the distance between them are all doubled and everything else remains unchanged, the maximum capacity of the wireless link

(a) increases by a factor of 2

(b) decrease by a factor of 2

(c) remains unchanged

(d) decreases by a factor of $\sqrt{2}$

Sol. (c)

As per friis free space propagation equation

$$P_r = \frac{P_t.A_{er}.A_{et}}{(\lambda R)^2}$$

where,

P_r = Received power

P_t = Transmitted power

A_{er} = Aperture area of receiver

A_{et} = Aperture area of transmitter

λ = Wave length

R = Distance between receiver and transmitter

Now, if A_{er}, A_{et} and R are doubled, then

$$P_r' = \frac{P_t(2A_{er})(2A_{et})}{(\lambda 2R)^2}$$

$$P_r' = \frac{P_t A_{er} A_{et}}{(\lambda R)^2}$$

$$P_r' = P_r$$

Hence, maximum capacity of the wireless link will be the same.

4. A periodic signal $x(t)$ has a trigonometric Fourier series expansion

$$x(t) = a_0 + \sum_{n=1}^{\infty}(a_n \cos n\omega_0 t + b_n \sin n\omega_0 t)$$

If $x(t) = -x(-t) = -x(t - \pi/\omega_0)$. We can counclude that

(a) a_n are zero for all n and b_n are zero for n even

(b) a_n are zero for all n and b_n are zero for n odd

(c) a_n are zero for n even and b_n are zero for n odd

(d) a_n are zero for n odd and b_n are zero for n even

Sol. (a)

Given, x(t) = – x(–t) = – x $\left(t-\frac{\pi}{\omega_0}\right)$

The given signal has

1. odd function symmetry

$$a_n = 0$$

2. Half-wave symmetry

a = 0 and contains only odd harmonics

$\therefore a_n$ are zero for all n and b_n are zero for n even.

5. A bar of Gallium Arsenide (GaAs) is doped with Silicon such that the Silicon atoms occupy Gallium and Arsenic sites in the GaAs crystal. Which one of the followng statement is true?

(a) Silicon atoms act as p-type dopants in Arsenic sites and n-type dopants in Gallium sites.

(b) Silicon atoms act as n-type dopants in Arsenic sites and p-type dopants in Gallium sites.

(c) Silicon atoms act as p-type dopants in Arsenic as well as Gallium sites.

(d) Silicon atoms act as n-type dopants in Arsenic as well as Gallium sites.

Sol. (a)

When GaAs is doped with Silicon, the two possibilities arise

(i) Silicon can replace Gallium

(ii) Silicon can replace Arsenic

So, if the Silicon replaces Gallium then Silicon has one more electron. So, the extra electron is available for conduction. It will make it n-type.

One the other hand, Silicon replaces Arsenic it has one less electron and it will make it p-type.

6. The miller effect in the context of a common Emitter amplifier explains :

(a) an increase in the low-frequency cutoff frequency

(b) an increase in the high-frequency cutoff frequency

(c) a decrease in the low-frequency cutoff frequency

(d) a decrease in the high-frequency cutoff frequency

Sol. (d)

A common emitter amplifier has a capacitance between the collector and the base, and the gain of CE amplifier is negative, so the Miller effect will occur which reduce the high-frequency response of the amplifier.

7. An $n^+ - n$ Silicon device is fabricated with uniform and non-degenerate donor doping concentrations of $N_{D1} = 1 \times 10^{18} \text{cm}^{-3}$ and $N_{D2} = 1 \times 10^{15} \text{cm}^{-3}$ corresponding to the n^+ and n regions respectively. At the operational temperature T, assume complete impurity ionization $kT/q = 25\text{mV}$ and intrinsic carrier concentration to be $n_i = 1 \times 10^{10} \text{cm}^{-3}$. What is the magnitude of the bulit-in potential of this device ?

(a) 0.748 V (b) 0.460 V

(c) 0.288 V (d) 0.173 V

Sol. (a)

The junction build-in voltage

$$V_0 = V_T \, ln \left(\frac{N_A N_D}{n_i^2} \right)$$

$$= 25 \times 10^{-3} \, ln \left[\frac{10^{18} \times 10^{15}}{(1 \times 10^{10})^2} \right]$$

$$= 25 \times 10^{-3} \times 29.9336 \text{ V}$$

$$= 0.748 \text{ Volts.}$$

8. Consider a stable system with transfer function

$$G(s) = \frac{s^p + b_1 s^{p-1} + ... + b_p}{s^q + a_1 s^{q-1} + ... + a_q}$$

where $b_1 ...... b_p$ and $a_1 .... a_q$ are real valued constants. The slope of the Bode log magnitude curve of G (s) converges to –60 dB/decade as $\omega \to \infty$. A possible pair of values for p and q is:

(a) p = 0 and q = 3

(b) p = 1 and q = 7

(c) p = 2 and q = 3

(d) p = 3 and q = 5

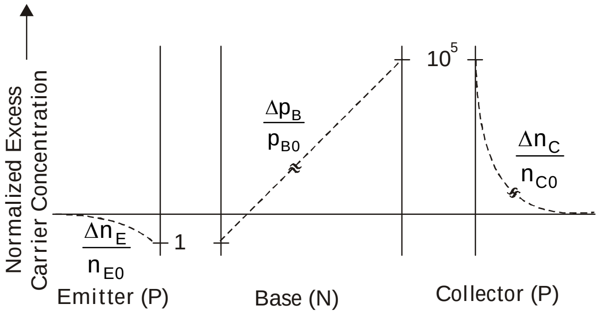
Sol. (a)

Final slope = –60dB/decade,

which indicates that p – q = 3.

option (a) satisfies this condition.

9. For a narrow base PNP BJT, the excess minority carrier concentrations (Δn_E for emitter, Δp_B for base, Δn_C for collector) normalized to equilibrium minority carrier concentrations n_{E0} for emitter, p_{B0} for base, n_{C0} for collector) in the quasi-nautral emitter, base and collector regions are shown below. Which one of the following biasing modes is the transistor operating in?



X and Y axes are not to scale

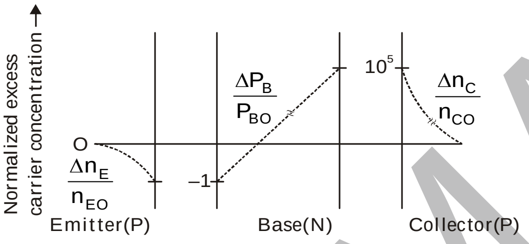
(a) Forward active

(b) Saturation

(c) Inverse active

(d) Cutoff

Sol. (c)



where,

Δn_E , ΔP_B , Δn_C are excess minority carrier concentration of emitter, base and collector region respectively.

n_{EO}, P_{BO}, n_{CO} are thermally generated minority carrier of emitter, base and collector region.

At collector – Base region ratio of excess minority carrier concentration to equilibrium minority carrier concentration is in order of 10^5(very high). This is possible when the junction is forward bias (injection).

At emitter – Base region, ratio of excess minority carrier concentration to equilibrium minority carrier concentration is in order of 1 (negligible). This is possible, when junction is reverse bias (no injection).

Hence, collector-base junction is forward biased and emitter base junction is reverse biased. So it in inverse active mode.

10. Consider the following statements for continous-time linear time invariant (LTI) system :

I. There is no bounded input bounded output (BIBO) stable system with a pole in the right half of the complex plane.

II. There is no casual and BIBO stable system with a pole in the right half of the complex plane.

Which one among the following is correct ?

(a) Both I and II are true

(b) Both I and II are not true

(c) Only I is true

(d) Only II is true

Sol. (d)

For stable system, ROC of pole must contain $j\omega - \text{axis}$. It is not compulsory that right sided signal is stable. So statement (i) is wrong.

There is non-causal system, its pole start from left side of s-plane and for BIBO stable system, its pole must contain $j\omega - \text{axis}$ and it go right side. So statement (ii) is correct.

11. The clock frequency of an 8085 microprossor is 5 MHz. If the time required to execute an instruction is 1.4 μs, then the number of T-states needed for executing the instruction is

(a) 1 (b) 6

(c) 7 (d) 8

Sol. (c)

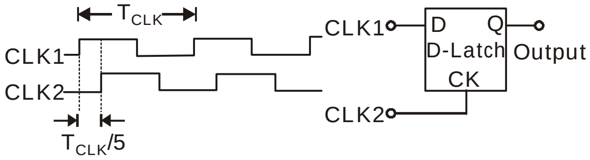
The number of T-states needed for executing the instruction = (Execution time of instruction)× (Clock frequency)

$$= 1.4 \times 10^{-6} \times 5 \times 10^6$$

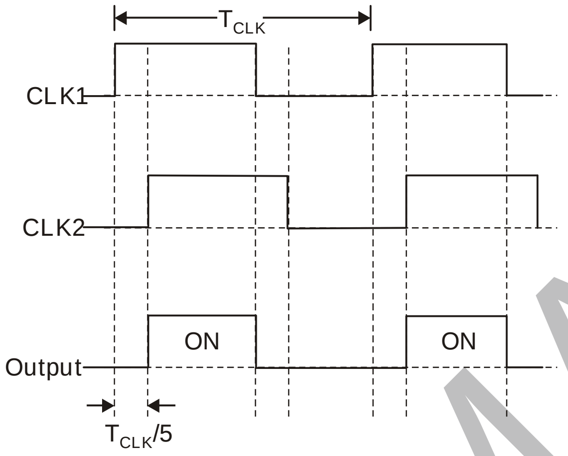
$$= 7$$

12. Consider the D-Latch shown in the figure which is transparent when its clock input CK is high and has zero propagation delay.

In the figure, the clock signal CLK1 has a 50% duty cycle and CLK2 is a one-fifth period delayed version of CLK1. The duty cycle at the output of the latch in percentage is



Sol. (30)



The output will be high only when both CLK1 and CLK2 are high:

$$\text{So,}\quad \text{Duty cycle} = \frac{\text{ON time}}{\text{Time Period}}$$

$$= \frac{\left(\frac{T_{CLK}}{2} - \frac{T_{CLK}}{5}\right)}{T_{CLK}}$$

$$= \frac{5-2}{10}$$

$$= 0.3 \text{ i.e., } 30\%$$

13. Which one of the following statements about differential pulse code modulation (DPCM) is true?

(a) The sum of message signal with its prediction is quantized

(b) The message signal sample is directly quantized and its prediction is not used

(c) The difference of message signal sample and a random signal is quantized

(d) The difference of message signal with its prediction is quantized.

Sol. (d)

Differential Pulse Code Modulation (DPCM) is a procedure of converting an analog into a digital signal in which an analog signal is sampled and then the difference between the actual sample value and its predicted value (predicted value is based on previous sample or samples) is quantized and then encoded forming a digital value.

14. The rank of the matrix $M = \begin{bmatrix} 5 & 10 & 10 \\ 1 & 0 & 2 \\ 3 & 6 & 6 \end{bmatrix}$ is

(a) 0 (b) 1

(c) 2 (d) 3

Sol. (c)

$$M = \begin{bmatrix} 5 & 10 & 10 \\ 1 & 0 & 2 \\ 3 & 6 & 6 \end{bmatrix}$$

$$\det\{M\} = 5(0–12)–1\ (60–60)+3\ (20–0)$$

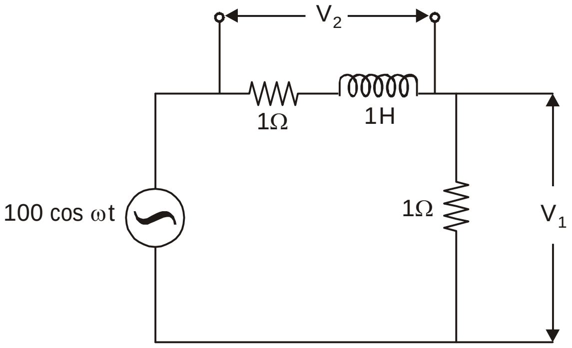
$$= -60 - 0 + 60 = 0$$

The one of the minor of matrix M has non zero determinant value. e.g.

$$M_{11} = \begin{bmatrix} 0 & 2 \\ 6 & 6 \end{bmatrix} \text{and} \left|M_{11}\right| = -12$$

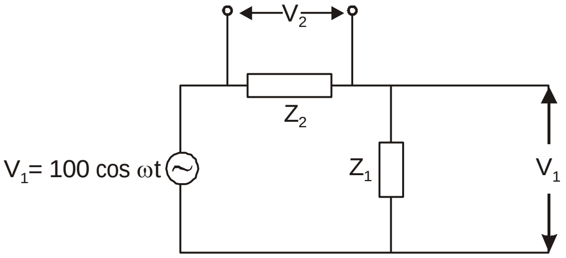
Hence rank of M is 2.

15. In the circuit shown the positive angular frequency ω (in radians per second) at which the magnitude of the phase difference between the volage V_1 and V_2 equals $\frac{\pi}{4}$ radians is____



Sol. (1)

The given circuit can be redrawn as



Where, $Z_1 = 1\Omega$ and $Z_2 = 1+j\omega 1$

and $V_1 = \frac{Z_1}{Z_1+Z_2}V_i$ and $V_2 = \frac{Z_2}{Z_1+Z_2}V_i$

Or $V_1 = \frac{1}{1+1+j\omega}V_i$ and

$V_2 = \frac{1+j\omega}{1+1+j\omega}V_i$

The magnitude of phase difference between V_1 and V_2

$$\left|-\tan^{-1}\frac{\omega}{2}-\left(\tan^{-1}\omega-\tan^{-1}\frac{\omega}{2}\right)\right|=\frac{\pi}{2}$$

Or $\tan^{-1} = \frac{\pi}{4}$

Or $\omega = 1$ rad/sec.

16. The voltage of an electromagnetic wave propagating in a coaxial cable with uniform characteristic impedance is $V(l) = e^{-\gamma l + j\omega t}$ volts, where l is the distance along the length of the cable in metres. $\gamma = (0.1 + j40)m^{-1}$ is the complex propagation constant and $\omega = 2\pi\times 10^9$ rad/s is the angular frequency. The absolute value of the attenuation in dB/metre is ______

Sol. (0.8686)

Given, γ = (0.1 + j40) m^{-1}

The propagation constant, $\gamma = \alpha + j\beta$

Where, α = attenuation constant

β = phase constant

$\therefore \quad \alpha = 0.1$ Np/m

$= 8.686\times 0.1$ dB/m

$= 0.8686$ dB/m

17. A good transconductance amplifier should have

(a) high input resistance and low output resistance

(b) low input resistance and high output resistance

(c) high input and output resistances

(d) low input and output resistances

Sol. (c)

For a transconductance amplifier

Input resistance, $R'_i = \frac{R_i}{1+\beta A}$

and output resitance,

$$R'_0 = \frac{R_0}{1+A\beta}$$

$\therefore$ for an ideal or good transconductance amplifier (where $A\beta \approx -1$)

$R'_i \to \infty$ and $R'_0 \to \infty$

18. The open loop transfer function

$$G(s) = \frac{(s+1)}{s^p(s+2)(s+3)}$$

where p is an integer is connected in unity feedback configuration as shown in the figure

Given that the steady state error is zero for unit step input and is 6 for unit ramp input. The value of the parameter p is _____

Sol. (1)

Steady state error,

$$e_{ss} = \lim_{s\to 0} s.R(s)\frac{1}{1+G(s)H(s)}$$

For unit ramp input

$$6 = \lim_{s\to 0} s.\frac{1}{s^2}.\frac{1}{1+\frac{(s+1)}{s^p(s+2)(s+3)}}$$

Or $$6 = \lim_{s\to 0}\frac{1}{s+\frac{(s+1)}{s^{p-1}(s+2)(s+3)}}$$

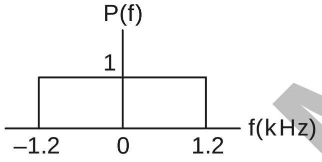
Or $$6 = \lim_{s\to 0}\frac{1}{0+\frac{1}{6s^{p-1}}}$$

∴ p = 1

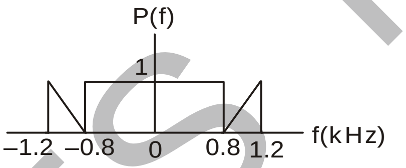
No need to verify for unit step input.

19. In a digital communication system, the overall pulse shape p (t) at the receiver before the sampler has the fourier transform P (f). If the symbols are transmitted at the rate of 2000 symbols per second, for which of the following cases is the inter symbol interference zero ?

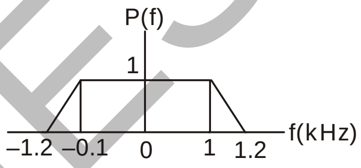
(a)



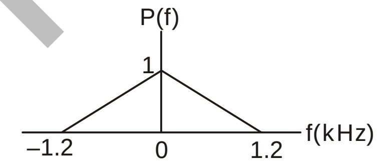
(b)



(c)



(d)



Sol.19 (b)

Condition for zero inter symbol interference

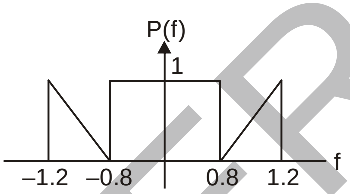
$$\frac{1}{T_S}\sum_{k=-\infty}^{\infty} P\left(f-\frac{k}{T_s}\right)=1\,\forall f$$

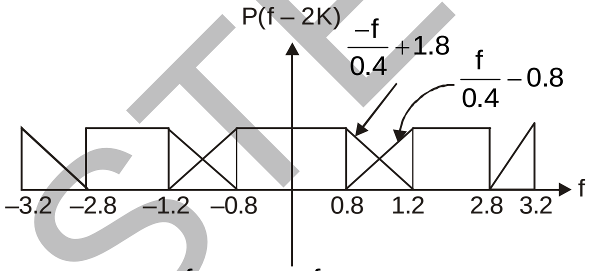
P(f) is fourier transform of P(t)

f_s = 2000 symbols/sec.

= 2k symbols/sec.

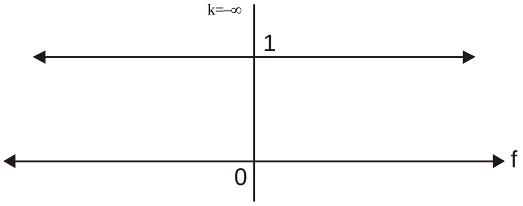
The above condition is satisfied by only option (b).



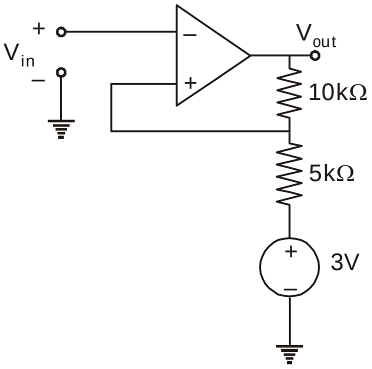


$$-\frac{f}{0.4}+1.8+\frac{f}{0.4}-0.8=1$$

$$\sum_{k=-\infty}^{\infty}P(f-2k)$$



20. For the operational amplifier circuit shown, the output saturation voltages are ±15 V . The upper and lower threshold voltages for the circuit are respectively.



(a) +5 V and – 5V

(b) +7 V and – 3V

(c) –3 V and + 7V

(d) +3 V and – 3V

Sol. (b)

For the given circuit, the upper and lower threshold voltage are given by

$$\text{UTP} = \frac{R_2}{R_1+R_2}.V_{sat} + \frac{R_1}{R_1+R_2}V_r$$

and $$\text{LTP} = -\frac{R_2}{R_1+R_2}V_{sat} + \frac{R_1}{R_1+R_2}V_r$$

Here, R_1= 10kΩ, R_2= 5kΩ, V_r= 3V and V_{sat}= 15V

$$\therefore \quad \text{UTP} = \frac{5}{5+10}\times 15 + \frac{10}{5+10}\times 3$$

$$= 5 + 2 = 7\text{V}$$

and $$\text{LTP} = -\frac{5}{5+10}\times 15 + \frac{10}{5+10}\times 3$$

$$= -5 + 2 = -3\text{V}$$

21. Consider the 5 × 5 matrix

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 5 & 1 & 2 & 3 & 4 \\ 4 & 5 & 1 & 2 & 3 \\ 3 & 4 & 5 & 1 & 2 \\ 2 & 3 & 4 & 5 & 1 \end{bmatrix}$$

It is given that A has only one real eigenvalue. Then the real eigenvalue of A is

(a) –25

(b) 0

(c) 15

(d) 25

Sol. (c)

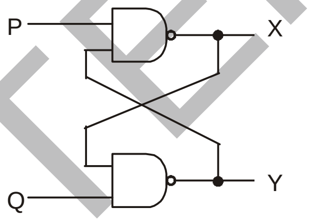
Characteristic equation is $|A-\lambda I|=0$

$$\begin{bmatrix} 1-\lambda & 2 & 3 & 4 & 5 \\ 5 & 1-\lambda & 2 & 3 & 4 \\ 4 & 5 & 1-\lambda & 2 & 3 \\ 3 & 4 & 5 & 1-\lambda & 2 \\ 2 & 3 & 4 & 5 & 1-\lambda \end{bmatrix}$$

For real eigen value, sum of either one row or coloumn must be zero.

$$\Rightarrow 1-\lambda+2+3+4+5=0, \ \therefore \lambda = 15$$

22. In the latch circuit shown, the NAND gates have non-zero but unequal propagation delays. The present input condition is P = Q = '0'. if the input condition is changed simultaneously to P = Q = '1' the outputs X and Y are



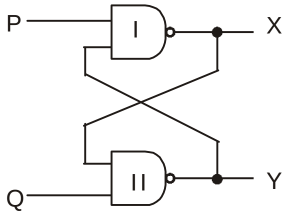
(a) X = 1, Y = 1

(b) either X = 1, Y = '0' or X = '0', Y = 1

(c) either X = 1, Y = '1' or X = '0', Y = '0'

(d) X = '0', Y = '0'

Sol. (b)



NAND Gate

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Given,

Present input P = Q = 0

then, X = Y = 1

Now, P = Q = 1,

then output X and Y will change as X = 0, Y = 1 or, X = 1, Y = 0 as per the propagation delay of NAND Gate.

If P = Q = 1, then X = 0, Y = 1 if propagation delay of NAND gate-I is less than NAND Gate-II, because both the input of NAND Gate-I are 1.

If P = Q = 1, then X = 1, Y = 0 if propagation delay of NAND Gate-II is less than NAND Gate-I because both the input of NAND Gate-II are 1.

So, option (b)

23. Consider a single input single output discrete-time system with $x[n]$ as input and y[n] as output, where the two are related as

$$y(n)=\begin{cases} n|x[n]|, & \text{for } 0\le n\le 10 \\ x[n]-x[n-1], & \text{Otherwise} \end{cases}$$

which one of the following statements is true about the system.

(a) It is causal and stable

(b) It is causal but not stable

(c) It is not causal but stable

(d) It is neither causal not stable

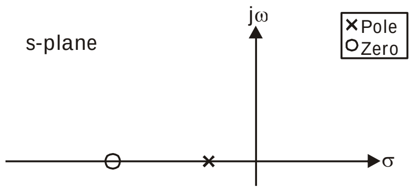
Sol. (a)

$$y[n] = \begin{cases} n\,|\times[n]| & \text{for } 0 \le n \le 10 \\ x[n]-x[n-1] & \text{otherwise} \end{cases}$$

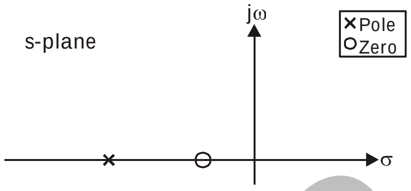
- Present output depends on present input and past input, so it is a causal system.
- For a bounded input, bounded output yields, so it is a stable system.

24. Which of the following can be the pole-zero configuration of a phase-lag controller (lag compensation)?

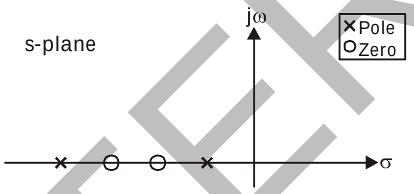
(a)



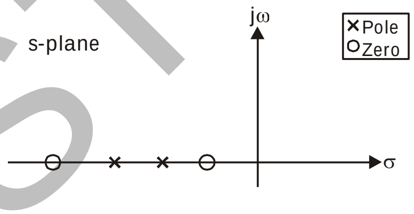
(b)



(c)



(d)



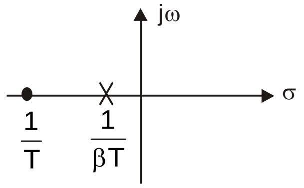
Sol. (a)

For phase-lag controller, the transfer function is

$$G(s) = \frac{1+sT}{1+s\beta T}$$

Where, $\beta > 1$

$\therefore$ The pole-zero configuration will be



25. Let (X_1, X_2) be independent random variables, X_1 has mean 0 and variance 1, while X_2 has mean 1 and variance 4. The mutual information $I(X_1; X_2)$ between X_1 and X_2 in bits is..............

Sol. (0)

Mutual information of two discrete random variable X_1 and X_2 can be defined as:

$I(X_1, X_2)$

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$$= \sum_{x_2 \in X_2} \sum_{x_1 \in X_1} P(x_1, x_2) \log\left[\frac{P(x_1, x_2)}{P(x_1)\, P(x_2)}\right]$$

If X_1 and X_2 are independent then $P(x_1, x_2) = P(x_1)P(x_2)$

$$\log\left[\frac{P(x_1, x_2)}{P(x_1)P(x_2)}\right] = \log\left[\frac{P(x_1)\, P(x_2)}{P(x_1)\, P(x_2)}\right]$$

$$= \log 1 = 0$$

$$I(X_1, X_2) = 0$$

26. In binary frequency shift keying (FSK), the given signal wavefonus are

$u_0(t) = 5\cos(20000\pi t); 0 \le t \le T,$ and

$u_1(t) = 5\cos(22000\pi t); 0 \le t \le T,$

where T is the bit-duration interval and t is in seconds. Both $u_0(t)$ and $u_1(t)$ are zero outside the interval $0 \le t \le T$. With a matched filter (correlator) based receiver, the smallest positive value of T (in milli seconds) required to have $u_0(t)$ and $u_1(t)$ uncorrelated is

(a) 0.25 ms (b) 0.5 ms

(c) 0.75 ms (d) 1.0 ms

Sol. (b)

$u_0(t) = 5\cos(20000\pi t)$; $0 \le + \le T$

$u_1(t) = 5\cos(22000\pi t)$; $0 \le + \le T$

$f_1 = 11000\text{Hz}$

$f_2 = 10000\text{Hz}$

For FSK wave form to be uncorrelated.

$$f_1 - f_2 = \frac{nR_b}{2} ; \; n = 1, 2, 3, \ldots$$

$$R_b = \frac{2(f_1 - f_2)}{n}$$

$$= \frac{2000}{n} \text{ bit/sec.}$$

$$R_{b(max.)} = 2000 \text{ bit/sec.}$$

$\therefore$ minimum value of n = 1,

$$T_{b(min.)} = \frac{1}{R_{b(max.)}} = 0.5 \text{ ms}$$

27. Two discrete-time signals x[n] and h[n] are both non-zero only for n = 0,1, 2 and are zero otherwise. It is given that

x[0] = 1, x[1] = 2, x[2] = 1, h(0) = 1

Let y[n] be the linear convolution of x[n] and h[n]. Given that y[1] = 3 and y[2] = 4, the value of the expression (10y[3] + y[4]) is.....

Sol. (31)

Given,

$$x[n] = [\underset{\uparrow}{1}, 2, 1]$$

and $$h[n] = [\underset{\uparrow}{1}, a, b]$$

We know that,

$$y[n] = x[n]*h[0]$$

$$= \begin{array}{c|ccc} & 1 & 2 & 1 \\ \hline 1 & 1 & 2 & 1 \\ a & a & 2a & a \\ b & b & 2b & b \\ \hline \end{array}$$

$$y[n] = [\underset{\uparrow}{1}, (2+a), (2a+b+1), (a+2b), b]$$

Given,

$y[1] = 3 = 2 + a$

Or $a = 1$

$y[2] = 4 = 2a + b + 1$

Or $b = 1$

$y[3] = a + 2b = 1 + 2 = 3$

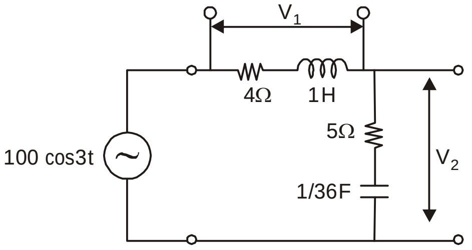
$y[4] = b = 1$

$\therefore$ (10y[3]+y[4]=10 × 3 + 1

= 31

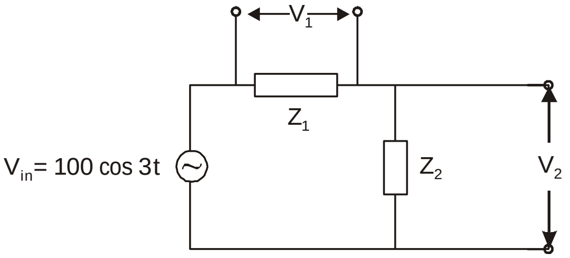
28. The figure shows an RLC circuit excited by the sumsoidal voltage 100 cos (3t) Volts, where t is in seconds. The ratio

$$\frac{\text{amplitude of } v_2}{\text{amplitude of } v_1} \text{ is ....}$$



Sol. (0.3846)

The given circuit can be redrawn as



Where, $Z_1 = 4 + j\omega 1$

and $Z_2 = 5 + \frac{36}{j\omega}$

Given, $\omega = 3$ rad/sec.

$\therefore$ $Z_1 = 4 + j3$

and $Z_2 = 5 + \frac{36}{j3} = 5 - j12$

From voltage division rule

$$V_1 = \frac{Z_1}{Z_1 + Z_2} V_{in}$$

and $$V_2 = \frac{Z_2}{Z_1 + Z_2} V_{in}$$

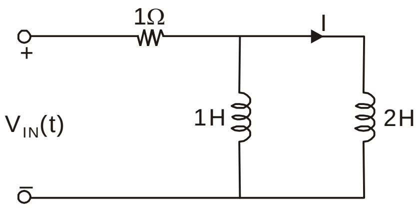
$$\therefore \quad \frac{|V_1|}{|V_2|} = \frac{|Z_1|}{|Z_2|} = \frac{\sqrt{16+9}}{\sqrt{25+144}}$$

$$= \frac{5}{13} = 0.3846$$

29. In the circuit shown the voltage $V_{IN}(t)$ is described by

$$V_{IN}(t) = \begin{cases} 0, & \text{for } t \le 0 \\ 15\text{Volts}, & \text{for } t \ge 0 \end{cases}$$

Where t is in seconds. The time (in seconds) at which the current I in the circuit will reach the value 2 Amperes is ....



Sol. (0.0954)

Equivalent inductance, $L_{eq} = \frac{2 \times 1}{2+1} = \frac{2}{3}$H

and equivalent resistance, $R_{eq} = 1\Omega$

$\therefore$ Time constant, $\tau = \frac{L}{R} = \frac{2}{3}$sec.

and current at time, t,

$$i(t) = \frac{V_{in}}{R}\left[1 - e^{-t/\tau}\right]$$

$$= \frac{15}{1}\left[1 - e^{-3t/2}\right]$$

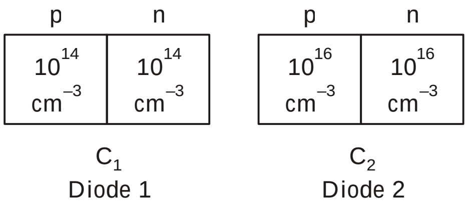
$$= 15\ (1 - e^{-1.5t})$$

$$i(t_0) = 2 = 15\ \left(1 - e^{-1.5t_0}\right)$$

Or $e^{-1.5t_0} = 0.8667$

$\therefore$ $t_0 = 0.0954$ sec.

30. As shown, two Silicon (Si) abrupt p–n junction diodes are fabricated with uniform donor doping concentrations of $N_{D1} = 10^{14}$ cm^{-3} and $N_{D2} = 10^{16}$ cm^{-3} in the n–regions of the diodes, and uniform acceptor doping concentration of $N_{A1} = 10^{14}$ cm^{-3} and $N_{A2} = 10^{16}$ cm^{-3} in the p–regions of the diodes, respectively. Assuming that the reverse bias voltage is in built-in potentials of the diodes, the ratio C_2/C_1 of then reverse bias capacitances for the same applied reverse bias is ....



Sol. (10)

Given that:

Donor doping concentration,

$$N_{D_1} = 10^{14}\ \text{cm}^{-3}$$

$$N_{D_2} = 10^{16}\ \text{cm}^{-3}$$

Acceptor doping concentration,

$$N_{A_1} = 10^{14}\ cm^{-3}$$

$$N_{A_2} = 10^{16}\ cm^{-3}$$

Since, $V_0 << V_R$

$\Rightarrow$ $V_0 + V_R = V_R$

$$C = \frac{\in A}{w}$$

$$\frac{C_2}{C_1} = \frac{\frac{\in A}{w_2}}{\frac{\in A}{w_1}} = \frac{w_1}{w_2}$$

$$= \frac{\sqrt{\frac{2\in V_R}{q}\left[\frac{1}{N_{A_1}}+\frac{1}{N_{D_1}}\right]}}{\sqrt{\frac{2\in V_R}{q}\left[\frac{1}{N_{A_2}}+\frac{1}{N_{D_2}}\right]}}$$

$$= \sqrt{\frac{\left[\frac{N_{D_1}+N_{A_1}}{N_{A_1}\cdot N_{D_1}}\right]}{\frac{N_{D_2}+N_{A_2}}{N_{D_2}\cdot N_{A_2}}}}$$

$$= \sqrt{\frac{\frac{10^{14}+10^{14}}{10^{14}\cdot 10^{14}}}{\frac{10^{16}+10^{16}}{10^{16}\cdot 10^{16}}}}$$

$$= \sqrt{\frac{\frac{2\times 10^{14}}{10^{28}}}{\frac{2(10^{16})}{10^{32}}}}$$

$$= \sqrt{\frac{2\times 10^{14}}{10^{28}}\times\frac{10^{32}}{2(10^{16})}}$$

$$= \sqrt{\frac{10^{46}}{10^{44}}}$$

$$= \sqrt{10^2} = 10$$

31. Let x(t) be a continuous time periodic signal with fundamental period T = 1 seconds. Let $\{a_k\}$ be the complex Fourier series coefficients of x(t). Where k is integer valued. Consider the following statements about x(3t).

I. The complex Fourier series coefficients of x(3t) are $\{a_k\}$ where k is integer valued

II. The complex Fourier series coefficients of x(3t) are $\{3a_k\}$ where k is integer valued

III. The fundamental angular frequency of x(3t) is 6π rad/s

For the three statements above, which one of the following is correct?

(a) Only II and III are true

(b) Only I and III are true

(c) Only III is true

(d) Only I is true

Sol. (b)

x(t) be a continuous time periodic signal,

Fundamental time period (T) = 1

So, $\omega_0 = 2\pi$ rad/sec.

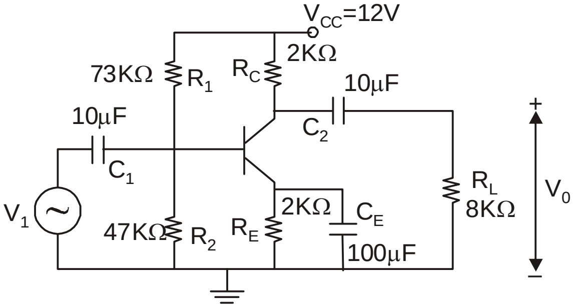
We know, $x(at) \rightarrow a_k,\ a\omega_0$

So, when x(t) is compressed by 3, frequency will expand by 3.

$$x(3t) \rightarrow a_k,\ 3\omega_0 = 6\pi$$

So, both statement I and II are correct.

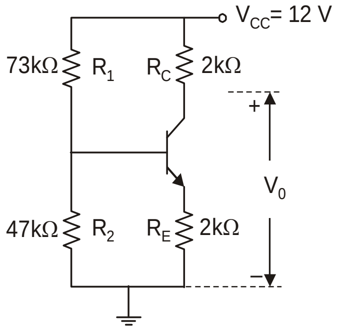
32. For the DC analysis of the Common-Emitter amplifier shown, neglect the base current and assume that the emitter and collector currents are equal. Given that V_T = 25mV, V_{BE} = 0.7V, and the BJT output resistance r_0 is practically infinite. Under these conditons the midband voltage gain magnitude Av = $|v_0/v_1|$ V/V, is.................



Sol. (128)

DC analysis: all capacitor are open circuit.

Now, Redrawing circuit,



$$V_{th} = \frac{12\times 47}{73+47} = 4.7\text{V}$$

$$R_{th} = \frac{73\times 47}{47+73} = 28.59\,k\Omega$$

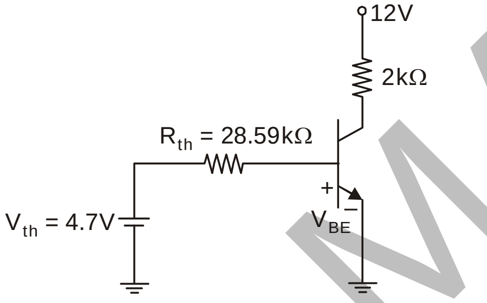


Fig.: DC Analysis

$$I_B = 0 \text{ (Given)}$$

then $\quad I_C = I_E$

Applying KVL in loop1

$$4.7 - 28.59K\cdot \cancelto{0}{I_B} - 0.7 - 2K\cdot I_E = 0$$

$$\Rightarrow 4.7 - 0.7 - 2K\cdot I_E = 0$$

$$I_E = \frac{4.7-0.7}{2K}$$

$$= \frac{4}{2K} = 2 \text{ m Amp.}$$

$\therefore \quad I_c = I_E$

$$= 2\text{m Amp.}$$

$$g_m = \frac{I_c}{V_T}$$

$$= \frac{2\text{m}}{25\text{m}} = 80 \text{ V}$$

Now from AC analysis,

$$A_v = -g_m\cdot R'_L$$

$$= -80(2||8)$$

$$= -80\left(\frac{2\times 8}{2+8}\right)$$

$$= \frac{-80\times 16}{10} = -128$$

$$|A_v| = 128$$

33. A continuous time signal x(t) = 4 cos(200 π t)+8, cos(400 π t), where t is in seconds, is the input to a linear time invariant (LTI) filter with the impulse response

$$h(t) = \begin{cases} \dfrac{2\sin(300\pi t)}{\pi t} & t\neq 0 \\ 600, & t=0 \end{cases}$$

Let y(t) be the output of this filter. The maximum value of |y(t)| is ....

Sol. (8)

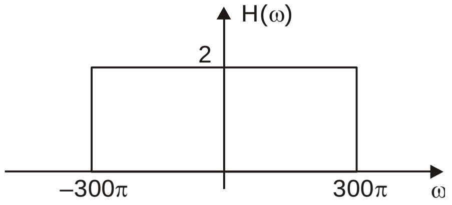
Given continuous time signal,

$$X(t) = 4\cos(200\pi t)+8\cos(400\pi t)$$

Impulse response, h(t) =

$$\begin{cases} \dfrac{2\sin(300\pi t)}{\pi t} & ;\ t\neq 0 \\ 600 & ;\ t=0 \end{cases}$$

So, its fourier transform $\rightarrow$ $H(\omega)$



Given input signal frequencies are 100, 200Hz.

So, the o/p signal

$$y(t) = 2\times 4\cos(200\pi t)$$

$$= 8\cos(200\pi t)$$

So, maximum value |y(t)| = 8

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34. Which one of the following is the general solution of the first order differential equation

$$\frac{dy}{dx} = (x + y = 1)^2,$$

where x, y are real?

(a) $y = 1 + x + \tan^{-1}(x + c)$, where c is a constant

(b) $y = 1 + x + \tan(x + c)$, where c is a constant

(c) $y = 1 - x + \tan^{-1}(x + c)$, where c is a constant

(d) $y = 1 - x + \tan(x + c)$, where c is a constant

Sol. (c)

Given,

$$\frac{dy}{dx} = (x + y - 1)^2 \quad \text{... (1)}$$

Let, $x+y-1 = t$

Then, $1 + \frac{dy}{dx} - 0 = \frac{dt}{dx}$

Or $\frac{dy}{dx} = \frac{dt}{dx} - 1$

From equation (1)

$$\frac{dt}{dx} - 1 = t^2$$

Or $\frac{dt}{1+t^2} = dx$

Or $\int \frac{dt}{1+t^2} = \int dx$

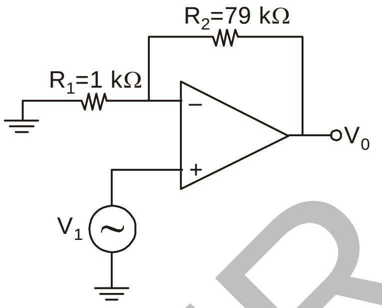
Or $\tan^{-1} t = x + c$

Or $t = \tan(x+c)$

Or $x+y-1 = \tan(x+c)$

Or $y = 1 - x + \tan(x+c)$

35. The amplifier circuit shown in the figure is implemented using a compensated operational amplifier (Op–amp) and has an open–loop voltage gain $A_0 = 10^5$V/V and an open–loop cut–off frequency, f_c = 8Hz The voltage gain of the amplifier at 15 kHz in V/V is............



Sol. (44.4)

In the given circuit

Feed back factor,

$$\beta = \frac{R_1}{R_1 + R_2}$$

$$= \frac{1}{1+79}$$

$$= \frac{1}{80}$$

Closeloop gain, $A_{0_f} = \frac{A_0}{1 + A_0\beta} \cong 80$

$$f_c' = f_c(1 + A_0\beta)$$

$$= 8\left(1 + \frac{10^5}{80}\right)\text{Hz}$$

$$= 10{,}008 \text{ Hz.}$$

Voltage gain at frequency

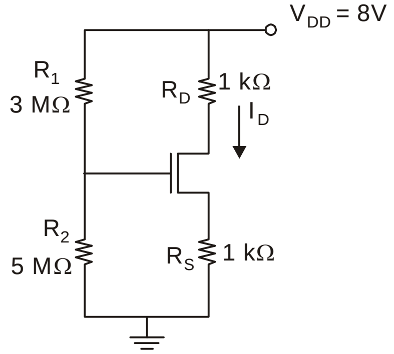
f = 15 kHz is

$$A_f = \frac{A_{0_f}}{\sqrt{1 + \left(\frac{f}{f_c'}\right)^2}}$$

$$= \frac{80}{\sqrt{\left[1 + \left(\frac{15000}{10{,}008}\right)^2\right]}}$$

$$= 44.4$$

36. For the circuit shown, assume that the NMOS transistor is in saturation. Its threshold voltage V_{in} = 1V and its transconductance parameter $\mu_n C_{0x}\left(\frac{W}{L}\right) = 1\text{mA}/\text{V}^2$. Neglect channel length modulation and body bias effects. Under these conditons, the drain current I in mA is ....



Sol. (2)

Given,

Threshold voltage, V_{th} = 1V

Transconductance parameter,

$$\mu_n C_{ox}\left(\frac{W}{L}\right) = 1\ mA/V^2$$

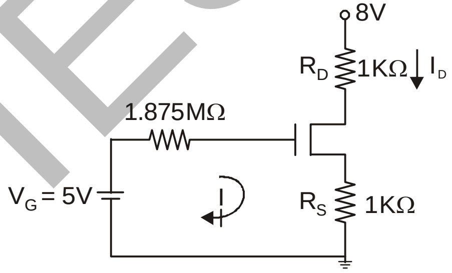
NMOS Transistor is in saturation,

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right).(V_{GS} - V_T)^2 \qquad ...(i)$$

From circuit,

$$V_G = V_{th} = \frac{8 \times 5}{3+5} = 5V$$

$$R_G = R_{th} = \frac{3 \times 5}{3+5} = 1.875M\Omega$$



Applying KVL in LOOP I.

$$\Rightarrow \quad 5 - 1.875M \cdot I_G - V_{GS} - 1 \cdot I_D = 0 \quad [\therefore I_G = 0]$$

$$\Rightarrow \quad 5 - V_{GS} - 1 \cdot I_D = 0$$

$$I_D = 5 - V_{GS} \qquad ...(ii)$$

Put the value of (ii) in (i),

$$5 - V_{GS} = \frac{1}{2}(V_{GS} - 1)^2$$

$$\Rightarrow \quad 10 - 2V_{GS} = V_{GS}^2 + 1 - 2V_{GS}$$

$$\Rightarrow \quad V_{GS}^2 = 10 - 1$$

$$= 9$$

$$V_{GS} = 3V$$

So, from equation (ii),

$$I_D = 5 - V_{GS} = 5 - 3 = 2V$$

37. A linear time invariant (LTI) system with the transfer function

$G(s) = \frac{K\left(s^2 + 2s + 2\right)}{\left(s^2 - 3s + 2\right)}$ is connected in unity feedback configuration as shown in the figure

For the closed loop system shown, the root locus for 0 < K < ∞ interesects the imaginary axis for K = 1.5. The closed loop system is stable for

(a) K > 1.5

(b) 1 < K < 1.5

(c) 0 < K < 1

(d) no positive value of K

Sol. (a)

The characteristic equation of given feedback system is

$$1 + \frac{k\left(s^2 + 2s + 2\right)}{\left(s^2 - 3s + 2\right)} = 0$$

Or $s^2(k+1) + s(2k-3) + 2(k+1) = 0$

The Routh Hurwitz table is

s^2 k+1 2(k+1)

$$\begin{array}{lll} s^1 & 2k-3 & 0 \\ s^0 & 2(k+1) & \end{array}$$

For system to be stable

$$k+1 > 0 \text{ and } 2k-3 > 0$$

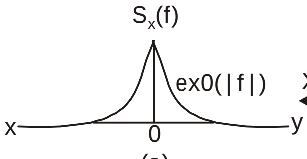
Or $\quad k > -1$ and $k > 1.5$

$\therefore \quad k > 1.5$

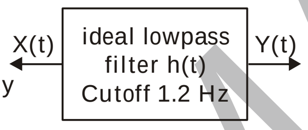
38. Let X(t) be a wide sense stationary random process with the power special density $S_x(f)$ as shown in Figure (a), where f is in Hertz (Hz). The random process X(t) is input to an ideal lowpass filter with the frequency response

$$H(f) = \begin{cases} 1 & |f| \le \frac{1}{2}\text{Hz} \\ 0, & |f| > \frac{1}{2}\text{Hz} \end{cases}$$

as shown in Figure (b). The output of the lowpass filter is Y(t).



(a)



(b)

Let E be the expectation operator and consider the following statements

I. E(X(t)) = E(Y(t))

II. $E(X^2(t)) = E(Y^2(t))$

II. $E(Y^2(t)) = 2$

Select the connect option

(a) only I is true

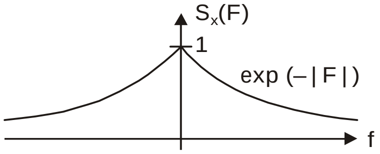
(b) only II and II are true

(c) only I and II are true

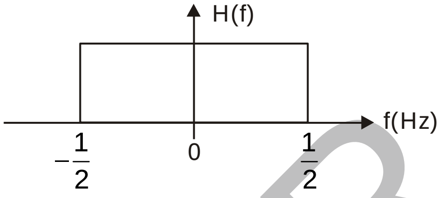
(d) only I and III are true

Sol. (a)

Given input power spectrum density $S_x(f)$



Ideal low pass filter have frequency response.



(I) $\quad E[x(t)] = E[y(t)]$

$\because \quad E[y(t)] = H(0)\, E[X(t)]$

and $\quad H(0) = 1$

so, $\quad E[y(t)] = Ex(t)]$

(II) $\quad E[x^2(t)] = E[y^2(t)]$

Since, Ideal LPF does not allow total power from input to output.

So, $\quad E[x^2(t)] \neq E[y^2(t)]$

(III) $\quad E[y^2(t)] = 2$

$$E[y^2(t)] = \int_0^\infty S_x(f)\,df$$

$$= 2$$

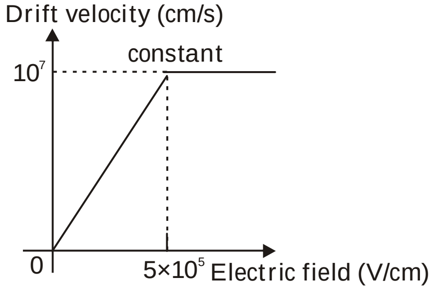
$\because$ from (II),

$$E[x^2(t)] \neq E[y^2(t)]$$

So, $\quad E[y^2(t)] \neq 2$

Hence, only statement-(I) is correct.

39. The dependence of drift velocity of electrons on electric field in a semiconductor is shown below. The semiconductor has a uniform electron concentration of $n = 1 \times 10^{16}$ cm^{-3} and electronic charge $q = 1.6 \times 10^{-19}$C. If a bias of 5 V is applied across a 1 mm region of this semiconductor, the resulting current density in this region in kA/cm^2, is ....



Sol. (1.6)

Electric field in the semiconductor

$$E = \frac{V}{t} = \frac{5}{1\times10^{-4}} = 5\times10^{4} \text{ V/cm}$$

Now,

$$\text{Mobility} = \frac{\text{Drift velocity}}{\text{Electric field Intensity}}$$

$$= \frac{10^{7} \text{ cm/s}}{5\times10^{5} \text{ V/cm}}$$

$$\left[\because E < 5\times10^{5} \text{V/cm}\right]$$

$$= 20 \text{ cm}^2\text{/V.sec}$$

Conductivity, $\sigma = ne\mu$

$$= 10^{16} \times 1.6 \times 10^{-19} \times 20$$

$$= 32 \times 10^{-3}$$

So, current density

$$J = \sigma E$$

$$= 32\times10^{-3} \times 5\times10^{4} \text{ A/cm}^2$$

$$= 1600 \text{ A/cm}^2$$

$$= 1.6 \text{ kA/cm}^2$$

40. Let f(x) = e^{x+x^2} for real x. From among the following, choose the Taylor series approximation of f(x) around x = 0, which includes all powers of x less than or equal to 3.

(a) $1 + x + x^2 + x^3$

(b) $1 + x + \frac{3}{2}x^2 + x^3$

(c) $1 + x + \frac{3}{2}x^2 + \frac{7}{6}x^3$

(d) $1 + x + 3x^2 + 7x^3$

Sol. (c)

Given, $f(x) = e^{x+x^2}$

$$f'(x) = e^{x+x^2}(1 + 2x)$$

$$f''(x) = (1 + 2x)^2 e^{x+x^2} + e^{x+x^2} \times 2$$

$$= e^{x+x^2}(3 + 4x^2 + 4x)$$

$$f'''(x) = (3 + 4x + 4x^2)(1 + 2x) e^{x+x^2} + e^{x+x^2}(4 + 8x)$$

Now, $f'(0) = 1,\ f''(0) = 3,$

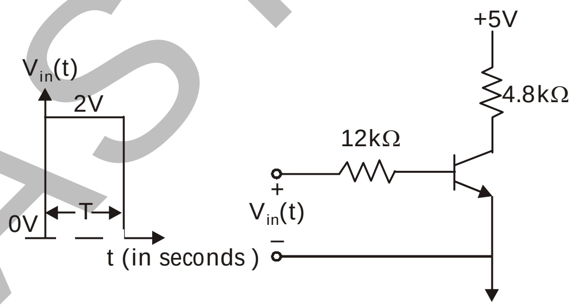
$$f'''(0) = 3 + 4 = 7$$

Taylor series of f(x) around x = 0 is

$$f(x) = f(0) + \frac{f'(0)}{1!}x + \frac{f''(0)}{2!}x^2 + \frac{f'''(0)}{3!}x^3 + \ldots\ldots$$

$$\therefore \quad f(x) = 1 + x + \frac{3}{2}x^2 + \frac{7}{6}x^3$$

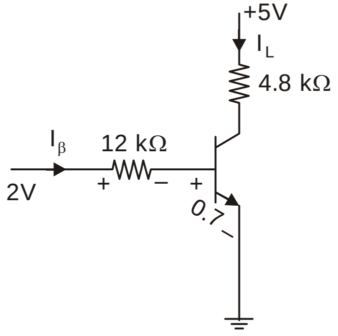
41. In the figure shown the upon transistor acts as a swich



For the input $V_m(t)$ as shown in the figure, the transistor switches between the cut–off and saturation regions of operation. When T is large, Assume collector–to–emitter voltage at saturation $V_{CE(sat)}$ = 0.2V and base–to–emitter voltage V_{BE} = 0.7V. The minimum value of the common–base current grain (α) of the transistor for the switching should be

Sol. (0.902)

Redrawn the ckt.



IES MASTER

Institute for Engineers (IES/GATE/PSUs)

ESE-2017 Conventional Test Schedule, Electronics Engineering

Date	Topic
5th Mar 2017	**N.T.** : BEE-1, MI-1, CS-1
	R.T. :
11th Mar 2017	**N.T.** : BEX-1, NT-1, EMT-1
	R.T. : BEE-1, CS-1, MI-1
19th Mar 2017	**N.T.** : BEE-2, NT-2, EMT-2, CO-1
	R.T. : BEX-1, EMT-1, NT-1
26th Mar 2017	**N.T.** : MI-2, NT-3, MAT-1, CS-2
	R.T. : BEE-2, NT-2, CS-1, EMT-2
2nd Apr 2017	**N.T.** : BEX-2, CS-3, CO-2
	R.T. : MI-2, CO-1, MAT-1, NT-2
9th Apr 2017	**N.T.** : ADC-1, EMT-3, COMM-1
	R.T. : CS-2, NT-1, EMT-1, BEX-1, EMT-2
16th Apr 2017	**N.T.** : ADC-2 BEX-3, ACT-1
	R.T. : BEE-2, MI-2, EMT-3, ADC-1, NT-2, CS-2, CS-3
23rd Apr 2017	**N.T.** : AET-1, MAT-2, ADC-3
	R.T. : ADC-2, BEX-2, BEE-1, MI-1, CS-2, ACT-1, NT-3, CO-2, COMM-1
30th Apr 2017	**N.T.** : AET-2, ACT-2, COMM-2
	R.T. : ADC-1, ADC-3, AET-1, CS-3, BEX-1, MAT-2, MAT-1
3rd May 2017	**N.T.** : COMM-3, MI-3, CO-3
	R.T. : ADC-3, AET-2, ACT-1, CO-1, CO-3, COMM-2, NT-3, MAT-2, ACT-2, MI-3
7th May 2017	**N.T.** : AET-3, ADC-4, MAT-3
	R.T. : CO-3, ACT-2, MAT-3, BEX-2, CS-2, EMT-3, BEX-3, AET-1 AET-2, COMM-2, ADC-4
9th May 2017	Full Length (Test Paper-1 + Test Paper-2)

Test Type	Timing	Day
Conventional Test	10:00 A.M. to 1:00 P.M.	Sunday
Conventional Full Length Test Paper-1	10:00 A.M. to 1:00 P.M.	Tuesday
Conventional Full Length Test Paper-2	02:00 P.M. to 5:00 P.M.	Tuesday

Note : The timing of the test may change on certain dates. Prior information will be given in this regard.

***N.T. :** New Topic. ***R.T. :** Revision Topic

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Subject Code Details

Basic Electronics Engineering (BEX)	**BEX-1**	**BEX-2**	**BEX-3**	
	♦ Basics of Semiconductors ♦ Diode : Basics, Characteristics & its types ♦ BJT, JFET, MOSFET-Basic Structure & Characteristics	♦ Transistor Amplifiers ♦ Oscillators & Other circuits ♦ Basic of Linear ICs ♦ Operational Amplifier & their applications	♦ Basics of ICs; Bipolar, MOS & CMOS ICs ♦ Optical Sources / Detectors ♦ Basics of Optoelectronics & Applications	
Basic Electrical Engineering (BEE)	**BEE-1**	**BEE-2**		
	♦ Basics of Circuit Theory and Electromagnetic Field Theory ♦ Single Phase AC circuits ♦ Transformer ♦ DC Machine	♦ Induction Machine ♦ Synchronous Machine ♦ Electrical Power Sources, Basics of Batteries & its uses		
Material Science (MAT)	**MAT-1**	**MAT-2**	**MAT-3**	
	♦ Crystalline Structure ♦ Dielectric properties of matter ♦ Ceramic materials	♦ Magnetic properties of materials ♦ Insulating laminates for electronics ♦ Conductors & Superconductors	♦ Semiconductor & Optical materials ♦ Nano materials Nano-optical / Magnetic / Electronic materials	
Electronic Measurement and Instrumentation (MI)	**MI-1**	**MI-2**	**MI-3**	
	♦ Error analysis & basics of measurement ♦ Basic measuring instruments ♦ Measurement of Energy & Power	♦ Measurement of Resistance ♦ AC Bridges ♦ Potentiometer ♦ Cathode Ray Oscilloscope (CRO) ♦ Q-meter	♦ Basics of electronic measurements ♦ Digital & electronic voltmeter ♦ Digital frequency meter ♦ Transducers & Displays ♦ Basics of Telemetry ♦ Data Acquisition System	
Network Theory (NT)	**NT-1**	**NT-2**	**NT-3**	
	♦ Network elements ♦ Network theorems ♦ 2-port networks	♦ Transient and Steady State Response ♦ Steady State Sinusoidal analysis ♦ Resonance	♦ Network Functions ♦ Graph Theory ♦ Filters ♦ State equations for networks	
Analog and Digital Circuits (ADC)	**ADC-1**	**ADC-2**	**ADC-3**	**ADC-4**
	♦ Small Signal equivalent of Diodes, BJTs and FETs ♦ Different Diode Circuits ♦ Biasing and Stability of BJTs & JFET amplifier circuits	♦ Analysis / Design of amplifiers signal & multi-stage ♦ Feedback & its uses ♦ Active filters, timers, multipliers, wave shaping, A/D & D/A converters	♦ Boolean Algebra & Logic Gates ♦ Combinational circuits : Design & Applications ♦ Memories and Microprocessor : Design & Applications	♦ Sequential circuits : Design & Applications ♦ Design IC Logic families
Among and Digital Communication (COMM)	**COMM-1**	**COMM-2**	**COMM-3**	
	♦ Probability Theory ♦ Analog Communication Systems	♦ Random Signals and Noise ♦ Digital Communication Systems	♦ Information Theory ♦ Multiple Access-TDMA, FDMA, CDMA ♦ Optical Communication	
Control Systems (CS)	**CS-1**	**CS-2**	**CS-3**	
	♦ Signals and Systems ♦ System Realization ♦ Transforms & their Applications	♦ Basics of Control Systems ♦ Block Diagram & Signal Flow Graphs ♦ Time Response Analysis ♦ Routh Hurwitz criteria & Root Locus Technique	♦ Frequency Response Analysis ♦ Stability in Frequency Domain ♦ Controllers and compensators ♦ State Space Analysis	
Computer Organization and Architecture (CO)	**CO-1**	**CO-2**	**CO-3**	
	♦ Basics of Computer Organization	♦ Operating Systems	♦ Database Management Systems ♦ Data Structure and Programming	
Electromagnetics (EMT)	**EMT-1**	**EMT-2**	**EMT-3**	
	♦ Elements of Vector Calculus ♦ Electrostatics ♦ Magnetostatics	♦ Maxwell's Equations ♦ Electromagnetic Wave propagation through different media ♦ Transmission Lines	♦ Waveguides ♦ antenna Theory	
Advanced Electronics Topics (AET)	**AET-1**	**AET-2**	**AET-3**	
	♦ VLSI Technology ♦ VLSI Design ♦ Mealy and Moore circuit design ♦ Pipeline concept and functions ♦ Designs for tesatblity and examples	♦ Digital Signals Processing ♦ Digital Filters ♦ Speech / Audio / Radar Signal Processing	♦ Microprocessors and Microcontrollers ♦ Embedded Systems	
Advanced communication Topics (ACT)	**ACT-1**	**ACT-2**		
	♦ Communication Networks : Principles / Practices / Technologies / Uses / OSI Model / Security ♦ Basic packet multiplexed streams / scheduling ♦ Protocols (TCP / TCP-IP)	♦ Microwave & Satellite Communication ♦ Fiber Optic Communication ♦ Cellular Networks : Types, Analysis		

In base loop;

$$-2V + 12I_B + 0.7 = 0$$

$$\Rightarrow \quad I_B = \frac{2-0.7}{12}$$

$$= \frac{1.3}{12} = 0.10833 \text{ mA}$$

From collector loop,

Transistor is in saturation region

$$-5V + 4.8I_C + 0.2 = 0$$

$$I_C = \frac{5-0.2}{4.8\times10^3}$$

$$= \frac{4.8}{4.8\times10^3} = 1\text{mA}$$

We know that,

In saturation,

$$I_B \geq I_{B\,min.} = \frac{I_{c\,sat}}{\beta}$$

$$\Rightarrow \quad I_B \geq \frac{1\text{mA}}{\beta}$$

$$\Rightarrow \quad \beta \geq \frac{1}{0.10833}$$

and, $\beta_{mm} = 9.23$

$$\alpha_{min} = \frac{\beta_{min.}}{1+\beta_{min.}}$$

$$= 0.902$$

$$\alpha_{min} = 0.902$$

42. The expression for an electric field in free space is $E = E_0(\hat{x}+\hat{y}+j2\hat{z})e^{-j(\omega t-kx+ky)}$ where x, y, z represent the spatial coordinates, t represents time and ω, k are constants. This electric field

(a) does not represent a plane wave

(b) represents a circularly polarized plane wave propagating normal to the z–axis

(c) represents and elliptically polarized plane wave propagating along the x–y plane

(d) represents a linearly polarized plane wave

Sol. (c)

$$E = E_0(\hat{x}+\hat{y}+j2\hat{z})e^{-j(\omega t-kx+ky)}$$

We know,

$$e^{-jkr} = e^{-j(-kx+ky)}$$

$$\therefore \quad kr = k(-x+y)$$

Propagation vector $\hat{a}_P$

$$= \frac{\nabla(kr)}{|\nabla(kr)|}$$

$$\nabla(kr) = k(-\hat{x}+\hat{y})$$

$$|\nabla(kr)| = k\sqrt{2}$$

$$\therefore \quad \hat{a}_P = \frac{\nabla(kr)}{|\nabla(kr)|}$$

$$= \frac{-\hat{x}+\hat{y}}{\sqrt{2}}$$

For plane wave,

$$\hat{a}_P\hat{E} = \left[\frac{-\hat{x}+\hat{y}}{\sqrt{2}}\right]\cdot E_0\left[\hat{x}+\hat{y}+j2\hat{z}\right]$$

$$\hat{a}_P E_P = 0$$

$\therefore$ Given is a plane wave,

As, E = $E_0(\hat{x}+\hat{y}+\hat{j}2\hat{z})e^{-j(\omega t-kx+ky)}$

For the given, plane of incidence is xy plane E in xy plane is parallel polarized, $E_{||} = |E|_{xy} = \sqrt{1+1}=\sqrt{2}$ and along z is perpendicular polarize $E_{||} = |E_z|_z = \sqrt{2^2}$ = 2.

$$|E_T| = |E_{||}| + |E_r|$$

$$= \sqrt{2}+2$$

$$|E_{||}| \neq |E_r|$$

and phase difference is 90°; i.e., given is a elliptically polarized plane wave.

43. The following FIVE instructions were executed on an 8085 microprocessor

MVI A, 33H

MVI B, 78H

ADD B

CMA

ANI 32H

The Accumulator value immediately after the execution of the fifth instruction is

(a) 00H (b) 10H

(c) 11H (d) 32H

Sol. (b)

MVI A 33H $\Rightarrow$ [A] = 33 H

MVI B 78H $\Rightarrow$ [B] = 78H

ADD B $\Rightarrow$ [A] $\Leftarrow$ [A]+[B]

$$\Rightarrow \begin{array}{r} 0011\ \ 0011 \\ +0111\ \ 1000 \\ \hline \underbrace{1010}_{A}\ \ \underbrace{1011}_{B} \end{array} \Rightarrow \text{AB H}$$

i.e. [A] = AB H

CMA $\Rightarrow$ complement accumulator

i.e. $[A] \Leftarrow \bar{A}$

where, $\bar{A} = \overline{1010\ \ 1011} = 0101\,0100$

$$\text{ANI 32H} \Rightarrow \begin{array}{r} 0011\ \ 0010 \\ 0101\ \ 0100 \\ \hline 0001\ \ 0000 \end{array} \Rightarrow 10\text{H}$$

$[A] = 10H$

i.e. option (B)

44. Which one of the following options correctly describes the location of the roots of the equation $s^4 + s^2 + 1 = 0$ on the complex plane?

(a) Four left half plane (LHP) roots

(b) One right half plane (RHP) root, one LHP root and two roots on the imaginary axis

(c) Two RHP roots and two LHP roots

(d) All four roots are on the imaginary axis

Sol. (c)

Given equation is,

$s^4 + s^2 + 1 = 0$

Let $s^2 = y$

then $y^2+y+1 = 0$

$$\Rightarrow \quad y = \frac{-1 \pm \sqrt{1-4}}{2} = \frac{-1}{2} \pm j\frac{\sqrt{3}}{2}$$

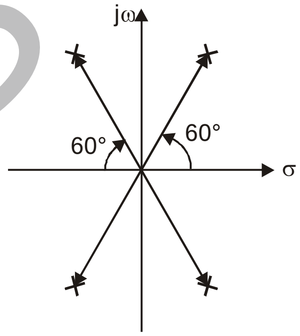
$$\Rightarrow \quad y = 1\angle 120^\circ \text{ and } 1\angle -120^\circ$$

for $y = \quad s^2 = 1\angle 120^\circ$

$$\Rightarrow \quad s = \pm(1\angle 60^\circ)$$

and, for $y = \ s^2 = 1\angle -120^\circ$

$$\Rightarrow s = \pm\ (1\ \angle -60^\circ)$$

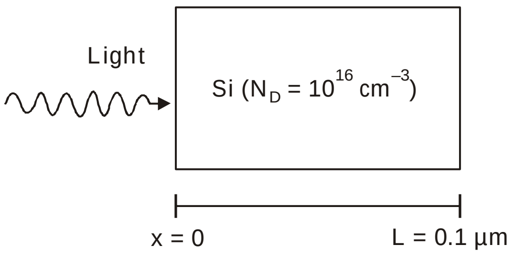


i.e. equation has two right half plane (RHP) roots and two left half plane (LHP) roots.

i.e. option (c).

45. As shown a uniformly doped Silicon (Si) bar of length L = 0.1 μm with a donor concentration $N_D = 10^{16}\ \text{cm}^{-3}$ is illuminated at x = 0 such that electron and hole pairs are generated at the rate of $G_L = G_{L0}\left(1 - \frac{x}{L}\right), 0 \le x \le L.$ where, $G_{L0} = 10^{17}\ \text{cm}^{-3}/\text{s}$.

Hole lifetime 10^{-4}s, electronic change q = 1.6×10^{-19} C, hole diffusion coefficient D_p = 100 cm^2/s and low level injection condition prevails. Assuming a linearly decaying steady state excess hole concentration that goes to 0 at x = L, the magnitude of the diffusion current density at x = L/2, in A/cm^2, is ___.



Sol. (16)

Given, $L = 0.1\,\mu m$

so, $N_D = 10^{16}/cm^3$ at $x = 0$

Hole pair generated rate,

$$G_L = G_{L_0}\left(1-\frac{x}{L}\right) ,$$

$0 \le x \le L$

Where, $G_{L_0} = 10^{17} cm^{-3} s^{-1}$,

$\tau = 10^{-4} s$,

$q = 1.6 \times 10^{-19} c$,

$D_P = 100\ cm^2/s$

$J_{p_{diff.}} = ?$

$\therefore$ Net hole density varying in the direction of x is:

$$P_n(x) = P_{n_0} + PP$$

$$= P_{n_0} + G_L I_P$$

$$= P_{n_0} + G_{L0} I_P \left(1-\frac{x}{L}\right)$$

$$J_{Pdiff.} = -eD_P\frac{dp}{dx}$$

$$= -eD_P\frac{dp}{dx}$$

$$= -eD_p\left[\frac{-G_{L0}\cdot I_P}{L}\right]$$

$$= \frac{1.6\times10^{-19}\times100\times10^{17}\times10^{-4}}{0.1\times10^{-4}}$$

$= 16\ A/cm^2$

46. Let $I = \int_C (2z\,dx + 2y\,dy + 2x\,dz)$ where x, y, z are real and let C be the straight line segment from point A: (0, 2, 1) to point B: (4, 1 –1). The value of I is _______

Sol. (–11)

$$I = \int_c (2zdx + 2ydy + 2xdz)$$

The equation of straight line joining A(0, 2, 1) and B (4, 1, –1) is given by

$$\frac{x-0}{4-0} = \frac{y-2}{1-2} = \frac{z-1}{-1-1}$$

$$\Rightarrow \frac{x}{4} = \frac{y-2}{-1} = \frac{z-1}{-2}$$

$$x = -4y + 8 = -2z + 2$$

$$\Rightarrow y = \frac{8-x}{4}$$

$$\therefore dy = \frac{-1}{4}dx$$

$$\text{and, } z = \frac{2-x}{2}$$

$$\therefore dz = \frac{-1}{2}dx$$

$$\text{then, } I = \int_0^4 \left[2\left(\frac{2-x}{2}\right)dx + 2\left(\frac{8-x}{4}\right)\left(\frac{-1}{4}dx\right) + 2x\left(\frac{-1}{2}dx\right)\right]$$

$$= \int_0^4 \left(2-x-1+\frac{x}{8}-x\right)dx$$

$$= \int_0^4 \left(1-\frac{15}{8}x\right)dx = \left[x-\frac{15}{16}x^2\right]_0^4$$

$= 4 - 15 = -11$

47. An optical fiber is kept along the z direction. The refractive indices for the electric fields along $\hat{x}$ and $\hat{y}$ directions in the fiber are $n_x = 1.50000$ and $n_y = 1.5001$, respectively ($n_x \ne n_y$ due to the imperfection in the fiber cross-section). The free space wavelength of a light wave propagating in the fiber is 1.5µm. If the lightwave is circularly polarized at the input of the fiber, the minimum propagation distance after which it becomes linearly polarized in centimeters, is_______

OUR TOP RESULTS IN ESE-2016

IES MASTER

Institute for Engineers (IES/GATE/PSUs)


AIR 1 CE

JATIN KUMAR


AIR 3 CE

RACHIT JAIN


AIR 4 CE

ADARSH R. SRIVASTAV


AIR 6 CE

NITISH GARG


AIR 7 CE

SHIVAM DWIVEDI


AIR 8 CE

AMRIT ANAND


AIR 9 CE

AVDHESH MEENA


AIR 10 CE

HIMANSHU TIWARI


AIR 11 CE

PRAKHAR TRIPATHI


AIR 12 CE

NITIN KR. AGARWAL


AIR 14 CE

MITARPAL TANWAR


AIR 15 CE

ASHISH GUPTA


AIR 16 CE

SIDDHARTH MAHAJAN


AIR 17 CE

DEVKISHAN KUMHAR


AIR 22 CE

BHARAT BHUSHAN DIXIT


AIR 24 CE

HISAM UDDIN


AIR 26 CE

PRASHANT TRIPATHI


AIR 28 CE

SHUBHANSHU JAIN


AIR 29 CE

MANISH KR. SHARMA


AIR 31 CE

ABHISHEK MITTAL


AIR 33 CE

SPARSH BHARDWAJ


AIR 1 ME

MOHAMMAD IDUL AHMED


AIR 3 ME

CHIRAG SRIVASTAV


AIR 5 ME

DEEPAK VIJAY


AIR 12 ME

SACHIN JAIN


AIR 13 ME

KHILENDRA SINGH CHAUHAN


AIR 14 ME

VINAY KUMAR


AIR 17 ME

SAMARTH AGARWAL


AIR 18 ME

ROOPAK TIWARI


AIR 40 ME

ANIL KUMAR


AIR 51 ME

ANKUR SINGH CHAUHAN


AIR 63 ME

NIMIT AGRAWAL


AIR 71 ME

SURYANK GUPTA


AIR 106 ME

ARPIT KUMAR


AIR 108 ME

P.S. MANI KUMAR


AIR 131 ME

RAHUL RAJPAL SINGH


AIR 132 ME

SACHINI KUMAR


AIR 156 ME

ARVIND KUMAR


AIR 38 EE

VIDYA


AIR 94 EE

RITA NAGDEVE


AIR 106 EE

RAJIV DAS


AIR 35 CE

RAVI MITTAL


AIR 37 CE

CHANDAN SINGH


AIR 38 CE

K.M.N.V.S.RAVI TEJA


AIR 39 CE

MAHAMMED UBAID


AIR 40 CE

J.K.KUMAR REDDY


AIR 43 CE

SHWET KUMAR


AIR 44 CE

GAURAV SINGLA


AIR 46 CE

VAIBHAV PODDAR


AIR 47 CE

AJIT KR. PALSANIA


AIR 48 CE

VIKRAM MITTU


AIR 51 CE

HARSHIT CHOUHAN


AIR 52 CE

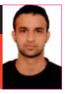
VIKAS KR. SEHRA


AIR 53 CE

AYUSH TIWARI


AIR 55 CE

SAGAR MAHESHWARI


AIR 59 CE

AKHILESH


AIR 61 CE

ABHIPRERNA AWANA


AIR 62 CE

MAYANK AGRAWAL


AIR 63 CE

THATI SONY


AIR 65 CE

SUSHIL KR. SINGH


AIR 66 CE

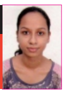
ANANT YADAV


AIR 67 CE

P JAMSHEER


AIR 68 CE

AVINASH SAHANI


AIR 69 CE

PAYAL GOYAL


AIR 70 CE

PRANAV


AIR 71 CE

DEEPAK NEGI


AIR 72 CE

KULDEEP SINGH


AIR 74 CE

NAVEEN YADAV


AIR 75 CE

VIVEK RANJAN PANDEY


AIR 76 CE

ANKUR GOYAL


AIR 77 CE

VIPUL KUMAR


AIR 78 CE

AMIT GUPTA


AIR 80 CE

DHAWAL SRIVASTAVA


AIR 81 CE

NITIN MANGWAL


AIR 87 CE

SHYAMAL KUMAR


AIR 88 CE

RAJAT KOTHARI


AIR 93 CE

AJAY KR. CHAUDHARY


AIR 95 CE

MADHURIMA BHATTACHARYA


AIR 97 CE

DIGVIJAY CHAUHAN


AIR 99 CE

ABHISHEK


AIR 105 CE

CHITRANSHU


AIR 106 CE

NITESH


AIR 108 CE

PRIYANK GUPTA


AIR 109 CE

MANOJ KUMAR MISHRA


AIR 110 CE

SHIVAM PRATAP SINGH


AIR 112 CE

MILIN MITTAL


AIR 113 CE

ANKIT


AIR 115 CE

KUNWAR CHRAYA


AIR 116 CE

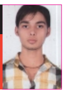
SIDDHARTH SONI


AIR 119 CE

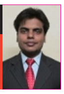
AJAY SHARMA


AIR 120 CE

ASHISH PANDEY


AIR 121 CE

DANISH KHAN


AIR 122 CE

OM NATH BIHARI


AIR 125 CE

GOPAL PATRALEKH


AIR 126 CE

AKASH ROUT


AIR 130 CE

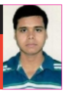
RANVIJAY AZAD


AIR 132 CE

GYANPRAKASH SONI


AIR 136 CE

MOHIT KUMAR


AIR 137 CE

NIRAJ KUMAR YADAV


AIR 138 CE

MOHNISH KR. SINHA


AIR 142 CE

ABHISHEK KUMAR YADAV


AIR 143 CE

VIJAY ANAND VERMA


AIR 145 CE

DIVIJ SAHANI


AIR 147 CE

MANISHA K. MEENA


AIR 150 CE

SATYAPAL SANNU


AIR 151 CE

AHTESHAMUL HAQ


AIR 153 CE

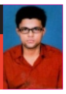
SURAJ PRATAP SINGH


AIR 154 CE

ALOK KUMAR VERMA


AIR 161 CE

JAY KARAN YADAV


AIR 165 CE

PRASANT KUMAR


AIR 166 CE

PUKHA RAM


AIR 168 CE

MAHENDRA SINGH JATAV


AIR 169 CE

ABHISHEK


AIR 171 CE

BUDDI PRAKASH MEENA


AIR 173 CE

DHEERESH KR.


AIR 174 CE

VINITA


AIR 175 CE

SAURAV SHIVHARE


AIR 179 CE

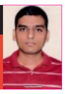
LALIT KUMAR


AIR 180 CE

NAVALPREET KAUR


AIR 183 CE

SANTOSH KR. MEENA


AIR 184 CE

ABHISHEK KUMAR


AIR 187 CE

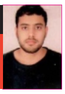
RAHUL JAJORIA


AIR 188 CE

BHARTI MEENA


AIR 189 CE

JITENDRA KR. MEENA


AIR 190 CE

SAURAV DEO


AIR 193 CE

PRADEEP KR. MEENA


AIR 194 CE

NITESH KR. SINGH


AIR 199 CE

AMIT KR. MEENA


AIR 203 CE

ACHAL KUMAR


AIR 207 CE

LALIT MOHAN MEENA


AIR 210 CE

SUNIL KR. MEENA


AIR 212 CE

AKASH CHANDRA


AIR 213 CE

MAHENDRA KR. MEENA


AIR 216 CE

SUMAN JEE


AIR 221 CE

ALOK OJHA


AIR 224 CE

ANKIT KR. SHUKLA

Received so far..... [If found any discrepancy please bring it to our notice.]

Sol. (0.375)

For to have linear polarization, phase difference has to be 0° or 180°. Given the light wave is circularly polarized that is initial phase difference is 90°.

$$\text{so,} \qquad \beta_1 z \sim \beta_2 z = \frac{\pi}{2}$$

$$\Rightarrow \quad \frac{w}{V_{Px}} z \sim \frac{w}{V_{Py}} z = \frac{\pi}{2}$$

$$\Rightarrow \quad \frac{2\pi f}{c}(\eta_x \sim \eta_y) z = \frac{\pi}{2}$$

$$\Rightarrow \quad \frac{2\pi}{\lambda}(\eta_x \sim \eta_y) z = \frac{\pi}{2}$$

$$\Rightarrow \quad z = \frac{\pi}{2} \times \frac{\lambda}{2\pi(\eta_x \sim \eta_y)}$$

$$= \frac{\lambda}{4(\eta_x \sim \eta_y)}$$

$$= \frac{1.5 \times 10^{-6}}{4 \times 0.0001}$$

$$= 0.375 \text{ cm}$$

48. The Nyquist plot of the transfer function

$$G(s) = \frac{K}{(s^2 + 2s + 2)(s + 2)}$$

does not encircle the point (–1 + j0) for K = 10 but does encircle the point (–1 + j0) for K = 100. Then the closed loop system (having unity gain feedback) is

(a) stable for K = 10 and stable for K = 100

(b) stable for K = 10 and unstable for K = 100

(c) unstable for K = 10 and sable for K = 100

(d) unstable for K = 10 and unstable for K = 100

Sol. (b)

Given open-loop transfer function

$$G(s) = \frac{k}{(s^2 + 2s + 2)(s + 2)}$$

poles: $s^2 + 2s + 2 = 0$

$$s = \frac{-2 \pm \sqrt{4-8}}{2} = \frac{-2 \pm j2}{2} = -1 \pm j$$

and s = –2

i.e. none of the poles of open-loop system lies on right half of s-plane.

i.e. P = 0.

Now, **for k = 10:**

No. of encirclement = 0

i.e. N = 0

since, Z = N + P = 0 + 0 = 0

i.e. none of the poles of closed loop system lies in right half of s-plane. So, system will be stable.

For **K = 100:**

No. of encirclement = 1

i.e. N = 1

since, Z = N + P = 1 + 0 = 1.

i.e. one pole of closed loop system lies in right half of s-plane. So, system will be unstable.

i.e. option (b).

49. A three dimensional region R of finite volume is described by

$$x^2 + y^2 \le z^3; 0 \le z \le 1.$$

where x, y, z are real. The volume of R (upto two decimal place) is________

Sol. $\left(\frac{\pi}{4}\right)$

$$\because \quad 0 \le z \le 1$$

$$\Rightarrow \quad z_{min} = 0$$

$$\& \ z_{max} = 1$$

$$\text{so,} \quad x^2 + y^2 \le z^3 \Rightarrow \begin{cases} \text{Min}(x^2 + y^2) = 0 \\ \text{Max}(x^2 + y^2) = 0 \end{cases}$$

$\Rightarrow$ $\min x = 0$ & $\min y = 0$

$\max y = \sqrt{1-y^2}$ & $\max x = 1$

so, $0 \le z \ge 1$, $0 \le y \le \sqrt{1-x^2}$, $0 \le x \le 1$

so, $\text{Volume} = \iiint (1)\,dx\,dy\,dz$

$$= \int_{x=0}^{1} \int_{z=0}^{1} \int_{y=0}^{\sqrt{1-x^2}} (1)\ dy\ dx\ dx$$

$$= \int_{z=0}^{1} \left[\int_{x=0}^{1} \sqrt{1-x^2}\ dx \right] dz$$

$$= \int_{z=0}^{1} \left(\frac{\pi}{4}\right) dz$$

$$= \frac{\pi}{4}$$

Method II: In cylindrical coordinates (x, y, z) $\approx (r, \theta, z)$

Where $x^2+y^2 \le z^3 = 0 \le z \le 1$

$$0 \le \theta \le 2\pi$$

$$0 \le r \le z^{\frac{3}{2}}$$

$$\left[\because x^2+y^2 = r^2\right]$$

$$V = \iiint (1)\ dx\ dy\ dz$$

$$= \iiint r\ dr\ d\theta\ dz$$

$$= \int_{z=0}^{1} \int_{\theta=0}^{2\pi} \int_{r=0}^{z^{3/2}} r \cdot dr \cdot d\theta\ dz$$

$$= \int_{z=0}^{1} \int_{\theta=0}^{2\pi} \left(\frac{z^3}{2}\right) d\theta\ dz$$

$$= \int_{\theta=0}^{2\pi} \left(\frac{z^4}{8}\right)_0^1 d\theta$$

$$= \frac{1}{8} \int_{0}^{2\pi} (1)\ d\theta$$

$$= \frac{\pi}{4}$$

50. Which one of the following gives the simplified sum of products expression for the Boolean function F = $m_0+m_2+m_3+m_5$, where m_0, m_2, m_3 and m_5 are minterms corresponding to the inputs A, B and C with A is the MSB and C as the LSB?

(a) $\bar{A}B + \bar{A}\bar{B}\bar{C} + A\bar{B}C$

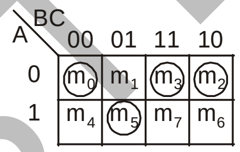
(b) $\bar{A}\bar{C} + \bar{A}B + A\bar{B}C$

(c) $\bar{A}\bar{C} + A\bar{B} + A\bar{B}C$

(d) $\bar{A}BC + \bar{A}\bar{C} + A\bar{B}C$

Sol. (b)

F =

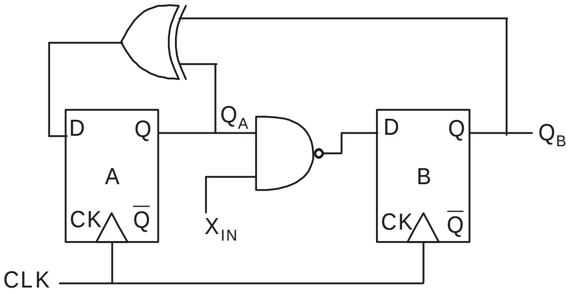


A \ BC	00	01	11	10
0	m_0	m_1	m_3	m_2
1	m_4	m_5	m_7	m_6

$$F = (m_0 + m_2) + (m_2 + m_3) + m_5$$

$$= \bar{A}\bar{C} + \bar{A}B + A\bar{B}C$$

51. A finite state machine (FSM) is implemented using the D flip-flops A and B and logic gates as shown in the figure below. The four possible states of the FSM are Q_AQ_B = 00, 01, 10, and 11



Assume that X_{IN} is held at a constant logic level throughout the operation of the FSM. When the FSM is initialized to the state Q_AQ_B = 00 and clocked, after a few clock cycle, it starts cycling through

(a) all of the four possible states if X_{IN} = 1

(b) three of the four possible states if X_{IN} = 0

(c) only two of the four possible states if X_{IN} = 1

(d) only two of the four possible states if $X_{IN} = 0$

Sol. (d)

When $X_{IN} = 0$:

	Q_A	Q_B	D_A	D_B
CLK 0	0	0	0	1
CLK 1	0	1	1	1
CLK 2	1	1	0	1
CLK 3	0	1	1	1
⋮	⋮	⋮	⋮	⋮

i.e. output Q_A Q_B starts cycling through only two of the four possible states.

When X_{IN} = 1:

	Q_A	Q_B	D_A	D_B
CLK 0	0	0	0	1
CLK 1	0	1	1	1
CLK 2	1	1	0	0
CLK 3	0	0	0	1
⋮	⋮	⋮	⋮	⋮

i.e. output Q_A Q_B starts cycling though three of the four possible states.

52. Let h[n] be the impulse response of a discrete-time linear time invariant (LTI) filter. The impulse response is given by

$$h[0]=\frac{1}{3}; h[1]=\frac{1}{3}; h[2]=\frac{1}{3}; \text{ and}$$

$$h[n]=0 \text{ for } n<0 \text{ and } n>2.$$

let $H(\omega)$ be the discrete-time Fourier transform (DTFT) of h[n]. where ω is the normalized angular frequency in radians. Given that $H(\omega_0)=0$ and $0<\omega_0<\pi$, the value of ω_0 (in radian) is equal to _______

Sol. (2.094)

$$h(0) = \frac{1}{3};$$

$$h(1) = \frac{1}{3};$$

$$h(2) = \frac{1}{3};$$

and $\quad h[n] = 0$

for and also given that $H(\omega_0) = 0$ and $0 < \omega_0 < \pi$

$$h[n] = \left[\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\right]$$

Since, $\quad h[n] = \frac{1}{3}\delta[n]+\frac{1}{3}\delta[n-1] +\frac{1}{3}\delta[n-2]$

So, $\quad H\left(e^{j\omega}\right) = \frac{1}{3}+\frac{1}{3}e^{-j\omega}+\frac{1}{3}e^{-2j\omega}$

$$= \frac{1}{3}e^{-j\omega}+\frac{1}{3}e^{-j\omega}(e^{j\omega}+e^{-j\omega})$$

$$\left[\frac{e^{j\omega}+e^{-j\omega}}{2}=\cos\omega\right]$$

$$H\left(e^{j\omega}\right) = \frac{1}{3}e^{-j\omega}\left[1+2\cos\omega\right]$$

$$H\left(e^{j\omega_0}\right) = 0 \qquad \text{when}$$

$$\Rightarrow \quad 1 + 2\cos\omega_0 = 0$$

$$\Rightarrow \quad \cos\omega_0 = \frac{-1}{2}$$

$$\Rightarrow \quad \omega_0 = \cos^{-1}\left(\frac{1}{2}\right) = 120°$$

$$= \frac{2\pi}{3} = 2.094 \text{ rad.}$$

53. A half wavelength dipole is kept in the x-y plane and oriented along 45° from the x-axis. Determine the direction of null in the radiation pattern for $0 \le \phi \le \pi$. Here the angle $\theta(0 \le \theta \le \pi)$ is measured from the z-axis, and the angle $\phi(0 \le \phi \le 2\pi.)$ is measured from the x-ais in the x–y plane.

(a) $\theta = 90°, \phi = 45°$

(b) $\theta = 45°, \phi = 90°$

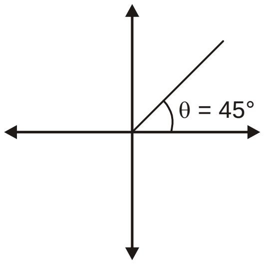
(c) $\theta = 90°,\ \phi = 135°$

(d) $\theta = 45°,\ \phi = 135°$

Sol. (a)

As the antenna is placed is xy-plane which is horizontal plane

$$\text{i.e., } \theta = \frac{\pi}{2}$$



As there is no field along antenna i.e. null along antenna,

$$\theta = 45°$$

as $\quad 0 \le \phi \le \pi$ given

$\therefore$ for the given antenna null is at θ = 90°, ϕ = 45°.

54. Starting with x = 1, the solution of the equation $x^3 + x = 1$, after two iterations of Newton-Raphson's method (upto two decimal places) is _____

Sol. (0.686)

Let,

$$f(x) = x^3 + x - 1$$

$$f'(x) = 3x^2 + 1$$

Using Newton – Raphson formula

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

Starting with $x_n = 1$

$$x_{n+1} = 1 - \frac{f(1)}{f'(1)} = 1 - \frac{1+1-1}{3\times 1+1}$$

$$= 1 - \frac{1}{4} = 0.75$$

Now, $\quad x'_n = 0.75$

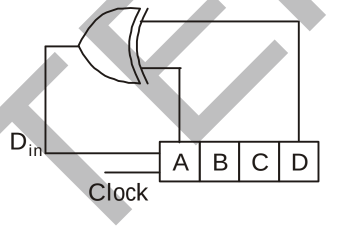
$$x'_{n+1} = 0.75 - \frac{f(0.75)}{f'(0.75)}$$

$$= 0.75 - \frac{(0.75)^3 + (0.75) - 1}{3\times(0.75)^2 + 1}$$

$$= 0.75 - \frac{0.171875}{2.6871}$$

$$= 0.686$$

55. A 4-bit shift register circuit configured for right-shift operation i.e. $D_{in} \to A, A \to B, B \to C, C \to D,$ is shown. If the present state of the shift register is ABCD = 1101, the number of clock cycles required to reach the state ABCD = 1111 is ________



Sol. (10)

CIK	A	B	C	D	$D_{in} = A \oplus D$
0	1	1	0	1	0
1	0	1	1	0	0
2	0	0	1	1	1
3	1	0	0	1	0
4	0	1	0	0	0
5	0	0	1	0	0
6	0	0	0	1	1
7	1	0	0	0	1
8	1	1	0	0	1
9	1	1	1	0	1
10	1	1	1	1	0

← Required State

$\therefore$ The number of Clock Cycles required =10.

Aptitude

1. 40% of deaths on city roads may be attributed to drunken driving. The number of degrees needs to represent this as a slice of a pie chart is

(a) 120

(b) 144

(c) 160

(d) 212

Sol. (b)

In pie-chart, 100% represents 360°

$$\therefore \quad 40\% = \frac{40}{100} \times 360 = 144°$$

2. Some tables are shelves. Some shelves are chains. All chairs are benches. Which of the following conclusions can be deduced from the preceding sentences?

(I) At least one bench is a table

(II) At least one shelf is a bench

(III) At least one shelf is a table

(IV) All benches are chairs

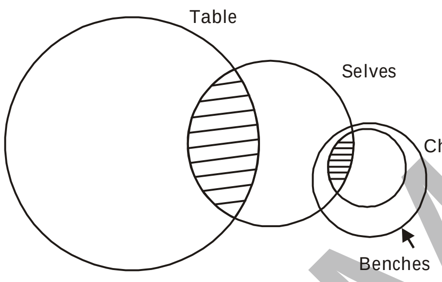
(a) Only I

(b) Only II

(c) Only II and III

(d) Only IV

Sol. (b)



i.e. at least one shelf is a bench.

3. In the summer, water consumption is known to decrease overall by 25%. A Water Board official states that in the summer household consumption decreases by 20% while other consumption increased by 70%.

Which of the following statements is correct?

(a) The ratio of household to other consumption is 8/17

(b) The ratio of household to other consumption is 1/17

(c) The ratio of household to other consumption is 17/8

(d) There are errors in the official's statement.

Sol. (d)

As the household consumption decreases by 20% and other consumption increase by 70% then the overall decrease must be less than 20%.

Hence, there are errors in the official's statement.

4. She has a sharp tongue and it can occasionally turn _________

(a) hurtful (b) left

(c) methodical (d) vital

Sol. (a)

Have a sharp tongue: To be someone who often criticizes and speaks in a severe way.

So, it can occasionally turn hurtful.

5. I _______ made arrangements had I _____ informed earlier.

(a) could have, been

(b) would have, being

(c) had, have

(d) had been, been

Sol. (a)

6. Truck (10 m long) and cars (5 m long) go on a single lane bridge. There must be gap of atleast 20 m after each truck and a gap of at least 15 m after each car. Truck and cars travel at a speed of 36 km/h. If cars and trucks go alternately, what is the maximum number of vehicles that can use the bridge in one hour?

(a) 1440 (b) 1200

(c) 720 (d) 600

Sol. (a)

Let the number of vehicles that can use the bridge in one hour are 2x (i.e. x cars and x trucks).

Speed of Cars and Trucks = 36 Km/h

$$= \frac{36 \times 5}{18} = 10\,\text{m/sec.}$$

$\therefore$ In one hour,

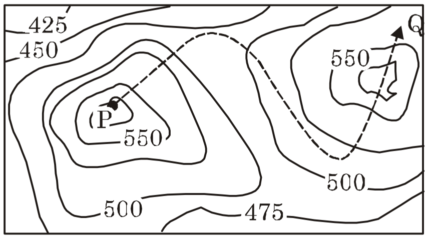
10 × 60 × 60 = (length of Cars + gap after each cars)× x + (length of Truck + gap after each Truck)× x

Or 36000 = (5+15)x+ (10+20)x

Or 50x = 36000

Or 2x = 1440

7. A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25 m intervals in this plot.



The path from P to Q is best described by

(a) Up-Down-Up-Down

(b) Down-Up-Down-Up

(c) Down-Up-Down

(d) Up-Down-Up

Sol. (c)

$$\underbrace{(>500) \rightarrow (550) \rightarrow (500)}_{\text{Down}} \rightarrow$$

$$\underbrace{(500) \rightarrow (550) \rightarrow (>550)}_{\text{Up}} \rightarrow \underbrace{(500) \rightarrow (<500)}_{\text{Down}}$$

8. "If you are looking for a history of India or for an account of the rise and fall of the British Raj, or for the reason of the cleaving of the subcontinent into two mutually antagonistic parts and the effects this mutilation will have in the respective sections, and ultimately on Asia, you will not find it in these pages for though I have spent a lifetime in the country. I lived too near the seat of events, and was too intimately associated with the actors, to get the perspective needed for the impartial recording of these matters".

Here, the word 'antagonistic' is closest in meaning to

(a) impartial

(b) argumentative

(c) separated

(d) hostile

Sol. (*)

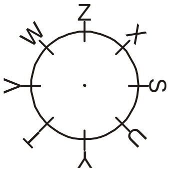
9. S, T, U, V, W, X, Y, and Z are seated around a circular table. T's neighbours are Y and V, Z is seated third to the left of T and second to the right of S. U's neighbours are S and Y; and T and W are not seated opposite each other. Who is third to the left of V?

(a) X (b) W

(c) U (d) T

Sol. (a)

The seating arrangement of different people according to questions is shown below



$\therefore$ X is third to the left of V.

10. There are 3 Indians and 3 Chinese in a group of 6 people. How many subgroups of this group can we choose so that every subgroup has at least one Indian?

(a) 56 (b) 52

(c) 48 (d) 44

Sol. (a)

The total number of required subgroups

$$= \left({}^3C_1 + {}^3C_2 + {}^3C_3\right) \times \left({}^3C_0 + {}^3C_1 + {}^3C_2 + {}^3C_3\right)$$

$$= (2^3 - 1)\ (2^3)$$

$$= 7 \times 8$$

$$= 56.$$