GATE 2024

ELECTRONICS ENGINEERING

Exam held on
11/02/2024
(Forenoon Session)

Memory based
Questions & Solutions

Corporate Office : 44-A/1, Kalu Sarai, New Delhi - 110016
MADE EASY Centres : • Delhi • Hyderabad • Bhopal • Jaipur • Pune • Kolkata
9021300500
www.madeeasy.in

SECTION - A GENERAL APTITUDE

Q.1 Highest prime factor of $3^{199} - 3^{196}$ is _____.

(a) 3 (b) 17

(c) 13 (d) 11

Ans. (c)

$$= 3^{196}(3^3 - 1) = 3^{196} \times 26 = 2 \times 3^{196} \times 13$$

Highest prime factors = 13

End of Solution

Q.2 $\dfrac{1}{\log_2 x} + \dfrac{1}{\log_3 x} + \dfrac{1}{\log_4 x} = 1$

If $x > 1$, then value of x is ____

(a) 4 (b) 12

(c) 24 (d) 36

Ans. (c)

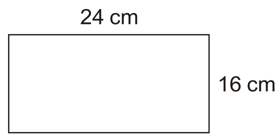
$$\log_x^2 + \log_x^3 + \log_x^4 = 1$$

$$\log_x^{24} = 1$$

$$x = 24$$

End of Solution

Q.3 For the given rectangular sheet



Condition 1 : Paper fold parallel to longer side two times.
Condition 2 : Paper fold parallel to smaller side two times.
Ratio of perimeter of condition 1 to condition 2.

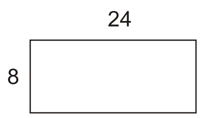
(a) 16 : 18 (b) 11 : 14

(c) 14 : 11 (d) 18 : 16

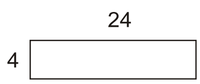
Ans. (C)

Condition 1:

Folding first time



Folding first time



$$\text{Perimeter} = 2(24 + 4) = 56 \text{ cm}$$

MADE EASY

Announcing

FOUNDATION COURSE

For ESE+GATE 2025 • GATE 2025

The foundation batches are taught comprehensively which cover the requirements of all technical-syllabus based examinations.

- Classes by experienced & renowned faculties.
- Similar teaching pedagogy in offline & online classes.
- Systematic subject sequence.
- Efficient teaching with comprehensive coverage.
- Exam oriented learning ecosystem.
- Interaction facility for doubt removal.
- Time bound syllabus completion.
- Concept of problems solving through workbooks.
- Comprehensive & updated study material.
- Regular performance assessment through class tests.

OFFLINE BATCHES AT DELHI

Commencing from

- **CE :** 15th Feb & 26th Feb
- **ME :** 15th Feb & 29th Feb
- **EE, EC & IN :** 15th Feb & 29th Feb
- **CS :** 15th Feb & 5th Mar

www.madeeasy.in 9021300500

LIVE-ONLINE BATCHES

Commencing from

Evening Batches : Hinglish

- **CE :** 20th Feb
- **ME :** 20th Feb
- **EE/EC/IN :** 20th Feb
- **CS :** 20th Feb

Evening Batches

English : 20th Feb

Morning Batches

Hinglish : 22nd Feb

Stream : CE

www.madeeasyprime.com 9021300500

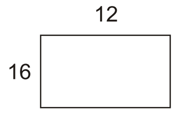
Low Cost EMI Facility Available | **Admissions open**

Delhi Centre : 44-A/1, Kalu Sarai, Near Hauz Khas Metro Station, New Delhi - 110016 | **Ph :** 9021300500

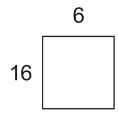
MADE EASY Centres : Delhi | Bhopal | Hyderabad | Jaipur | Kolkata | Pune | www.madeeasy.in

Condition 2:

Folding first time



Folding second time



$$\text{Perimeter} = 2(16 + 6) = 44 \text{ cm}$$

$$\text{Ratio} = 56 : 44 = 14 : 11$$

End of Solution

Q.4 Five years ago, son's and father's age ratio was 1 : 4. After five years the ratio is 2 : 5. Find the father age at the birth of son.

(a) 30 years
(b) 36 years
(c) 28 years
(d) 32 years

Ans. (a)

Five year ago

$$\text{Son's age} = x$$

$$\text{Father's age} = 4x$$

Five year after

$$\text{Son's age} = x + 10$$

$$\frac{x+10}{4x+10} = \frac{2}{5}$$

$$5x + 50 = 8x + 20$$

$$3x = 30$$

$$x = 10$$

Son's age five year ago = 10

Father's age five year age = 40

At the time of son's birth father's age = 40 – 10 = 30 year

End of Solution

Q.5 P, Q, R, S and T have launched a new startup. Two of the team are sibling. The office of the startup has just three rooms. All of them agree that the sibling should not share the same room If S and Q are single children and PR TS Q PQ RT S. Then which one of the given options is the sibling.

PR	TS	Q

PQ	RT	S

(a) T and Q
(b) T and S
(c) T and R
(d) P and T

Ans. (d)

End of Solution

■■■■

SECTION - B TECHNICAL

SIGNALS AND SYSTEMS

Q.1 For the given Causal LTI System,

Transfer function $$H(z) = \frac{2z^2+3}{\left(z+\frac{1}{3}\right)\left(z-\frac{1}{3}\right)}$$

which of the following statement(s) is/are correct?

(a) System is minimum phase

(b) Final value of impulse response is 0

(c) Initial value of impulse response is 2

(d) System is stable

Ans. **(b, c, d)**

Given: $$H(z) = \frac{2z^2+3}{\left(z+\frac{1}{3}\right)\left(z-\frac{1}{3}\right)}$$

System is non-minimum phase system. Since zero are lying outside the unit circle.

Final value: $$h(\infty) = \lim_{z\to 1}(z-1)\frac{2z^2+3}{\left(z+\frac{1}{3}\right)\left(z-\frac{1}{3}\right)} = 0$$

Initial value: $$h(0) = \lim_{z\to\infty}\frac{(2z^2+3)}{\left(z+\frac{1}{3}\right)\left(z-\frac{1}{3}\right)} = \lim_{z\to\infty}\frac{z^2\left[2+\frac{3}{z^2}\right]}{z^2\left[1+\frac{1}{3z}\right]\left[1-\frac{1}{3z}\right]}$$

$$= \lim_{z\to\infty}\frac{\left[2+\frac{3}{z^2}\right]}{\left[1+\frac{1}{3z}\right]\left[1-\frac{1}{3z}\right]} = \frac{2}{1\times 1} = 2$$

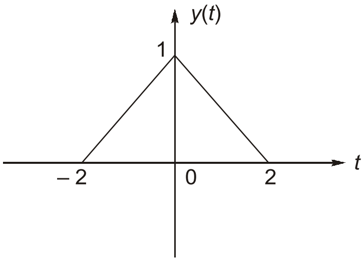
$$z = -\frac{1}{3},\ z = \frac{1}{3}$$

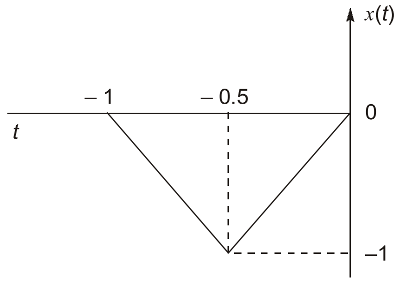
$$|z| = \frac{1}{3} = 0.33$$

System is stable. Since $|\text{pole}| < 1$ i.e. pole are lying inside the unit circle.

End of Solution

Q.2 For the given $x(t)$ and $y(t)$.





If $x(t) \leftrightarrow X(f)$ and $y(t) \leftrightarrow Y(f)$. Find $Y(f)$ in terms of $X(f)$.

(a) $-\frac{1}{4}X(4f)e^{-jf\pi}$

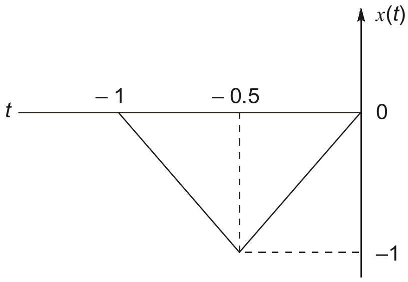
(b) $-4X\left(\frac{f}{4}\right)e^{-j4\pi f}$

(c) $-4X(4f)e^{-j4\pi f}$

(d) $-4X\left(\frac{f}{4}\right)e^{-j4\pi f}$

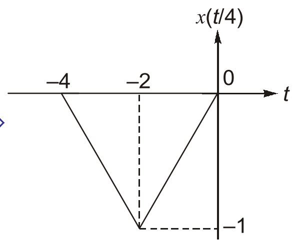
Ans. (c)

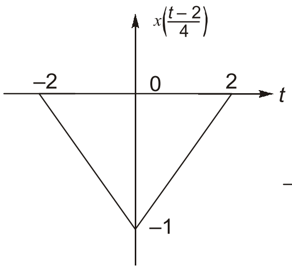
Given:

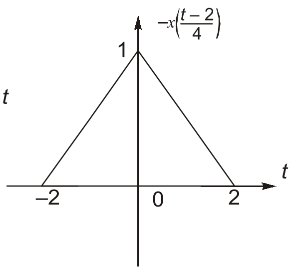


Length of $x(t)$ is 1 and length of $y(t)$ is 4.

$\Rightarrow$







$\therefore$
$$y(t) = -x\left(\frac{t-2}{4}\right)$$

$$y(t) = -x\left(\frac{t}{4}-\frac{2}{4}\right) = -x\left(\frac{t}{4}-\frac{1}{2}\right)$$

On taking Fourier transform, we get

$x(t) \leftrightarrow X(f)$

$$x\left(\frac{t}{4}-\frac{1}{2}\right) \leftrightarrow 4X(4f)e^{-j4\pi f}$$

$$-x\left(\frac{t}{4}-\frac{1}{2}\right) \leftrightarrow -4X(4f)e^{-j4\pi f}$$

End of Solution

Q.3 Causal and stable LTI system with impulse response $h(t)$ produces output $y(t)$ for input $x(t)$.

A signal $x(0.5t)$ is applied to another Causal and Stable LTI system with impulse response $h(0.5t)$, output $y(t)$ is?

(a) $4y(0.5t)$ (b) $2y(0.5t)$

(c) $0.25y(0.25t)$ (d) $0.25y(0.5t)$

Ans. **(b)**

$$y(t) = x(t) * h(t)$$

$x(t) \leftrightarrow X(\omega)$

$$x(0.5t) \leftrightarrow 2X(2\omega)$$

$$h(0.5t) \leftrightarrow 2H(2\omega)$$

$$y(t) \leftrightarrow Y(\omega)$$

$$Y(\omega) \leftrightarrow X(\omega) \times H(\omega)$$

After scaling, $Y_1(\omega) = 2X(2\omega) \times 2H(2\omega)$

$$= 4X(2\omega) \times H(2\omega)$$

After taking inverser Fourier transform

$$y_1(t) = 2y(0.5t)$$

End of Solution

Q.4 If $y(n)$ = DFT (DFT(DFT(DFT($x(n)$)))) and $x(n)$ = {1, 1, 2, 3}, then find $y(0)$ is ____.

Ans. **(16)**

$$y(n) = \text{DFT DFT DFT DFT } \{x(n)\}$$

$$x(n) \xrightarrow{\text{2 times DFT}} Nx(-n) \xrightarrow{\text{2 times DFT}} N^2 x(n)$$

$$y(n) = N^2\{x(n)\} = 16\, x(n)$$

$$= \{16, 16, 32, 48\}$$

$$y(0) = 16$$

End of Solution

Q.5 If $x(t) = 2\cos\left(8\pi t + \frac{\pi}{3}\right)$ as input signal to an LTI system $x(t)$ sample at rate 15 Hz then $x_s(t)$. $x_s(t)$ pass through $h(t) = \frac{\sin 2\pi t}{\pi t}\cos\left(38\pi t - \frac{\pi}{2}\right)$. The output $x_o(t)$ of LTI system is equal to

(a) $15\cos\left(38\pi t - \frac{\pi}{6}\right)$ (b) $15\cos\left(38\pi t + \frac{\pi}{3}\right)$

(c) $15\sin\left(38\pi - \frac{\pi}{3}\right)$ (d) $15\sin\left(38\pi t + \frac{\pi}{6}\right)$

Ans. (a)

$$x(t) = 2\cos\left(8\pi t + \frac{\pi}{3}\right), \quad \omega_o = 8\pi$$

$$f_s = 15 \text{ Hz}$$

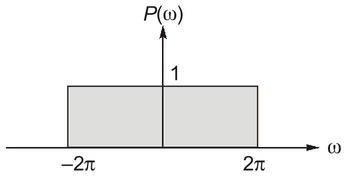
$$x(t) \xrightarrow{\text{sample}} x_s(t) \xrightarrow{h(t)} x_o(t)$$

$$\Rightarrow \quad h(t) = \frac{\sin 2\pi t}{\pi t}\cos\left(38\pi t - \frac{\pi}{2}\right)$$

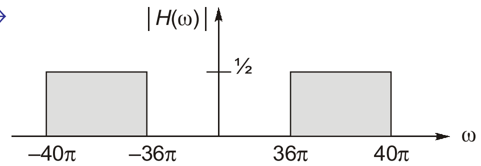
Let $p(t) = \dfrac{\sin 2\pi t}{\pi t}$

$$h(t) = p(t)\cos\left(38\pi t - \frac{\pi}{2}\right)$$

$$p(t) = \frac{\sin 2\pi t}{\pi t} \leftrightarrow$$



$$h(t) = p(t)\cos\left(38\pi t - \frac{\pi}{2}\right) \leftrightarrow$$



After sampling: $X_s(\omega) = f_s \sum_{n=-\infty}^{\infty} X(\omega - n\omega_s)$

Frequency components present in sampler output $n\omega_s \pm \omega_o$

ω_o, $\omega_s + \pm \omega_o$, $2\omega_s \pm \omega_o$, ...

8π, $30\pi \pm 8\pi$, $60\pi \pm 8\pi$, ...

8π, 22π, 38π, 52p, 68π, ... (rad/sec)

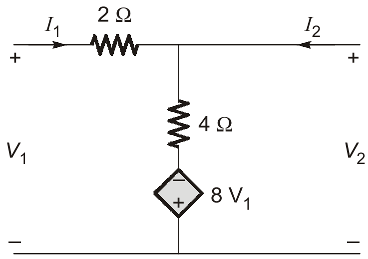
System will pass '38π' component of input.

$$x_o(t) = 2 \times \frac{f_s}{2}\cos\left[38\pi t + \frac{\pi}{3} - \frac{\pi}{2}\right] = 15\cos\left(38\pi t - \frac{\pi}{6}\right)$$

End of Solution

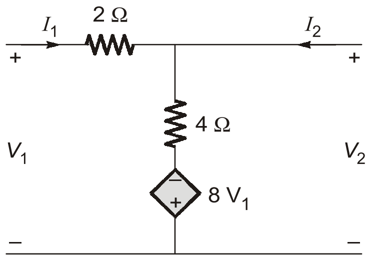
NETWORK THEORY

Q.6 For the 2-port network shown in figure, the parameter Y_{21} is ________.

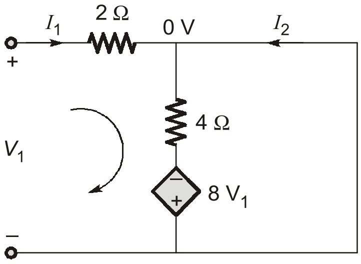


Ans. (1.5)

Given two-port network,



$$Y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0}$$



by applying KVL in the loop,

$$V_1 - 2I_1 - 4(I_1 + I_2) + 8V_1 = 0$$

$$9V_1 - 6I_1 - 4I_2 = 0$$

but $\quad I_1 = \dfrac{V_1 - 0}{2} \Rightarrow \dfrac{V_1}{2} = I_1$

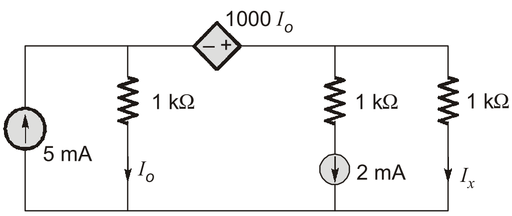
$$\therefore \quad 9V_1 - 6\left(\frac{V_1}{2}\right) - 4I_2 = 0$$

$$6V_1 = 4I_2$$

$$\therefore \quad \frac{I_2}{V_1} = \frac{6}{4} = \frac{3}{2} = 1.5 \text{ ℧}$$

End of Solution

Q.7 Calculate the value of I_x from the circuit shown below.



Ans. (2)

V_1 and V_2 are super node. KCL at V_1 and V_2.

$$\frac{V_1}{10^3} + \frac{V_2}{1\times10^3} + 2\times10^{-3} = 5 \times 10^{-3} \qquad \text{...(1)}$$

$$I_0 = \frac{V_1}{10^3}$$

$$V_2 - V_1 = 10^3 I_0 = 10^3 \times \frac{V_1}{10^3} = V_1$$

$$V_2 = 2V_1$$

$$V_1 = \frac{V_2}{2} \quad ...(ii)$$

Put in equation (i)

$$\frac{1}{2}V_2 + V_2 = 3$$

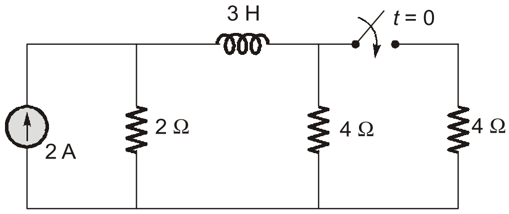
$$V_2 = 2 \text{ V}$$

$$I_x = \frac{V_2}{10^3} = 2 \text{ mA}$$

$$I_x = 2 \text{ mA}$$

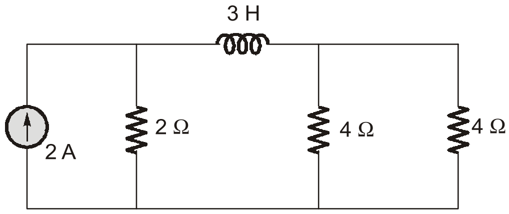
End of Solution

Q.8 For the circuit shown in the figure, the value of time constant (τ) is ________.

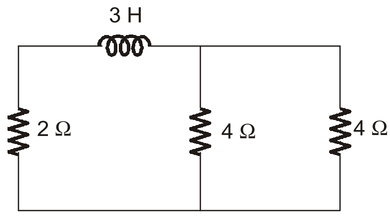


Ans. (0.75)

After the switch closed



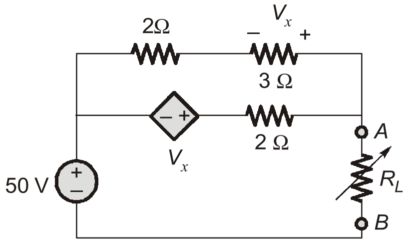
For time constant, current source is open circuit.



$$\therefore \quad \tau = \frac{L_{eq}}{R_{eq}} = \frac{3}{2+2} = \frac{3}{4} = 0.75 \text{ sec}$$

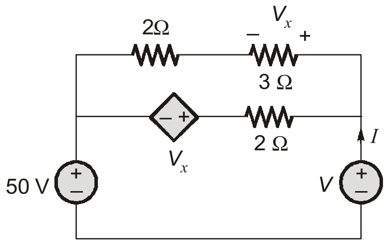
End of Solution

Q.9 Consider the network shown below :



Find R_L such that maximum power absorbed by load is ________ Ω.

Ans. (2.5)



$$I = \frac{V - V_x}{2} + \frac{V}{5} = \frac{V}{2} - \frac{V_x}{2} + \frac{V}{5}$$

But, $$V_x = \frac{V}{5} \times 3$$

∴ $$I = \frac{V}{2} - \frac{1}{2} \times \frac{3V}{5} + \frac{V}{5} = \frac{V}{2} - \frac{3V}{10} + \frac{V}{5}$$

$$I = \frac{5V - 3V + 2V}{10} = \frac{4V}{10}$$

∴ $$\frac{V}{I} = \frac{10}{4} = 2.5\ \Omega$$

End of Solution

ENGINEERING MATHEMATICS

Q.10 If $y(t) = (At + B)e^{-2t}$ is complementary function of differential equation. The differential equation then find it.

(a) $\frac{d^2y}{dx^2} + 5\frac{dy}{dx} + 6y = f(t)$

(b) $\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = f(t)$

(c) $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + 1 = f(t)$

(d) $\frac{d^2y}{dx^2} + 2\frac{dy}{dx} - 1 = f(t)$

Ans. (b)

$\because$ Given $\quad CF = (At + B)e^{-2t} \approx (C_1 + C_2 t)e^{-2t}$

i.e. roots of auxiliary equation are $m = -2, -2$

So, AE is $(m + 2)(m + 2) = 0$

$$m^2 + 4m + 4 = 0$$

Replace $m \rightarrow D$ we get,

$$(D^2 + 4D + 4)y = 0$$

i.e. the required different

$$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = f(t)$$

End of Solution

Q.11 The value of $\oint_{|z|=3} \frac{\sin \pi z}{z^2(z-2)} dz$?

(a) $-\pi^2 i$
(b) $2\pi^2 i$
(c) $-2\pi^2 i$
(d) $0.5\pi^2 i$

Ans. (a)

Poles of $f(z)$ are $z = \underset{\text{simple pole}}{2}$ and $\underset{\text{Double pole}}{0}$

R_1 = Residue of $f(z)$ = at $(z = 2)$

$$= \lim_{z \to 2} \cdot (z-2) f(z) = \lim_{z \to 2} \cdot \left(\frac{\sin \pi z}{z^2} \right) = 0$$

R_2 = Residue of $f(z)$ (at($z = 0$, $m = 2$)

$$R_2 = \frac{1}{\lfloor 2-1} \left[\frac{d^{2-1}}{dz^{2-1}} (z-0)^2 f(z) \right]_{z=0}$$

$$\left[\frac{d}{dz} \left[\frac{\sin \pi z}{z-2} \right] \right]_{z=0} = \left[\frac{(z-2)\cos \pi z(\pi) - \sin \pi z}{(z-2)^2} \right]_{z=0}$$

$$= \frac{(0-2)\cos(2\pi) \cdot \pi - \sin 0}{(0-2)^2} = \frac{-2\pi}{4} = \frac{-\pi}{2}$$

By C –R.T,

$$I = \oint_c f(z) dz = 2\pi i (R_1 + R_2)$$

$$= 2\pi i \left(0 - \frac{\pi}{2} \right) = -\pi^2 i$$

End of Solution

Q.12 Eigen vectors of the matrix $\begin{bmatrix} 1 & K \\ 2 & 1 \end{bmatrix}$ are

(a) x
(b) x
(c) x
(d) x

Ans. **(*)MSQ**

C Eq is $\quad |A-\lambda I| = 0$

or $\quad \lambda^2 - 2\lambda + (1 - 2K) = 0$

$$\lambda = 1 \pm \sqrt{2K}$$

E vector for $\lambda = 1 \pm \sqrt{2K}$:

$$AX = \lambda X$$

$$(A - \lambda I)X = 0$$

$$\begin{bmatrix} -\sqrt{2K} & K \\ 2 & -\sqrt{2K} \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$\Rightarrow \quad -\sqrt{2K}\,x_1 + Kx_2 = 0$

or $\quad x_1 = \sqrt{\frac{K}{2}}x_2$

$$X = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \sqrt{K/2} \\ 1 \end{bmatrix} \approx \begin{bmatrix} 1 \\ \sqrt{\frac{2}{K}} \end{bmatrix}$$

Similarly other E vector is

$$X = \begin{bmatrix} -\sqrt{\frac{K}{2}} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -\sqrt{\frac{2}{K}} \end{bmatrix}$$

End of Solution

Q.13 The following vectors do not forms basis for any vector space then find a = ?
(2 –3 a), (3 –1 3), (1 – 5 7)

(a) 5
(b) 8
(c) 7
(d) 9

Ans. **(a)**

$\because$ given vectors form basis so there must be L.I and its condition is,

$$|A| \neq 0$$

or
$$\begin{vmatrix} 2 & 3 & 1 \\ -3 & -1 & -5 \\ a & 3 & 7 \end{vmatrix} \neq 0$$

$$2[-7 + 15] - 3[-21 + 5a] + 1[-9 + a] \neq 0$$
$$16 + 63 - 15a - 9 + a \neq 0$$
$$-14a \neq -70$$
$$\Rightarrow \quad a \neq 5$$

End of Solution

Q.14 Consider the equation $\frac{\partial \rho}{\partial t} + \vec{\nabla}\cdot(\rho\vec{u}) = 0$ where ρ is scalar function of (x, y, z, t) and $\vec{u}$ is vector function (x, y, z, t) then which are true?

(a) $\int_V \frac{\partial \rho}{\partial t} dV = -\int_V \vec{\nabla}\cdot(\rho\vec{u})dV$

(b) $\int \frac{\partial \rho}{\partial t} dV = \int_S \rho(\vec{u})\hat{n}ds$

(c) $\int_V \frac{\partial \rho}{\partial t} dV = -\int_S \rho\vec{u}\cdot(\hat{n}ds)$

(d) $\int_V \frac{\partial \rho}{\partial t} dV = \int_S \vec{\nabla}\cdot(\rho\vec{u})ds$

Ans. **(c)**

Option (a) is obviously true by given statement

Now using Gauss Divergence theorem in RHS of (a) i.e

$$\int_V \frac{\partial P}{\partial t} dV = -\int_V \vec{\nabla}\cdot(\rho\vec{u})dV = -\int_S (\rho\vec{u})\cdot d\vec{s} = -\int_S (\rho\vec{u})\cdot\hat{n}d\vec{s}$$

Hence option (c) is correct.

End of Solution

ELECTRONIC DEVICES AND CIRCUITS

Q.15 In a solar cell, voltage corresponds to maximum voltage point is 0.3 V. The photocurrent is 1 mA. The thermal voltage is 30 mV. then find the reverse saturation current ____ (nA).

Ans. **(45.3)**

$$V_{oc} = 0.3 \text{ V}$$
$$I_{ph} = I_{sc} = 1 \text{ mA}$$
$$V_{th} = 30 \text{ mV}$$
$$V_{OC} = V_{th} \ln\left(1 + \frac{I_{sc}}{I_s}\right)$$
$$V_{OC} \simeq V_{th} \ln\left(\frac{I_{sc}}{I_s}\right)$$
$$e^{\frac{V_{OC}}{V_{th}}} = \frac{I_{sc}}{I_s}$$
$$e^{\frac{0.3}{30\times10^{-3}}} = \frac{10^{-3}}{I_s}$$
$$I_s = 45.30 \text{ nA}$$

End of Solution

Q.16 P-substrate MOS capacitor with t_{ox} (oxide thickness) = 100 nm and Q_{OX} (oxide charge) = 10^{-8} C/cm^2 Work function energy of metal $q\phi_m = 4.6$ eV, $\varepsilon_{ox} = 4\varepsilon_0$, $\varepsilon_0 = 8.85 \times 10^{-14}$ F/cm. If flat band voltage is zero then work function energy of semiconductor is _______eV.

Ans. (4.32)

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{4 \times 8.85 \times 10^{-14}}{100 \times 10^{-9} \times 100}$$

$$= 4 \times 8.85 \times 10^{-14} \times 10^{5} = 35.4 \times 10^{-9} \text{ F/cm}^2$$

$$V_{FB} = \frac{Q_{ox}}{C_{ox}} + \phi_{ms}$$

$$0 = \frac{Q_{ox}}{C_{ox}} + \phi_{ms}$$

$$\frac{Q_{ox}}{C_{ox}} = \frac{10^{-8}}{35.4 \times 10^{-9}} = \frac{10}{35.4} \text{ volt}$$

$Q_{ox} \rightarrow$ Positive

$\therefore \quad \frac{Q_{ox}}{C_{ox}} \rightarrow$ Negative

$$0 = \frac{-10}{35.4} + \phi_{ms}$$

$$\phi_{ms} = \frac{10}{35.4}$$

$$\phi_m - \phi_s = \frac{10}{35.4}$$

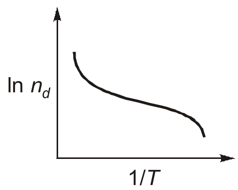
$$\phi_s = \phi_m - \frac{10}{35.4} = 4.6 - \frac{10}{35.4} = 4.317 \text{ volt}$$

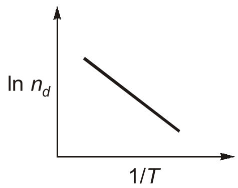
$\therefore \quad q\phi_s = 4.317 \simeq 4.32$ eV

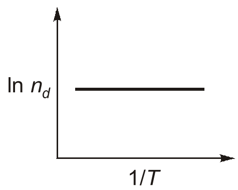
Work function energy of semiconductor.

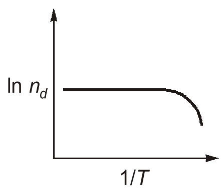
End of Solution

Q.17 For a n-type semiconductor, the doping concentration graph with temperature is given as

(a) 

(b) 

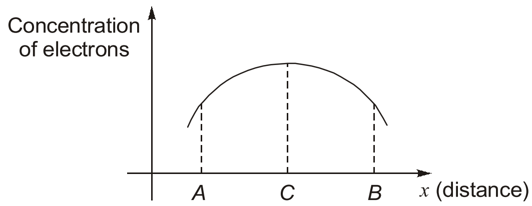
(c) 

(d) 

Ans. (a)

End of Solution

Q.18 In a semiconductor the concentration graph with the distance x is given then which of the following option(s) is/are correct?



(a) In between B and C, the diffusion current is from C to B.
(b) In between B and C, the diffusion current is from B to C.
(c) In between A and C, the drift current is from A to C.
(d) In between A and C, the electric field is from C to A.

Ans. (b, d)

End of Solution

Q.19 Which of the following option(s) is/are correct?
(a) In low level injection the β decreases with increases collector current.
(b) In high level injection the β decreases with increases collector current.
(c) β in saturation region is less than in active region.
(d) β decreases with increases breakdown collector emitter voltage.

Ans. (b, c)

End of Solution

Q.20 MOS is in linear region with operating point I_{DS} = 5 μA and V_{DS} = 0.1 volt, $\mu_n C_{ox}\frac{W}{L}$ = 50 μA/V². when V_{GS} = constant and V_{DS} = 1.5 V, then find it's transconductance at operating point ______ μA/V.

Ans. (52.5)
For linear region of MOS,

$$I_D = \mu_n C_{ox}\left(\frac{W}{L}\right)\left[(V_{GS}-V_T)V_{DS}-\frac{1}{2}V_{DS}^2\right]$$

$$5\times10^{-6} = 50\times10^{-6}\left[(V_{GS}-V_T)0.1-\frac{1}{2}(0.1)^2\right]$$

$$\frac{1}{10} = (V_{GS}-V_T)0.1-\frac{1}{2}\times0.1^2$$

$$0.1+0.5(0.1)^2 = (V_{GS}-V_T)0.1$$

$$1+0.5(0.1) = (V_{GS}-V_T)$$

$$1.05\text{ volt} = V_{GS}-V_T$$

Now: $V_{GS}\to$ fix

$$V_{DS} = 1.5$$

$V_{DS} > V_{GS}-V_T \Rightarrow$ MOS is in saturation

$$g_{m\,(sat)} = \mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_T)$$
$$= 50 \times 10^{-6} \times 1.05$$
$$= 52.5 \times 10^{-6} \text{ A/V} = 52.5 \ \mu\text{A/V}$$

End of Solution

ELECTROMAGNETICS

Q.21 $\bar{E} = A_y e^{-j\frac{2\pi}{3}x}\hat{a}_y$ is travelling in air in +ve x direction is incident on perfect conductor normally at $x = 0$. Value of x where magnetic field is zero for first time.

(a) $-\frac{3}{2}$

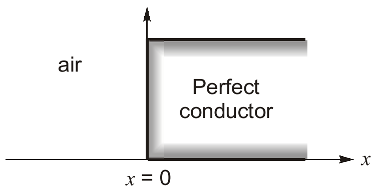
(b) $-\frac{3}{4}$

(c) -6

(d) -2.5

Ans. (b)

At perfect conductor,



$$\Gamma = -1$$
$$\Rightarrow \quad \Gamma = 1\angle\pi$$

As we know that H_{min} occurs at E_{max}.

Hence, $E_{max} = E_0[1 + |\Gamma|]$

$$H_{min} = \frac{E_0}{\eta}[1+|\Gamma|] \text{ at } 2\beta x_{max} = 2n\pi + \theta_\Gamma$$

So, $2\beta x_{max} = 2n\pi + \theta_\Gamma$

$$\Rightarrow \quad \frac{4\pi}{\lambda}x_{max} = 2n\pi + \pi$$

$$\Rightarrow \quad x_{max} = (2n+1)\frac{\lambda}{4}; \quad n = 0, 1, 2, 3...$$

So, for 1st value of x for H-field to be zero is

$$x_{max} = \frac{\lambda}{4} \quad [\text{at } n = 0]$$

Now, from the equation given,

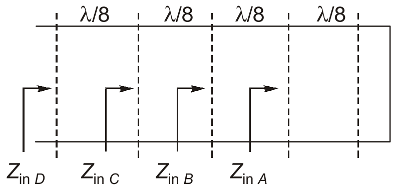
$$\beta = \frac{2\pi}{3}$$
$$\Rightarrow \quad \frac{2\pi}{\lambda} = \frac{2\pi}{3}$$
$$\Rightarrow \quad \lambda = 3$$

Hence, $x_{max} = \frac{3}{4}$

If the reference is not at interference then $x = -\frac{3}{4}$.

End of Solution

Q.22 The load impedance is short circuited.

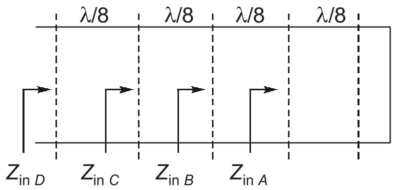


Normalised impedance

$\bar{Z}_{in\,A}, \bar{Z}_{in\,B}, \bar{Z}_{in\,C}, \bar{Z}_{in\,D}$?

	Z_{inA}	Z_{inB}	Z_{inC}	Z_{inD}
(a)	$1j$	∞	$-1j$	0
(b)	$0.4j$	∞	$-0.4j$	0
(c)	∞	$1j$	0	$-1j$
(d)	∞	$0.4j$	0	$-0.4j$

Ans. **(a)**



$Z_{s/c} = jZ_o \tan \beta l.$

$\Rightarrow$ Normalized impedance,

$$\bar{Z}_{S/C} = \frac{Z_{S/C}}{Z_0} = j\tan\beta l$$

$$\bar{Z}_{in\,A} = j\tan\left(\frac{2\pi}{\lambda}\cdot\frac{\lambda}{8}\right) = j\tan(\pi/4) = j1.$$

$$\bar{Z}_{in\,B} = j\tan\left(\frac{2\pi}{\lambda}\cdot\frac{\lambda}{4}\right) = \infty$$

$$\bar{Z}_{in\,C} = j\tan\left(\frac{2\pi}{\lambda}\cdot\frac{3\lambda}{8}\right) = -j\,1$$

$$\bar{Z}_{in\,D} = j\tan\left(\frac{2\pi}{\lambda}\cdot\frac{\lambda}{2}\right) = 0$$

End of Solution

Q.23 A lossless transmission line, $Z_0 = 50\ \Omega$ terminated with unknown load.

$|\Gamma| = 0.6$

As one moves towards generator from the load, max. value of input impedance magnitude looking towards the load is ______ Ω.

Ans. (200)

As we know that

$$Z_{max} = SZ_0$$

Now,

$$S = \frac{1+|\Gamma|}{1-|\Gamma|} = \frac{1+0.6}{1-0.6} = \frac{1.6}{0.4} = 4$$

$\therefore$ $$Z_{max} = 4 \times 50 = 200\ \Omega.$$

End of Solution

Q.24 For the given,

$\vec{F}_1 = A(y\hat{i} + x\hat{j})$ and $\vec{F}_2 = A(y\hat{i} - x\hat{j})$, then which is electrostatic field?

(a) Both $\vec{F}_1$ and $\vec{F}_2$

(b) $\vec{F}_1$ is electrostatic not $\vec{F}_2$

(c) $\vec{F}_1$ is not and $\vec{F}_2$ is electrostatic

(d) Neither $\vec{F}_1$ nor $\vec{F}_2$

Ans. (b)

For an electrostatic field, $\nabla \times \bar{F} = 0$

$$\bar{F}_1 = A\left[y\hat{i} + x\hat{j}\right]$$

$$\Rightarrow \quad \Delta \times \bar{F}_1 = A\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ y & x & 0 \end{vmatrix}$$

$$= A\left[0\hat{i} - 0\hat{j} + (1-1)\hat{k}\right]$$

$$= 0$$

$$\bar{F}_2 = A\left[y\hat{i} - x\hat{j}\right]$$

$$\Rightarrow \quad \Delta \times \bar{F}_2 = A\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ y & -x & 0 \end{vmatrix}$$

$$= A\left[0\hat{i} - 0\hat{j} + (-1-1)\hat{k}\right]$$

$$= -2A\hat{k}$$

Hence, $\bar{F}_1$ is electrostatic, $\bar{F}_2$ is not electrostatic (*b*)

End of Solution

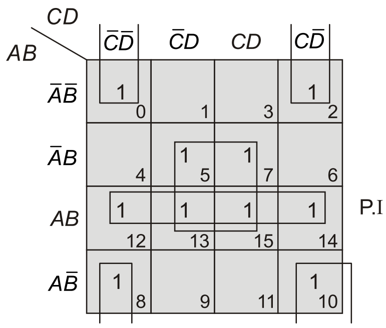
DIGITAL CIRCUITS

Q.25 F = $\Sigma m(0.2, 5, 7, 8, 10, 12, 13, 14, 15)$, then Essential prime implicants are

(a) $BD, \bar{B}\bar{D}$
(b) $AB, \bar{B}\bar{D}$
(c) BD, AB
(d) $BD, \bar{B}\bar{D}, AB$

Ans. (a)

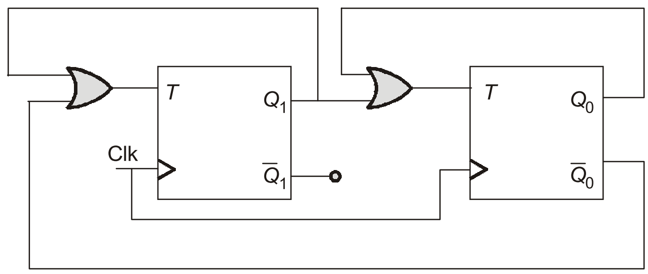
$f(A, B, C, D) = \Sigma m(0.2, 5, 7, 8, 10, 12, 13, 14, 15)$



BD E.P.I $\quad \bar{B}\bar{D}$ E.P.I

End of Solution

Q.26 Consider the sequential circuit :



The sequence of Q_1Q_0 is

(a) 11 → 00 → 10 → 01
(b) 00 → 10 → 01 → 00
(c) 00 → 01 → 10 → 00
(d) 01 → 10 → 11 → 01

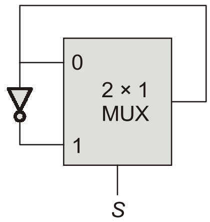
Ans. (b)

clk	T_1 ($Q_1 + \bar{Q}_0$)	T_0 ($Q_1 + Q_0$)	Q_1	Q_0
			0	0
	1	0	1	0
	1	1	0	1
	0	1	0	0

00 → 10 → 01 → 00

End of Solution

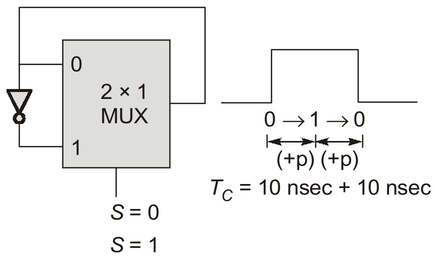
Q.27 Given MUX delay –10 ns



If S is select 1 then Y is

(a) constant 1
(b) 100 MHz
(c) 50 MHz
(d) Zero

Ans. (c)



For $S = 1$, $T_C = 20$ nsec

$$f_c = \frac{1}{20}\times 10^9 = 0.05 \times 10^6 \times 10^3 = 50 \text{ MHz}$$

End of Solution

CONTROL SYSTEMS

Q.28 40 dB/dec is similar to

(a) 12 dB/oct
(b) 6 dB/oct
(c) 10 dB/oct
(d) 5 dB/oct

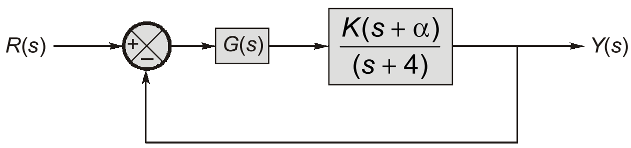
Ans. (a)

$20 \times n$dB/decade = $6 \times n$ dB/octave

40dB/decade = 12 dB/octave

End of Solution

Q.29 For the system shown below, where input $R(s) = \frac{1}{s^2}$, for poles are present at $-1 \pm j\sqrt{3}$, then find the value of α.



(a) 0
(b) 1
(c) 2
(d) 3

Ans. (b)

$$G(S)C(s) = \frac{1}{S^2}\frac{k(S+\alpha)}{(S+4)}$$

Characteristic equation is

$$S^3 + 4S^2 + kS + \alpha = 0 \qquad \text{...(I)}$$

Poles of the system present at $= -1 \pm j\sqrt{3}$

Characteristic equation is

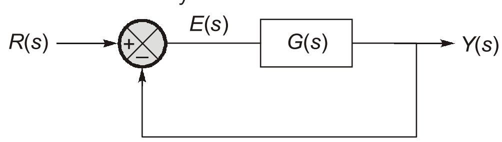
$$(S + a)[(S + 1)^2 + 3] = 0$$
$$(S + a)(S^2 + 2S + 4) = 0$$
$$S^3 + (2 + a)S^2 + (4 + 2a)S + 4a = 0 \qquad \text{...(II)}$$

Compare equation (I) and (II)

$$2 + a = 4$$
$$a = 2$$
$$4 + 2a = k$$
$$k = 8$$
$$k\alpha = 4a$$
$$\alpha = \frac{8}{8} = 1$$
$$\alpha = 1$$

End of Solution

Q.30 Consider the feedback control system shown below :



where $$G(s) = \frac{6}{s(s+1)(s+2)}$$

If $r(t) = u(t)$, then $e(t)$ is equal to

(a) $\lim_{t\to\infty} e(t) = \frac{1}{3}$

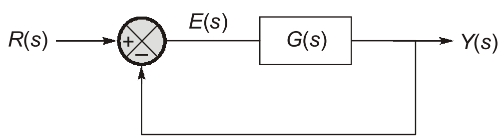
(b) $\lim_{t\to\infty} e(t) = 0$

(c) $\lim_{t\to\infty} e(t) = \frac{1}{4}$

(d) Not exist because $e(t)$ is oscillatory.

Ans. (d)

Given system is



$$G(s) = \frac{6}{s(s+1)(s+2)}$$

The characteristic equation,

$$1 + G(s) = 0$$

$$1 + \frac{6}{s(s+1)(s+2)} = 0$$

$$s(s+1)(s+2) + 6 = 0$$

$$s^3 + 3s^2 + 2s + 6 = 0$$

Clearly, here the internal coefficient product is equal to external coefficient product i.e.,

$$3 \times 2 = 6 \times 1$$

Hence, the given system is marginally stable system.

$\therefore$ $e(t)$ not exist because system is oscillatory system.

End of Solution

Q.31 Consider the state space representation of a system,

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix}u(t)$$

$$y(t) = [-2 \quad -5]x(t)$$

Find transfer function of the system.

(a) x
(b) x
(c) x
(d) x

Ans. **(*)MSQ**

$$\text{Transfer function T(s)} = C[SI - A]^{-1}B + D$$

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$C = [-2 \; -5]; \quad [SI - A] = \begin{bmatrix} S & -1 \\ 2 & S+3 \end{bmatrix}$$

$$[SI - A]^{-1} = \frac{1}{S^2 + 3S + 2}\begin{bmatrix} S+3 & 1 \\ -2 & S \end{bmatrix} = \begin{bmatrix} \frac{S+3}{S^2+3S+2} & \frac{1}{S^2+3S+2} \\ \frac{-2}{S^2+3S+2} & \frac{S}{S^2+3S+2} \end{bmatrix}$$

$$[S1 - A]^{-1}B = \begin{bmatrix} \frac{1}{S^2+3S+2} \\ \frac{S}{S2+3S+2} \end{bmatrix}$$

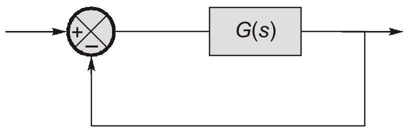
$$C[SI - A]^{-1}B = [-2 \; -5]\begin{bmatrix} \frac{1}{S^2+3S+2} \\ \frac{S}{S^2+3S+2} \end{bmatrix}$$

$$T(s) = \frac{-2-5s}{S^2+3S+2} = \frac{-(5S+2)}{S^2+3S+2}$$

$$T(s) = \frac{-(5S+2)}{S^2+3S+2}$$

End of Solution

Q.32 Consider the unity feedback system shown below:



where, $G(s) = \dfrac{K}{(s+1)(s+2)(s+3)}$

Find K so that at impulse response of closed loop system decays faster than e^{-t}.

(a) $-24 \le K \le -6$
(b) $-4 \le K \le -1$
(c) $7 \le K \le 21$
(d) $1 \le K \le 5$

Ans. **(d)**

Given, $G(s) = \dfrac{K}{(S+1)(S+2)(S+3)}$

Impulse response of system is

$$Y(s) = \frac{K}{(S+1)(S+2)(S+3)+K}$$

Given: At impulse response of closed loop system decay faster than e^{-t}

Hence, put $s = s - 1$,

∴ The new characteristic equation is,

$(s - 1 + 1)(s - 1 + 2)(s - 1 + 3) + K = 0$

$s(s + 1)(s + 2) + K = 0$

$s^3 + 3s^2 + 2s + K = 0$

By RH criterion,

s^3	1	2
s^2	3	K
s^1	$\frac{6-K}{3}$	
s^0	K	

∴ $K > 0$; $\dfrac{6-K}{3} > 0 \Rightarrow K < 6$

∴ $0 < K < 6$

Hence, option (d) satisfies above range of K.

End of Solution

COMPUTER ORGANIZATION

Q.33 For a machine supporting 32 bit micro instructions. It supports 26 registers and 40 bit instruction length. The instruction supported by the machine having 5 instructions sets containing 3 registers field, one opcode field and one is for data then the maximum unsigned value of data is ________.

Ans. (1048575)

Total instruction length → 40 bits

32 bit microinstruction, hence opcode length in 5 bits

$$2^n = 32 = 2^5$$

$$n = 5 \text{ bits}$$

Total Registers = 26

∴ Each register field would be $2^n = 26$

$$n = \log_2(26)$$

∴ $n \approx 5$ bits

Number of fields in the instruction → 5

opcode field → 1 i.e., 5 bits

3 register fields → i.e., 3 (5 bits) = 15 bits

Immediate data field → 1; i.e., x bits

∴ Number of bits for immediate field = Total – (5 + 15)

= 40 – 20 = 20 bits

∴ The range of immediate data operand = 0 to $2^n - 1$

Here $n = 20$.

Hence maximum unsigned value = $2^{20} - 1 = (1048575)_{10}$

End of Solution

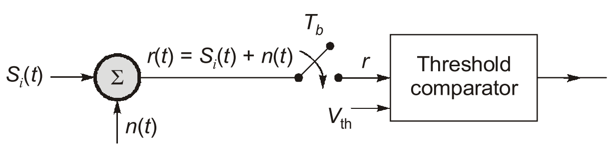
COMMUNICATION SYSTEMS

Q.34 A source r is transmitting 3 symbols {–4, 0, 4} with equal probabilities over a Gaussian channel having 0 mean and variance 4. The optimum probability of error is :

(where $Q(x) = \frac{1}{\sqrt{2\pi}}\int_x^{\infty} e^{-t^2/2}dt$)

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

Ans. (b)



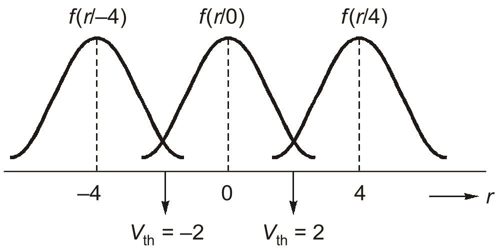
$$f_N(n) = \frac{1}{\sqrt{2\pi}} e^{\frac{-n^2}{2\times 4}} = N(0,\ 4)$$

transmission of $-4 \rightarrow r = -4 + n$

$$f(r/-4) = \frac{1}{\sqrt{2\pi}} e^{\frac{-(r+4)^2}{2\times 4}}$$

transmission of $0 \rightarrow r = n$

$$f(r/0) = \frac{1}{\sqrt{2\pi}} e^{-\frac{r^2}{2\times 4}}$$



transmission of $4 \rightarrow r = 4 + n$

$$f(r/4) = \frac{1}{\sqrt{2\pi}} e^{\frac{-(r-4)^2}{2\times 4}}$$

$$P_e = P(-4)\ P_{e-4} + P(0)\ P_{e0} + P(4) P_{e4}$$

Given $\quad P(-4) = P(0) = P(4) = \frac{1}{3}$

$$P_{e-4} = P(r > -2)$$
$$= 1 - (1 - F_r(2))$$
$$= 1 - \left(1 - Q\left(\frac{-2+4}{2}\right)\right)$$
$$= Q(1)$$
$$P_{e0} = P(r < -2) + P(r > 2)$$
$$= F_r(-2) + \{1 - F_r(2)\}$$
$$= \left(1 - Q\left(\frac{-2-0}{2}\right)\right) + Q\left(\frac{2-0}{2}\right)$$
$$= [1 - Q(-1)] + Q(1) = 2Q(1)$$
$$P_{e4} = P(r < 2)$$
$$= F_r(2)$$
$$= 1 - Q\left(\frac{2-4}{2}\right)$$
$$= 1 - Q(-1)$$
$$= Q(1)$$
$$P_e = \frac{1}{3}Q(1) + \frac{2}{3}Q(1) + \frac{1}{3}Q(1)$$
$$= \frac{4}{3}Q(1)$$

End of Solution

Q.35 For the given amplitude modulated signal

$X_{AM}(t) = A\cos 400\pi t + B\cos 360\pi t + B\cos 440\pi t$

Given: Carrier power = 50 W

Ratio of side band to total power $= \frac{1}{9}$

Then find the value of B = ?

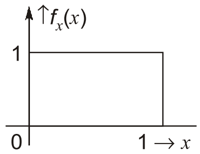
Ans. (2.5)

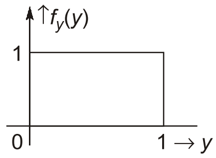
$$P_C = \frac{A^2}{2} = 50$$
$$A = 10$$
$$\frac{P_{SB}}{P_t} = \frac{\mu^2}{2+\mu^2} = \frac{1}{9}$$
$$\mu = \frac{1}{2}$$
$$B = \frac{A_c\mu}{2} = \frac{10}{2} \times \frac{1}{2} = 2.5$$

End of Solution

Q.36 Suppose X and Y are two identically independent uncorrelated random variables distributed uniformly in [0, 1]. Then the probability that $(X \geq Y)$ = __________.

Ans. (0.5)

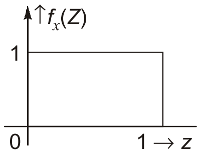


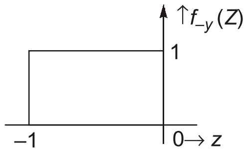


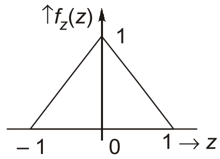
$$P(X \geq Y) = P(X - Y \geq 0)$$

Let $Z = X + (-Y)$

$$P(Z \geq 0) = \int_0^{\infty} f_z(Z)\,d_z$$
$$f_z(z) = f_x(z) * f_{-y}(z)$$



*




$$P(Z \geq 0) = \frac{1}{2}$$

End of Solution

Q.37 A source transmits symbols from an alphabet of size 16. The value of maximum achievable entropy (in bits) is_____.

Ans. **(4)**

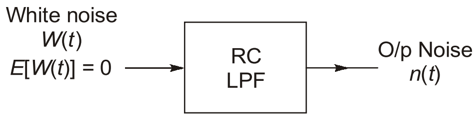
$$H_{max} = \log_2 16 = 4$$

End of Solution

Q.38 A white Gaussian $W(t)$ with zero mean and PSD $= \frac{N_o}{2}$, when applied to a 1st order RC LPF produces on output $n(t)$. At a particular time $t = t_k$, the variance of the RV $n(t_k)$ is

(a) $\frac{2N_o}{RC}$
(b) $\frac{N_o}{4RC}$
(c) $\frac{N_o}{RC}$
(d) None of these

Ans. **(b)**



$$E[n(t)] = E[W(t)] \cdot H(0)$$
$$E[n(t)] = 0$$
$$E[n^2(t)] = \{E(n(t)\}^2 + \text{var}[n(t)]$$
$$\text{var}[n(t)] = E[n^2(t)]$$

at $t = t_k$

$$\text{var}[n(t)]|_{t=t_k} = E[n^2(t_k)] = E[n(t_k)\cdot n(t_k)] = R_n(0)$$
$$S_n(f) = S_W(f)\cdot|H(f)|^2$$
$$= \frac{N_0}{2}\cdot\frac{1}{1+(\omega RC)^2}$$
$$R_n(\tau) = \text{IFT}[S_n(f)] = \frac{N_0}{4RC}\cdot e^{\frac{-|\tau|}{RC}}$$
$$R_n(0) = \frac{N_0}{4RC}$$

End of Solution

Q.39 Random process signal

$x(t) = A\cos(2\pi f_0 t + \theta)$

A & $\theta \rightarrow$ Independently in random process

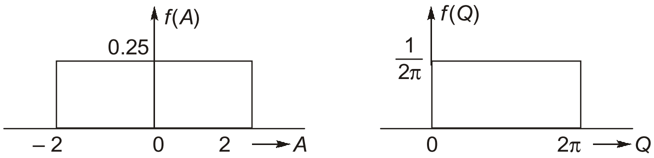
A $\rightarrow$ Uniformly distributed [–2, 2]

$\theta \rightarrow$ Uniformly distributed $[0, 2\pi]$

$R_x(t) = \frac{2}{3}\cos 2\pi f_o \tau$

$x(t)$ is 8 bits mid rise quantizer, then SNR = _____. (in dB)

Ans. (45.15)



$$S = R_x(0) = \frac{2}{3}$$

$$N_q = \frac{\Delta^2}{12}$$

$$\Delta = \frac{2-(-2)}{2^8} = \frac{4}{2^8}$$

$$N_q = \frac{\frac{4^2}{2^{16}}}{12} = \frac{2^4}{12\times 2^{16}} = \frac{1}{12\times 2^{12}}$$

$$\frac{S}{N_q} = \frac{2}{3}\times\frac{12\times 2^{12}}{1} = 32{,}768$$

$$\left(\frac{S}{N_q}\right)_{dB} = 10\ \log 32768 = 45.15\ \text{dB}$$

End of Solution

Q.40 A digital communication system transmits through a noiseless bandlimited channel [– w, w]. The received signal z(t) at output of receiving filter is given by $y(t) = \sum_n b(n)x(t-nT)$ where, b(n) are the symbols and x(t) is the overall system response to single symbol the received signal at t = mT the Fourier transform $x(t)$ is $X(f)$, the Nyquist condition that X(f) must satisfy for zero inter symbol interference at the receiver is _______.

(a) $\sum_{m=-\infty}^{\infty} X\left(f+\frac{m}{T}\right) = \frac{1}{T}$

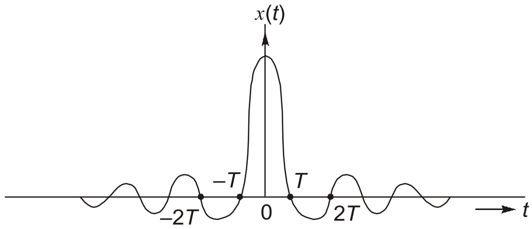
(b) $\sum_{m=-\infty}^{\infty} X(f+mT) = \frac{1}{T}$

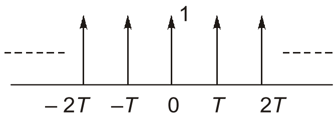
(c) $\sum_{m=-\infty}^{\infty} X\left(f+\frac{m}{T}\right) = T$

(d) $\sum_{m=-\infty}^{\infty} X(f+mT) = T$

Ans. (c)

For zero ISI, $x(t)$ should have zero crossings at $\pm T$, $\pm 2T$, $\pm 3T$....





$$= \sum_{m=-\infty}^{\infty} \delta(t - mT)$$

$$x(t) \sum_{m=-\infty}^{\infty} \delta(t - mT) = x(0)\delta(t)$$

$$\frac{1}{T}\sum_{m=-\infty}^{\infty} X\left(f - \frac{m}{T}\right) = x(0)$$

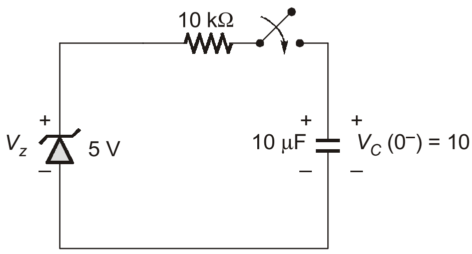
$$\sum_{m=-\infty}^{\infty} X\left(f - \frac{m}{T}\right) = x(0)T$$

(or) $$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = x(0)T$$

End of Solution

ANALOG CIRCUITS

Q.41 For the circuit shown below:



Power dissipation in zener diode is ________ mW.

Ans. (2.5)

$$I = \frac{10 - 5}{10k} = 0.5 \text{ mA}$$

Maximum power dissipation in zener diode is

$$P_D = V_z \times I_{max}$$
$$= 5 \times 0.5$$
$$= 2.5 \text{m Watt}$$
$$P_D = 2.5 \text{m Watt}$$

End of Solution

Q.42 For the NMOS operating in the linear region having operating point I_{DS} = 5 μA and V_{DS} = 0.1 V and $\mu_n C_{ox}$ W/L = 50 μA/V². For V_{GS} being constant and V_{DS} = 1.5 V, then transconductance at operating point is ________ μA/V.

Ans. (52.5)

$$I_{DS} = \mu_n C_{ox}\frac{W}{L}\left[(V_{GS}-V_{TH})V_{DS}-\frac{V_{DS}^2}{2}\right]$$

$$V_{GS} - V_{TH} = 1.05 \text{ V}$$

$$V_{DS} = 1.5 \text{ V} > V_{GS} - V_{TH} \rightarrow \text{Saturation region}$$

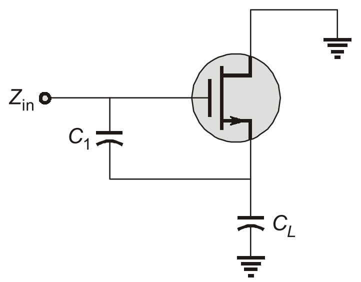
$$g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{Th})$$

$$= 50 \times \frac{\mu A}{2} \times 1.05$$

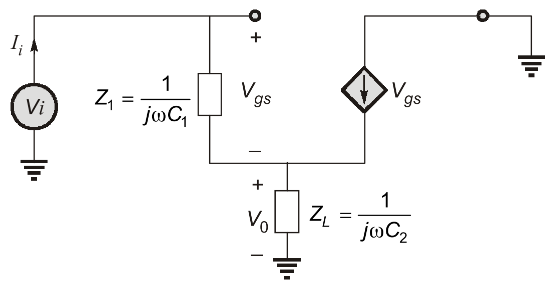
$$= 52.5 \ \mu\text{A/V}$$

End of Solution

Q.43 For the given MOSFET circuit shown in figure find the input impedance as shown in the figure.



Ans. (*)

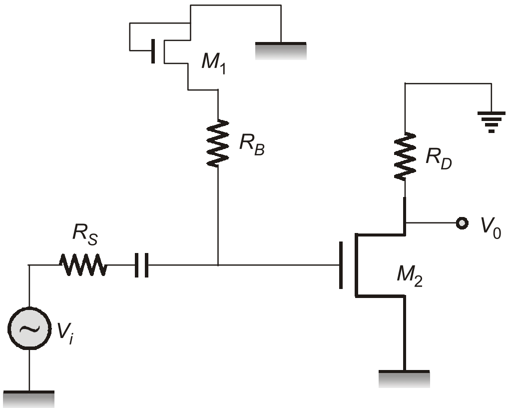


$$I_i = \frac{V_i - V_0}{z_i} = \frac{V_i}{z_i} - \frac{V_0}{z_i} \quad \text{...(I)}$$

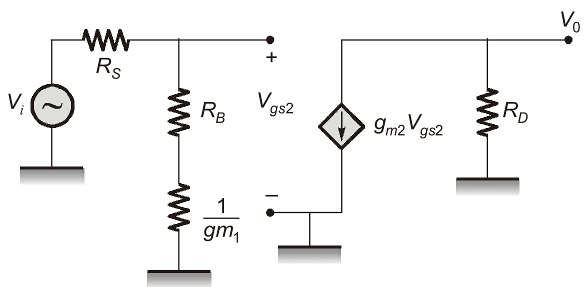
$$V_0 = (I_i + g_m V_{gs}) z_L$$
$$V_0 = I_i z_L + g_m V_{gs} z_L$$
$$V_0 = I_i (z_L + g_m z_1 z_L)$$
$$I_i = \frac{V_1^i}{z_1} - \frac{I_i (z_L + g_m z_1 z_L)}{z_1}$$
$$I_i \frac{[z_1 + z_L + g_m z_1 z_L]}{z_1} = \frac{V_L^i}{z_1}$$
$$\frac{V_L^i}{I_i} = z_1 + z_L + g_m z_1 z_L$$
$$z_{in} = \frac{1}{j\omega C_1} + \frac{1}{j\omega C_L} - \frac{g_m}{\omega^2 C_1 C_L}$$

End of Solution

Q.44 Find $\left|\frac{V_0}{V_{in}}\right|$ = ________. (Assume channel length is negligible)



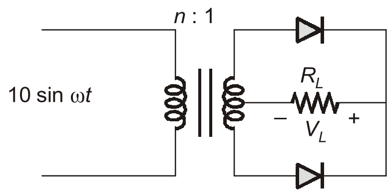
Ans. ()



$$V_0 = -g_{m2} V_{gs} R_D$$
$$V_{gs} = V_L^i \times \frac{R_B + \frac{1}{g_{m1}}}{R_S + R_B + \frac{1}{g_{m1}}}$$
$$\left|\frac{V_0}{V_{in}}\right| = \frac{g_{m2} R_D \left(R_B + \frac{1}{g_{m1}}\right)}{R_S + R_B + \frac{1}{g_{m1}}}$$

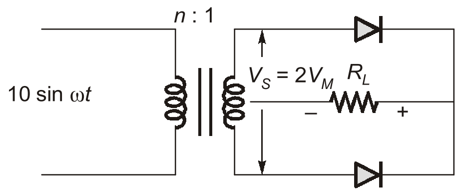
End of Solution

Q.45 For a center tapped full wave rectifier having both the diodes are idea. Then the value of 'n' is, if the input voltage is 10 sin ωt and the average voltage across R_L is $\frac{2.5}{\pi}$ volt.



(a) 8
(b) 4
(c) 2
(d) 16

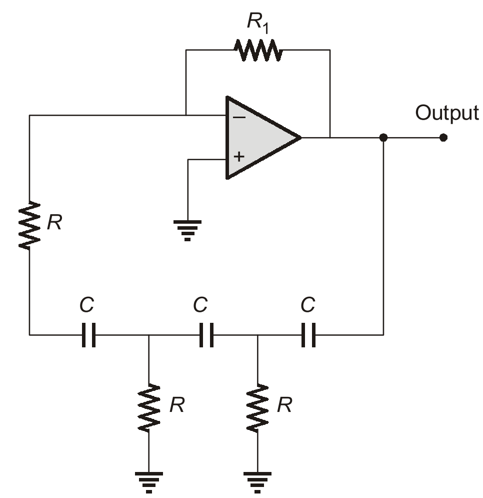
Ans. (b)



Given,
$$V_{DC} = \frac{2V_M}{\pi} = \frac{2.5}{\pi}$$
$$V_M = \frac{2.5}{2}$$
$$\therefore \quad 2V_M = V_S = 2.5 \text{ V}$$
$$n : 1 = \frac{V_P}{V_s} : 1$$
$$= \frac{10}{2.5} : 1$$
$$= 4 : 1$$
$$\therefore \quad n = 4$$

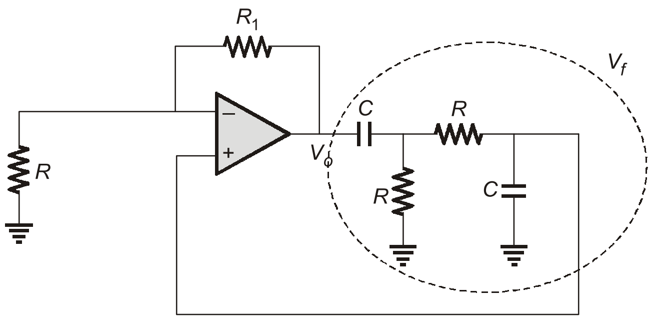
End of Solution

Q.6 For the given op-amp circuit shown below :



The frequency of oscillation and the relationship between R_1 and R is ______.

Ans. (b)



$$\beta = \frac{V_f}{V_o} = \frac{1}{3 + j\left(\omega RC - \frac{1}{\omega RC}\right)}$$

For sustained frequency of oscillaton,

$$\omega RC - \frac{1}{\omega RC} = 0$$

$$\omega_o = \frac{1}{RC} \text{ or } f_o = \frac{1}{2\pi RC}$$

$$\beta = \frac{1}{3} \;;\; A = 3$$

$$1 + \frac{R_1}{R} = 3$$

$$\frac{R_1}{R} = 2$$

$$R_1 = 2R$$

■■■■