GATE EC 2009

Q.1 - Q.20 carry one mark each.

MCQ 1.1 The order of the differential equation

$$\frac{d^2y}{dt^2} + \left(\frac{dy}{dt}\right)^3 + y^4 = e^{-t}$$

is

(A) 1 (B) 2

(C) 3 (D) 4

SOL 1.1 The highest derivative terms present in DE is of 2nd order.
Hence (B) is correct answer.

MCQ 1.2 The Fourier series of a real periodic function has only

(P) cosine terms if it is even

(Q) sine terms if it is even

(R) cosine terms if it is odd

(S) sine terms if it is odd

Which of the above statements are correct ?

(A) P and S (B) P and R

(C) Q and S (D) Q and R

SOL 1.2 The Fourier series of a real periodic function has only cosine terms if it is even and sine terms if it is odd.
Hence (A) is correct answer.

MCQ 1.3 A function is given by $f(t) = \sin^2 t + \cos 2t$. Which of the following is true ?

(A) f has frequency components at 0 and $\frac{1}{2\pi}$ Hz

(B) f has frequency components at 0 and $\frac{1}{\pi}$ Hz

(C) f has frequency components at $\frac{1}{2\pi}$ and $\frac{1}{\pi}$Hz

(D) f has frequency components at $\frac{0.1}{2\pi}$ and $\frac{1}{\pi}$ Hz

SOL 1.3 Given function is

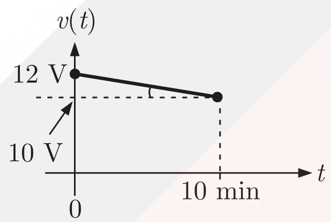
$$f(t) = \sin^2 t + \cos 2t = \frac{1-\cos 2t}{2} + \cos 2t = \frac{1}{2} + \frac{1}{2}\cos 2t$$

The function has a DC term and a cosine function. The frequency of cosine terms is

$$\omega = 2 = 2\pi f \to f = \frac{1}{\pi} \text{ Hz}$$

The given function has frequency component at 0 and $\frac{1}{\pi}$ Hz.
Hence (B) is correct answer.

MCQ 1.4 A fully charged mobile phone with a 12 V battery is good for a 10 minute talk-time. Assume that, during the talk-time the battery delivers a constant current of 2 A and its voltage drops linearly from 12 V to 10 V as shown in the figure. How much energy does the battery deliver during this talk-time?



(A) 220 J (B) 12 kJ
(C) 13.2 kJ (D) 14.4 J

SOL 1.4 The energy delivered in 10 minutes is

$$E = \int_0^t VIdt = I\int_0^t Vdt = I \times Area$$

$$= 2 \times \frac{1}{2}(10+12) \times 600 = 13.2 \text{ kJ}$$

Hence (C) is correct option.

MCQ 1.5 In an n-type silicon crystal at room temperature, which of the following can have a concentration of 4×10^{19} cm^{-3}?

(A) Silicon atoms (B) Holes
(C) Dopant atoms (D) Valence electrons

SOL 1.5 Only dopant atoms can have concentration of 4×10^{19} cm^{-3} in $n-$type silicon at room temperature.
Hence option (C) is correct.

MCQ 1.6 The full form of the abbreviations TTL and CMOS in reference to logic families are

(A) Triple Transistor Logic and Chip Metal Oxide Semiconductor
(B) Tristate Transistor Logic and Chip Metal Oxide Semiconductor
(C) Transistor Transistor Logic and Complementary Metal Oxide Semiconductor
(D) Tristate Transistor Logic and Complementary Metal Oxide Silicon

SOL 1.6 TTL → Transistor - Transistor logic
CMOS → Complementary Metal Oxide Semi-conductor
Hence (C) is correct answer.

MCQ 1.7 The ROC of z-transform of the discrete time sequence

$$x(n) = \left(\frac{1}{3}\right)^n u(n) - \left(\frac{1}{2}\right)^n u(-n-1) \text{ is}$$

(A) $\frac{1}{3} < |z| < \frac{1}{2}$ (B) $|z| > \frac{1}{2}$

(C) $|z| < \frac{1}{3}$ (D) $2 < |z| < 3$

SOL 1.7 Hence (A) is correct answer

$$x[n] = \left(\frac{1}{3}\right)^n u(n) - \left(\frac{1}{2}\right)^n u(-n-1)$$

Taking z transform we have

$$X(z) = \sum_{n=0}^{n=\infty}\left(\frac{1}{3}\right)^n z^{-n} - \sum_{n=-\infty}^{n=-1}\left(\frac{1}{2}\right)^n z^{-n}$$

$$= \sum_{n=0}^{n=\infty}\left(\frac{1}{3}z^{-1}\right)^n - \sum_{n=-\infty}^{n=-1}\left(\frac{1}{2}z^{-1}\right)^n$$

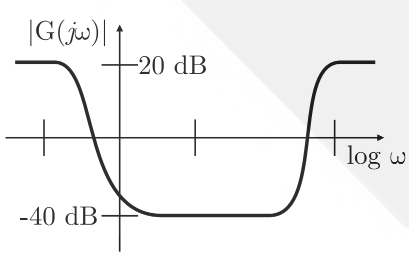
First term gives $\frac{1}{3}z^{-1} < 1 \rightarrow \frac{1}{3} < |z|$

Second term gives $\frac{1}{2}z^{-1} > 1 \rightarrow \frac{1}{2} > |z|$

Thus its ROC is the common ROC of both terms. that is

$$\frac{1}{3} < |z| < \frac{1}{2}$$

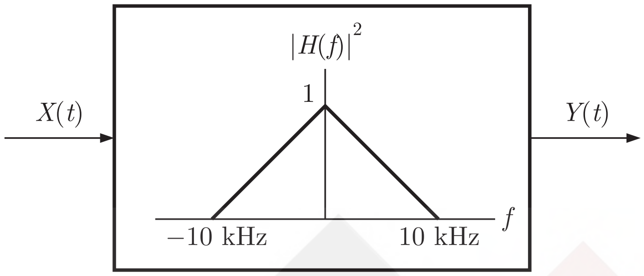
MCQ 1.8 The magnitude plot of a rational transfer function $G(s)$ with real coefficients is shown below. Which of the following compensators has such a magnitude plot ?



(A) Lead compensator (B) Lag compensator
(C) PID compensator (D) Lead-lag compensator

SOL 1.8 This compensator is roughly equivalent to combining lead and lad compensators in the same design and it is referred also as PID compensator.
Hence (C) is correct option

MCQ 1.9 A white noise process $X(t)$ with two-sided power spectral density 1×10^{-10} W/Hz is input to a filter whose magnitude squared response is shown below.



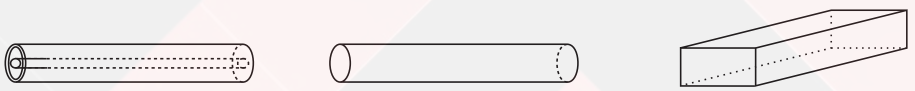
The power of the output process $Y(t)$ is given by

(A) 5×10^{-7} W (B) 1×10^{-6} W

(C) 2×10^{-6} W (D) 1×10^{-5} W

SOL 1.9 Correct Option is ( )

MCQ 1.10 Which of the following statements is true regarding the fundamental mode of the metallic waveguides shown ?



(A) Only P has no cutoff-frequency

(B) Only Q has no cutoff-frequency

(C) Only R has no cutoff-frequency

(D) All three have cutoff-frequencies

SOL 1.10 Rectangular and cylindrical waveguide doesn't support TEM modes and have cut off frequency.
Coaxial cable support TEM wave and doesn't have cut off frequency.
Hence (A) is correct option.

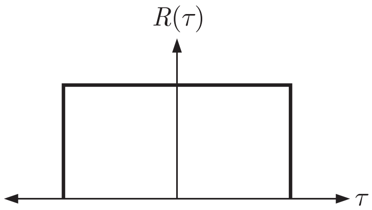
MCQ 1.11 A fair coin is tossed 10 times. What is the probability that only the first two tosses will yield heads?

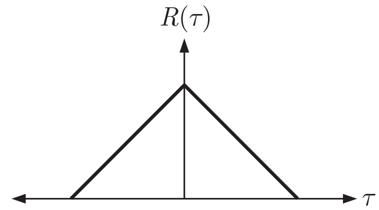
(A) $\left(\frac{1}{2}\right)^2$ (B) ${}^{10}C_2\left(\frac{1}{2}\right)^2$

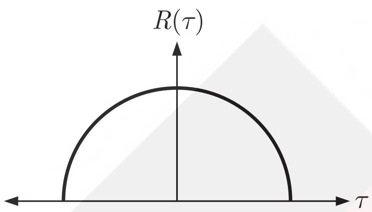
(C) $\left(\frac{1}{2}\right)^{10}$ (D) ${}^{10}C_2\left(\frac{1}{2}\right)^{10}$

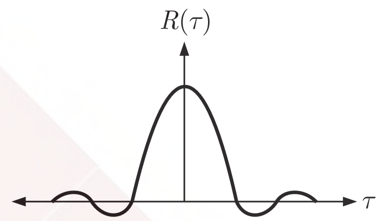
SOL 1.11 Number of elements in sample space is 2^{10}. Only one element $\{H, H, T, T, T, T, T, T, T, T\}$ is event. Thus probability is $\frac{1}{2^{10}}$
Hence (C) is correct answer.

MCQ 1.12 If the power spectral density of stationary random process is a sine-squared function of frequency, the shape of its autocorrelation is

(A) 

(B) 

(C) 

(D) 

SOL 1.12 Correct Option is ( )

MCQ 1.13 If $f(z) = c_0 + c_1 z^{-1}$, then $\oint\limits_{\text{unit circle}} \frac{1 + f(z)}{z} dz$ is given by

(A) $2\pi c_1$ (B) $2\pi(1 + c_0)$

(C) $2\pi j c_1$ (D) $2\pi(1 + c_0)$

SOL 1.13 Hence (C) is correct answer

We have

$$f(z) = c_0 + c_1 z^{-1}$$

$$f_1(z) = \frac{1 + f(z)}{z} = \frac{1 + c_0 + c_1 z^{-1}}{z} = \frac{z(1 + c_0) + c_1}{z^2}$$

Since $f_1(z)$ has double pole at $z = 0$, the residue at $z = 0$ is

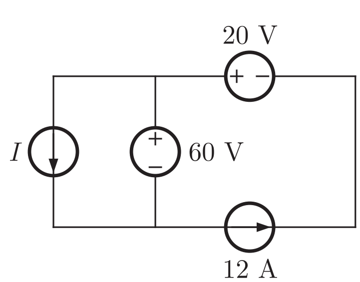
$$\text{Res } f_1(z)_{z=0} = \lim_{z \to 0} z^2 . f_1(z) = \lim_{z \to 0} z^2 . \left(\frac{z(1 + c_0) + c_1}{z^2} \right) = c_1$$

Hence

$$\oint\limits_{\text{unit circle}} f_1(z)\, dz = \oint\limits_{\text{unit circle}} \frac{[1 + f(z)]}{z} dz = 2\pi j \text{ [Residue at } z = 0]$$

$$= 2\pi j c_1$$

MCQ 1.14 In the interconnection of ideal sources shown in the figure, it is known that the 60 V source is absorbing power.

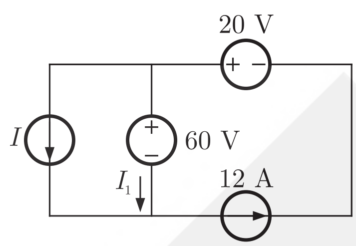


Which of the following can be the value of the current source I?

(A) 10 A (B) 13 A

(C) 15 A (D) 18 A

SOL 1.14 Circuit is as shown below



Since 60 V source is absorbing power. So, in 60 V source current flows from + to - ve direction

So, $$I + I_1 = 12$$

$$I = 12 - I_1$$

I is always less then 12 A So, only option (A) satisfies this conditions.

Hence (A) is correct option.

MCQ 1.15 The ratio of the mobility to the diffusion coefficient in a semiconductor has the units

(A) V^{-1} (B) $cm.V^{1}$

(C) $V.cm^{-1}$ (D) $V.s$

SOL 1.15 Hence option (A) is correct.

Unit of mobility μ_n is $$= \frac{\text{cm}^2}{V.\text{sec}}$$

Unit of diffusion current D_n is $$= \frac{\text{cm}^2}{\text{sec}}$$

Thus unit of $\frac{\mu_n}{D_n}$ is $$= \frac{\text{cm}^2}{V \cdot \text{sec}} \Big/ \frac{\text{cm}^2}{\text{sec}} = \frac{1}{V} = V^{-1}$$

MCQ 1.16 In a microprocessor, the service routine for a certain interrupt starts from a fixed location of memory which cannot be externally set, but the interrupt can be delayed or rejected Such an interrupt is

(A) non-maskable and non-vectored

(B) maskable and non-vectored

(C) non-maskable and vectored

(D) maskable and vectored

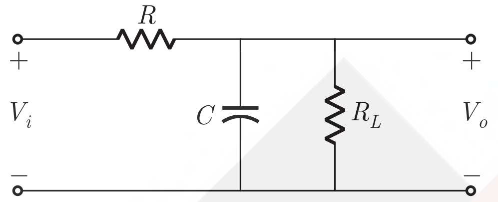
SOL 1.16 Vectored interrupts : Vectored interrupts are those interrupts in which program control transferred to a fixed memory location.

Maskable interrupts : Maskable interrupts are those interrupts which can be rejected

or delayed by microprocessor if it is performing some critical task.
Hence (D) is correct answer.

MCQ 1.17 If the transfer function of the following network is

$$\frac{V_o(s)}{V_i(s)} = \frac{1}{2+sCR}$$



The value of the load resistance R_L is

(A) $\frac{R}{4}$ (B) $\frac{R}{2}$

(C) R (D) $2R$

SOL 1.17 For given network we have

$$V_0 = \frac{(R_L \| X_C)\, V_i}{R + (R_L \| X_C)}$$

$$\frac{V_0(s)}{V_i(s)} = \frac{\frac{R_L}{1+sR_L C}}{R + \frac{R_L}{1+sR_L C}} = \frac{R_L}{R + RR_L sC + R_L}$$

$$= \frac{R_L}{R + RR_L sC + R_L} = \frac{1}{1 + \frac{R}{R_L} + RsC}$$

But we have been given

$$T.F. = \frac{V_0(s)}{V_i(s)} = \frac{1}{2+sCR}$$

Comparing, we get

$$1 + \frac{R}{R_L} = 2 \quad \Rightarrow R_L = R$$

Hence (C) is correct option.

MCQ 1.18 Consider the system

$$\frac{dx}{dt} = Ax + Bu \quad \text{with} \quad A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \text{ and } B = \begin{bmatrix} p \\ q \end{bmatrix}$$

where p and q are arbitrary real numbers. Which of the following statements about the controllability of the system is true ?

(A) The system is completely state controllable for any nonzero values of p and q

(B) Only $p = 0$ and $q = 0$ result in controllability

(C) The system is uncontrollable for all values of p and q

(D) We cannot conclude about controllability from the given data

SOL 1.18 Hence (C) is correct option.

Here $A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ and $B = \begin{bmatrix} p \\ q \end{bmatrix}$

$$AB = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} p \\ q \end{bmatrix}$$

$$S = \begin{bmatrix} B & AB \end{bmatrix} = \begin{bmatrix} p & q \\ q & p \end{bmatrix}$$

$$S = pq - pq = 0$$

Since S is singular, system is completely uncontrollable for all values of p and q.

MCQ 1.19 For a message signal $m(t) = \cos(2\pi f_m t)$ and carrier of frequency f_c, which of the following represents a single side-band (SSB) signal ?

(A) $\cos(2\pi f_m t)\cos(2\pi f_c t)$ (B) $\cos(2\pi f_c t)$

(C) $\cos[2\pi(f_c + f_m)t]$ (D) $[1 + \cos(2\pi f_m t)\cos(2\pi f_c t)$

SOL 1.19 Hence (C) is correct option.

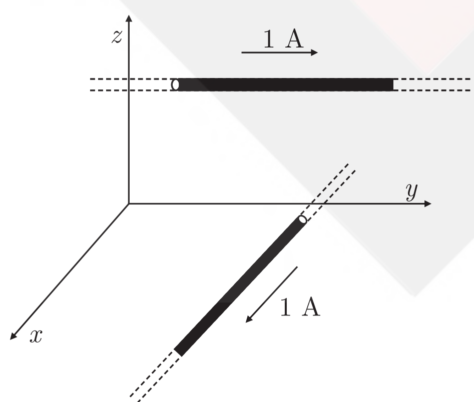
$$\cos(2\pi f_m t)\cos(2\pi f_c t) \longrightarrow \text{DSB suppressed carrier}$$

$$\cos(2\pi f_c t) \longrightarrow \text{Carrier Only}$$

$$\cos[2\pi(f_c + f_m)t] \longrightarrow \text{USB Only}$$

$$[1 + \cos(2\pi f_m t)\cos(2\pi f_c t)] \longrightarrow \text{USB with carrier}$$

MCQ 1.20 Two infinitely long wires carrying current are as shown in the figure below. One wire is in the $y-z$ plane and parallel to the $y-$ axis. The other wire is in the $x-y$ plane and parallel to the $x-$ axis. Which components of the resulting magnetic field are non-zero at the origin ?



(A) x, y, z components (B) x, y components

(C) y, z components (D) x, z components

SOL 1.20 Due to 1 A current wire in $x-y$ plane, magnetic field be at origin will be in x direction.

Due to 1 A current wire in $y-z$ plane, magnetic field be at origin will be in z

direction.
Thus x and z component is non-zero at origin.
Hence (D) is correct option.

Q.21 to Q.60 carry two marks each.

MCQ 1.21 Consider two independent random variables X and Y with identical distributions. The variables X and Y take values 0, 1 and 2 with probabilities $\frac{1}{2}, \frac{1}{4}$ and $\frac{1}{4}$ respectively. What is the conditional probability $P(X+Y=2|X-Y=0)$?

(A) 0 (B) 1/16

(C) 1/6 (D) 1

SOL 1.21 Hence (C) is correct option.
We have

$$p(X=0) = p(Y=0) = \frac{1}{2}$$

$$p(X=1) = p(Y=1) = \frac{1}{4}$$

$$p(X=2) = p(Y=2) = \frac{1}{4}$$

Let $X+Y=2 \longrightarrow A$
and $X-Y=0 \longrightarrow B$
Now

$$P(X+Y=2|X-Y=0) = \frac{P(A \cap B)}{P(B)}$$

Event $P(A \cap B)$ happen when $X+Y=2$ and $X-Y=0$. It is only the case when $X=1$ and $Y=1$.

Thus $$P(A \cap B) = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$$

Now event $P(B)$ happen when

$X-Y = 0$ It occurs when $X=Y$, i.e.
$X = 0$ and $Y=0$ or
$X = 1$ and $Y=1$ or
$X = 2$ and $Y=2$

Thus $$P(B) = \frac{1}{2} \times \frac{1}{2} + \frac{1}{4} \times \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} = \frac{6}{16}$$

Now $$\frac{P(A \cap B)}{P(B)} = \frac{1/16}{6/16} = \frac{1}{6}$$

MCQ 1.22 The Taylor series expansion of $\frac{\sin x}{x-\pi}$ at $x=\pi$ is given by

(A) $1 + \frac{(x-\pi)^2}{3!} + \ldots$ (B) $-1 - \frac{(x-\pi)^2}{3!} + \ldots$

(C) $1-\frac{(x-\pi)^2}{3!}+...$ (D) $-1+\frac{(x-\pi)^2}{3!}+...$

SOL 1.22 Hence (D) is correct answer.

We have $f(x)=\frac{\sin x}{x-\pi}$

Substituting $x-\pi=y$,we get

$$f(y+\pi)=\frac{\sin(y+\pi)}{y}=-\frac{\sin y}{y}=\frac{-1}{y}(\sin y)$$

$$=\frac{-1}{y}\left(y-\frac{y^3}{3!}+\frac{y^5}{5!}-...\right)$$

or $$f(y+\pi)=-1+\frac{y^2}{3!}-\frac{y^4}{5!}+...$$

Substituting $x-\pi=y$ we get

$$f(x)=-1+\frac{(x-\pi)^2}{3!}-\frac{(x-\pi)^4}{5!}+...$$

MCQ 1.23 If a vector field $\vec{V}$ is related to another vector field $\vec{A}$ through $\vec{V}=\nabla\times\vec{A}$, which of the following is true? (Note : C and S_C refer to any closed contour and any surface whose boundary is C.)

(A) $\oint_C\vec{V}\cdot\vec{d}l=\int_S\int_C\vec{A}\cdot\vec{d}S$ (B) $\oint_C\vec{A}\cdot\vec{d}l=\int_S\int_C\vec{V}\cdot\vec{d}S$

(C) $\oint_C\Delta\times\vec{V}\cdot\vec{d}l=\int_S\int_C\Delta\times\vec{A}\cdot\vec{d}S$ (D) $\oint_C\Delta\times\vec{V}\cdot\vec{d}l=\int_S\int_C\vec{V}\cdot\vec{d}S$

SOL 1.23 Hence (B) is correct option.

We have $V=\nabla\times A$ ...(1)

By Stokes theorem

$$\oint A\cdot dl=\oiint(\nabla\times A)\cdot ds \qquad ...(2)$$

From (1) and (2) we get

$$\oint A\cdot dl=\oiint V\cdot ds$$

MCQ 1.24 Given that $F(s)$ is the one-side Laplace transform of $f(t)$, the Laplace transform of $\int_0^t f(\tau)\,d\tau$ is

(A) $sF(s)-f(0)$ (B) $\frac{1}{s}F(s)$

(C) $\int_0^s F(\tau)\,d\tau$ (D) $\frac{1}{s}[F(s)-f(0)]$

SOL 1.24 By property of unilateral laplace transform

$$\int_{-\infty}^t f(\tau)\,d\tau \overset{L}{\longleftrightarrow} \frac{F(s)}{s}+\frac{1}{s}\int_{-\infty}^{0^-}f(\tau)\,d\tau$$

Here function is defined for $0<\tau<t$, Thus

$$\int_0^t f(\tau) \overset{L}{\longleftrightarrow} \frac{F(s)}{s}$$

Hence (B) is correct answer.

MCQ 1.25 Match each differential equation in Group I to its family of solution curves from Group II

Group I	Group II
A. $\frac{dy}{dx} = \frac{y}{x}$	1. Circles
B. $\frac{dy}{dx} = -\frac{y}{x}$	2. Straight lines
C. $\frac{dy}{dx} = \frac{x}{y}$	3. Hyperbolas
D. $\frac{dy}{dx} = -\frac{x}{y}$	

(A) $A-2, B-3, C-3, D-1$

(B) $A-1, B-3, C-2, D-1$

(C) $A-2, B-1, C-3, D-3$

(D) $A-3, B-2, C-1, D-2$

SOL 1.25 Hence (A) is correct answer

(A) $$\frac{dy}{dx} = \frac{y}{x}$$

or $$\int \frac{dy}{y} = \int \frac{dx}{x}$$

or $$\log y = \log x + \log c$$

or $$y = cx \text{ Straight Line}$$

Thus option (A) and (C) may be correct.

(B) $$\frac{dy}{dx} = -\frac{y}{x}$$

or $$\int \frac{dy}{y} = -\int \frac{dx}{x}$$

or $$\log y = -\log x + \log c$$

or $$\log y = \log \frac{1}{x} + \log c$$

or $$y = \frac{c}{x} \text{ Hyperbola}$$

MCQ 1.26 The Eigen values of following matrix are

$$\begin{bmatrix} -1 & 3 & 5 \\ -3 & -1 & 6 \\ 0 & 0 & 3 \end{bmatrix}$$

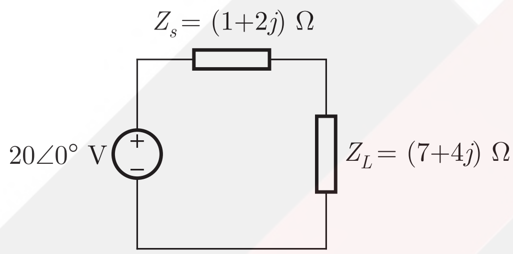
(A) $3,\ 3+5j,\ 6-j$

(B) $-6+5j,\ 3+j,\ 3-j$

(C) $3+j,\ 3-j,\ 5+j$ (D) $3,\ -1+3j,\ -1-3j$

SOL 1.26 Sum of the principal diagonal element of matrix is equal to the sum of Eigen values. Sum of the diagonal element is $-1-1+3=1$.In only option (D), the sum of Eigen values is 1.
Hence (D) is correct answer.

MCQ 1.27 An AC source of RMS voltage 20 V with internal impedance $Z_s=(1+2j)\,\Omega$ feeds a load of impedance $Z_L=(7+4j)\,\Omega$ in the figure below. The reactive power consumed by the load is



(A) 8 VAR (B) 16 VAR
(C) 28 VAR (D) 32 VAR

SOL 1.27 From given circuit the load current is

$$I_L=\frac{V}{Z_s+Z_L}=\frac{20\angle 0°}{(1+2j)+(7+4j)}=\frac{20\angle 0°}{8+6j}$$

$$=\frac{1}{5}(8-6j)=\frac{20\angle 0°}{10\angle\phi}=2\angle-\phi \qquad \text{where } \phi=\tan^{-1}\frac{3}{4}$$

The voltage across load is

$$V_L=I_LZ_L$$

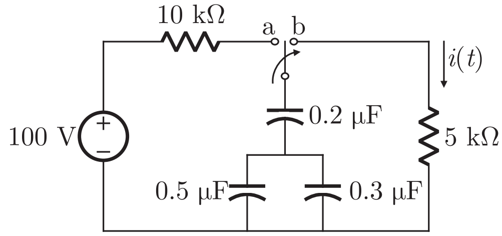
The reactive power consumed by load is

$$P_r=V_LI_L^*=I_LZ_L\times I_L^*=Z_L|I_L|^2$$

$$=(7\times 4j)\left|\frac{20\angle 0°}{8+6j}\right|^2=(7+4j)=28+16j$$

Thus average power is 28 and reactive power is 16.
Hence (B) is correct option.

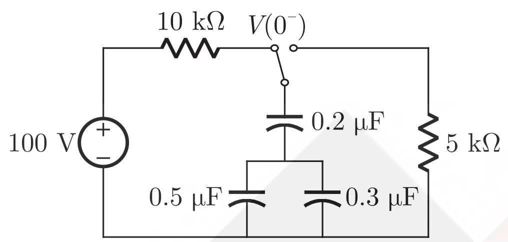
MCQ 1.28 The switch in the circuit shown was on position a for a long time, and is move to position b at time $t=0$. The current $i(t)$ for $t>0$ is given by



(A) $0.2e^{-125t}u(t)$ mA (B) $20e^{-1250t}u(t)$ mA

(C) $0.2e^{-1250t}u(t)$ mA (D) $20e^{-1000t}u(t)$ mA

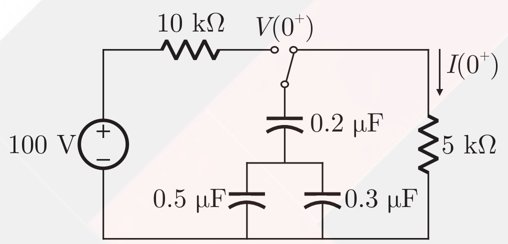
SOL 1.28 At $t = 0^-$, the circuit is as shown in fig below :



$$V(0^-) = 100 \text{ V}$$

Thus $$V(0^+) = 100 \text{ V}$$

At $t = 0^+$, the circuit is as shown below



$$I(0^+) = \frac{100}{5k} = 20 \text{ mA}$$

At steady state i.e. at $t = \infty$ is $I(\infty) = 0$

Now $$i(t) = I(0^+)\, e^{-\frac{t}{RC_{eq}}} u(t)$$

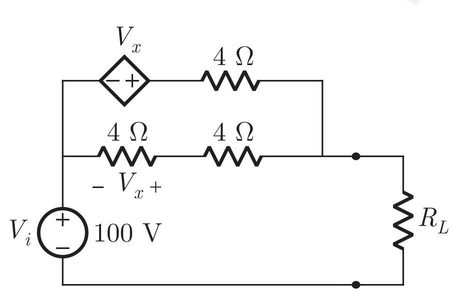
$$C_{eq} = \frac{(0.5\mu + 0.3\mu)0.2\mu}{0.5\mu + 0.3\mu + 0.2\mu} = 0.16\ \mu\text{F}$$

$$\frac{1}{RC_{eq}} = \frac{1}{5 \times 10^3 \times 0.16 \times 10^{-6}} = 1250$$

$$i(t) = 20e^{-1250t}u(t) \text{ mA}$$

Hence (B) is correct option.

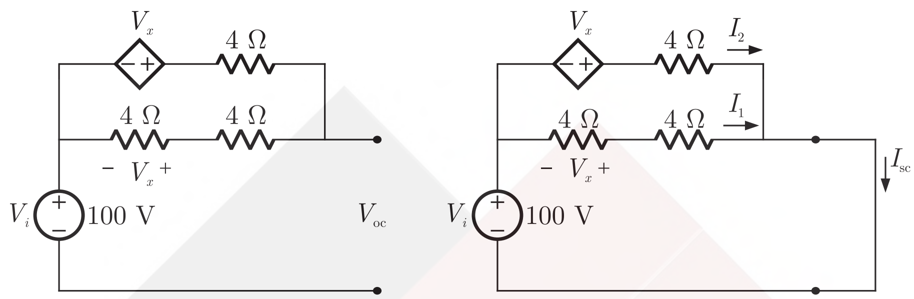
MCQ 1.29 In the circuit shown, what value of R_L maximizes the power delivered to R_L?



(A) $2.4\,\Omega$ (B) $\frac{8}{3}\,\Omega$

(C) $4\,\Omega$ (D) $6\,\Omega$

SOL 1.29 For $P_{\max}$ the load resistance R_L must be equal to thevenin resistance R_{eq} i.e. $R_L = R_{eq}$. The open circuit and short circuit is as shown below



The open circuit voltage is

$$V_{oc} = 100 \text{ V}$$

From fig

$$I_1 = \frac{100}{8} = 12.5 \text{ A}$$

$$V_x = -4 \times 12.5 = -50 \text{ V}$$

$$I_2 = \frac{100 + V_x}{4} = \frac{100 - 50}{4} = 12.5 \text{ A}$$

$$I_{sc} = I_1 + I_2 = 25 \text{ A}$$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{100}{25} = 4\,\Omega$$

Thus for maximum power transfer $R_L = R_{eq} = 4\,\Omega$
Hence (C) is correct option.

MCQ 1.30 The time domain behavior of an RL circuit is represented by

$$L\frac{di}{dt} + Ri = V_0(1 + Be^{-Rt/L}\sin t)\,u(t).$$

For an initial current of $i(0) = \frac{V_0}{R}$, the steady state value of the current is given by

(A) $i(t) \to \frac{V_0}{R}$ (B) $i(t) \to \frac{2V_0}{R}$

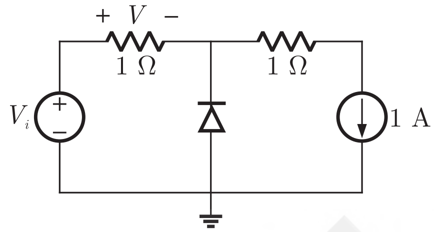
(C) $i(t) \to \frac{V_0}{R}(1+B)$ (D) $i(t) \to \frac{2V_0}{R}(1+B)$

SOL 1.30 Steady state all transient effect die out and inductor act as short circuits and forced response acts only. It doesn't depend on initial current state. From the given time domain behavior we get that circuit has only R and L in series with V_0. Thus at steady state

$$i(t) \to i(\infty) = \frac{V_0}{R}$$

Hence (A) is correct option.

MCQ 1.31 In the circuit below, the diode is ideal. The voltage V is given by



(A) min $(V_i, 1)$ (B) max $(V_i, 1)$

(C) min $(-V_i, 1)$ (D) max $(-V_i, 1)$

SOL 1.31 Let diode be OFF. In this case 1 A current will flow in resistor and voltage across resistor will be $V = 1.V$

Diode is off, it must be in reverse biased, therefore

$$V_i - 1 > 0 \rightarrow V_i > 1$$

Thus for $V_i > 1$ diode is off and $V = 1\,V$

Option (B) and (C) doesn't satisfy this condition.

Let $V_i < 1$. In this case diode will be on and voltage across diode will be zero and $V = V_i$

Thus $V = \min(V_i, 1)$

Hence (A) is correct option.

MCQ 1.32 Consider the following two statements about the internal conditions in a n −channel MOSFET operating in the active region.

S1 : The inversion charge decreases from source to drain

S2 : The channel potential increases from source to drain.

Which of the following is correct?

(A) Only S2 is true

(B) Both S1 and S2 are false

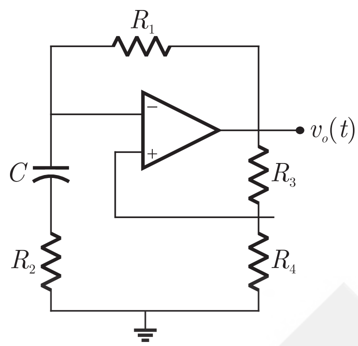
(C) Both S1 and S2 are true, but S2 is not a reason for S1

(D) Both S1 and S2 are true, and S2 is a reason for S1

SOL 1.32 Both S1 and S2 are true and S2 is a reason for S1.

Hence option (D) is correct.

MCQ 1.33 In the following a stable multivibrator circuit, which properties of $v_0(t)$ depend on R_2?



(A) Only the frequency

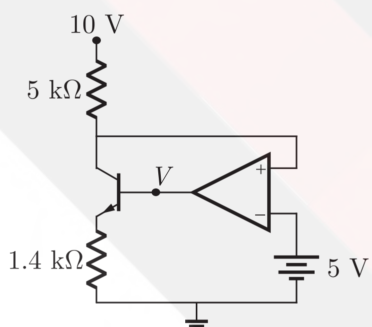
(B) Only the amplitude

(C) Both the amplitude and the frequency

(D) Neither the amplitude nor the frequency

SOL 1.33 The R_2 decide only the frequency.
Hence (A) is correct option

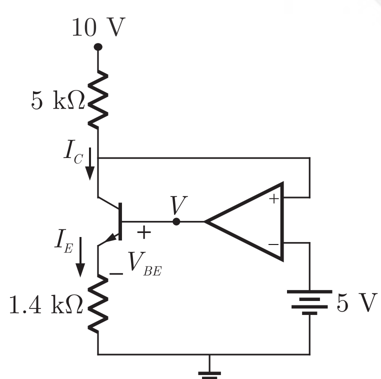
MCQ 1.34 In the circuit shown below, the op-amp is ideal, the transistor has $V_{BE} = 0.6$ V and $\beta = 150$. Decide whether the feedback in the circuit is positive or negative and determine the voltage V at the output of the op-amp.



(A) Positive feedback, $V = 10$ V. (B) Positive feedback, $V = 0$ V

(C) Negative feedback, $V = 5$ V (D) Negative feedback, $V = 2$ V

SOL 1.34 The circuit is shown in fig below



The voltage at non inverting terminal is 5 V because OP AMP is ideal and inverting terminal is at 5 V.

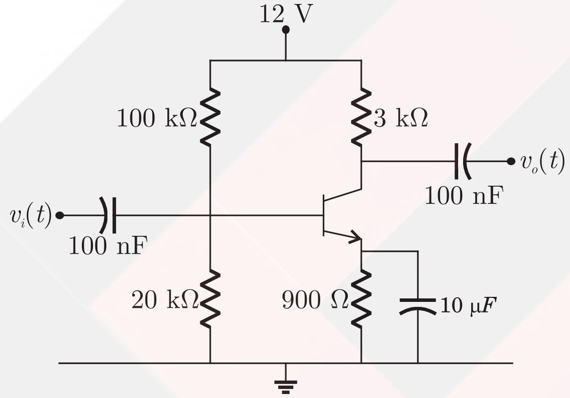
Thus $$I_C = \frac{10-5}{5k} = 1 \text{ mA}$$

$$V_E = I_E R_E = 1m \times 1.4k = 1.4V \qquad I_E = I_C$$
$$= 0.6 + 1.4 = 2V$$

Thus the feedback is negative and output voltage is $V = 2V$.

Hence (D) is correct option.

MCQ 1.35 A small signal source $V_i(t) = A\cos 20t + B\sin 10^6 t$ is applied to a transistor amplifier as shown below. The transistor has $\beta = 150$ and $h_{ie} = 3\Omega$. Which expression best approximate $V_0(t)$



(A) $V_0(t) = -1500(A\cos 20t + B\sin 10^6 t)$

(B) $V_0(t) = -1500(A\cos 20t + B\sin 10^6 t)$

(C) $V_0(t) = -1500B\sin 10^6 t$

(D) $V_0(t) = -150B\sin 10^6 t$

SOL 1.35 The output voltage is

$$V_0 = A_r V_i \approx -\frac{h_{fe} R_C}{h_{ie}} V_i$$

Here $R_C = 3\,\Omega$ and $h_{ie} = 3\,\text{k}\Omega$

Thus $$V_0 \approx -\frac{150 \times 3\text{k}}{3\text{k}} V_i$$

$$\approx -150(A\cos 20t + B\sin 10^6 t)$$

Since coupling capacitor is large so low frequency signal will be filtered out, and best approximation is

$$V_0 \approx -150B\sin 10^6 t$$

Hence (D) is correct option.

MCQ 1.36 If $X = 1$ in logic equation $[X + Z\{\overline{Y} + (\overline{Z} + X\overline{Y})\}]\{\overline{X} + \overline{X}(X + Y)\} = 1$, then

(A) $Y = Z$
(B) $Y = \overline{Z}$
(C) $Z = 1$
(D) $Z = 0$

SOL 1.36 We have $[X+Z\{\overline{Y}+(\overline{Z}+X\overline{Y})\}][\overline{X}+\overline{Z}(X+Y)]=1$

Substituting $X=1$ and $\overline{X}=0$ we get

$[1+Z\{\overline{Y}+(\overline{Z}+1\,\overline{Y})\}][0+\overline{Z}(1+Y)]=1$

or $[1][\overline{Z}(1)]=1$ $\qquad 1+A=1$ and $0+A=A$

or $\overline{Z}=1 \leftrightarrow Z=0$

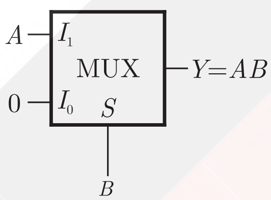
Hence (D) is correct answer

MCQ 1.37 What are the minimum number of 2- to -1 multiplexers required to generate a 2- input AND gate and a 2- input Ex-OR gate

(A) 1 and 2 (B) 1 and 3

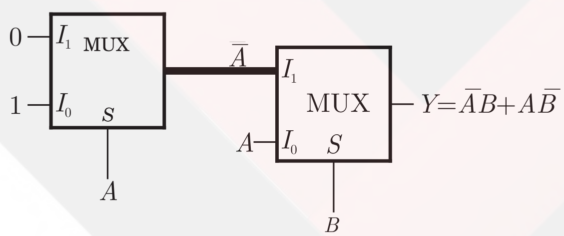
(C) 1 and 1 (D) 2 and 2

SOL 1.37 The AND gate implementation by 2:1 mux is as follows



$$Y=\overline{A}I_0+AI_1=AB$$

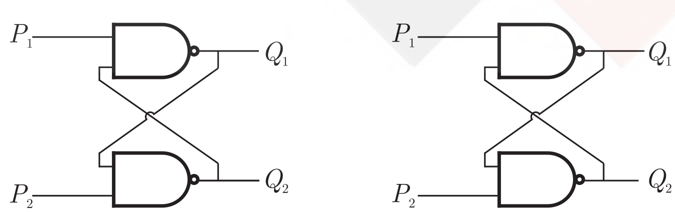
The $EX-OR$ gate implementation by 2:1 mux is as follows



$$Y=\overline{B}I_0+BI_1=A\overline{B}+B\overline{A}$$

Hence (A) is correct answer.

MCQ 1.38 Refer to the NAND and NOR latches shown in the figure. The inputs (P_1, P_2) for both latches are first made (0, 1) and then, after a few seconds, made (1, 1). The corresponding stable outputs (Q_1, Q_2) are



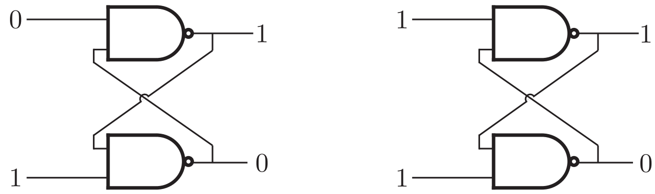
(A) NAND: first (0, 1) then (0, 1) NOR: first (1, 0) then (0, 0)

(B) NAND : first (1, 0) then (1, 0) NOR : first (1, 0) then (1, 0)

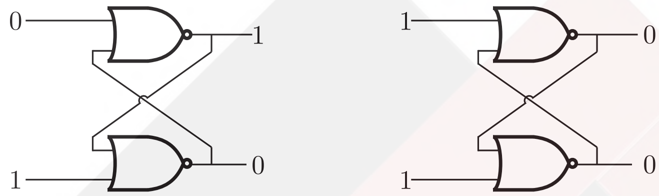
(C) NAND : first (1, 0) then (1, 0) NOR : first (1, 0) then (0, 0)

(D) NAND : first (1, 0) then (1, 1) NOR : first (0, 1) then (0, 1)

SOL 1.38 For the NAND latche the stable states are as follows

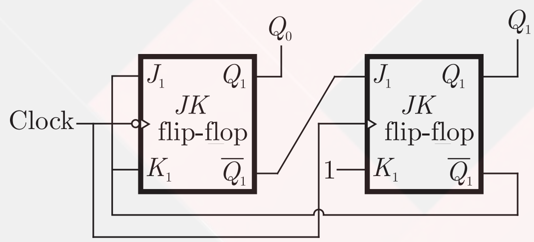


For the NOR latche the stable states are as follows



Hence (C) is correct answer.

MCQ 1.39 What are the counting states (Q_1, Q_2) for the counter shown in the figure below



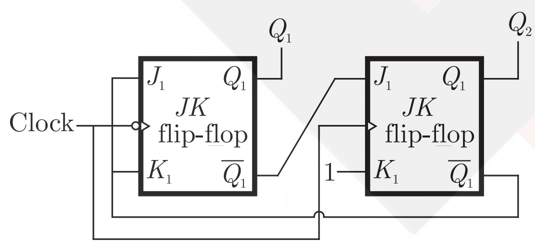
(A) 11, 10, 00, 11, 10,...

(B) 01, 10, 11, 00, 01...

(C) 00, 11, 01, 10, 00...

(D) 01, 10, 00, 01, 10...

SOL 1.39 The given circuit is as follows.



The truth table is as shown below. Sequence is 00, 11, 10, 00 ...

CLK	J_1	K_1	Q_1	J_2	K_2	Q_2
1	1	1	0	1	1	0
2	1	1	1	1	1	1
3	0	0	1	0	1	0
4	1	1	0	1	1	0

Hence (A) is correct answer.

MCQ 1.40 A system with transfer function $H(z)$ has impulse response $h(.)$ defined as $h(2)=1, h(3)=-1$ and $h(k)=0$ otherwise. Consider the following statements.

S1 : $H(z)$ is a low-pass filter.

S2 : $H(z)$ is an FIR filter.

Which of the following is correct?

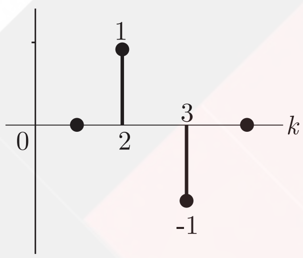
(A) Only S2 is true

(B) Both S1 and S2 are false

(C) Both S1 and S2 are true, and S2 is a reason for S1

(D) Both S1 and S2 are true, but S2 is not a reason for S1

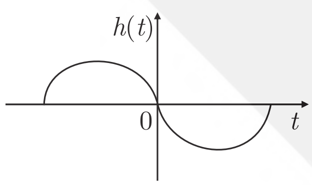
SOL 1.40 We have $h(2)=1,\ h(3)=-1$ otherwise $h(k)=0$. The diagram of response is as follows :



It has the finite magnitude values. So it is a finite impulse response filter. Thus S_2 is true but it is not a low pass filter. So S_1 is false.

Hence (A) is correct answer.

MCQ 1.41 Consider a system whose input x and output y are related by the equation $y(t)=\int_{-\infty}^{\infty} x(t-\tau)\, g(2\tau)\, d\tau$ where $h(t)$ is shown in the graph.



Which of the following four properties are possessed by the system ?

BIBO : Bounded input gives a bounded output.

Causal : The system is causal,

LP : The system is low pass.

LTI : The system is linear and time-invariant.

(A) Causal, LP

(B) BIBO, LTI

(C) BIBO, Causal, LTI

(D) LP, LTI

SOL 1.41 Here $h(t)\neq 0$ for $t<0$. Thus system is non causal. Again any bounded input $x(t)$ gives bounded output $y(t)$. Thus it is BIBO stable.

Here we can conclude that option (B) is correct.
Hence (B) is correct answer.

MCQ 1.42 The 4-point Discrete Fourier Transform (DFT) of a discrete time sequence {1,0,2,3} is

(A) $[0,\ -2+2j,\ 2,\ -2-2j]$ (B) $[2,\ 2+2j,\ 6,\ 2-2j]$

(C) $[6,\ 1-3j,\ 2,\ 1+3j]$ (D) $[6,\ -1+3j,\ 0,\ -1-3j]$

SOL 1.42 Hence (D) is correct answer

We have $x[n] = \{1,0,2,3)$ and $N=4$

$$X[k] = \sum_{n=0}^{N-1} x[n]\, e^{-j2\pi nk/N} \quad k = 0,1...N-1$$

For $N=4$, $$X[k] = \sum_{n=0}^{3} x[n]\, e^{-j2\pi nk/4} \quad k = 0,1,...3$$

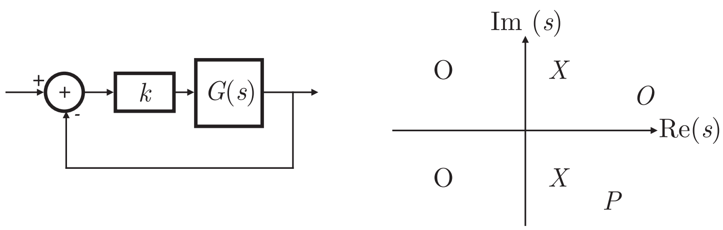
Now $$X[0] = \sum_{n=0}^{3} x[n]$$
$$= x[0]+x[1]+x[2]+x[3] = 1+0+2+3 = 6$$
$$x[1] = \sum_{n=0}^{3} x[n]\, e^{-j\pi n/2}$$
$$= x[0]+x[1]\, e^{-j\pi/2}+x[2]\, e^{-j\pi}+x[3]\, e^{-j\pi 3/2}$$
$$= 1+0-2+j3 = -1+j3$$
$$X[2] = \sum_{n=0}^{3} x[n]\, e^{-j\pi n}$$
$$= x[0]+x[1]\, e^{-j\pi}+x[2]\, e^{-j2\pi}+x[3]\, e^{-j\pi 3}$$
$$= 1+0+2-3 = 0$$
$$X[3] = \sum_{n=0}^{3} x[n]\, e^{-j3\pi n/2}$$
$$= x[0]+x[1]\, e^{-j3\pi/2}+x[2]\, e^{-j3\pi}+x[3]\, e^{-j9\pi/2}$$
$$= 1+0-2-j3 = -1-j3$$

Thus $[6, -1+j3,\ \ 0, -1-j3]$

MCQ 1.43 The feedback configuration and the pole-zero locations of

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

are shown below. The root locus for negative values of k, i.e. for $-\infty < k < 0$, has breakaway/break-in points and angle of departure at pole P (with respect to the positive real axis) equal to



(A) $\pm\sqrt{2}$ and 0° (B) $\pm\sqrt{2}$ and 45°

(C) $\pm\sqrt{3}$ and 0° (D) $\pm\sqrt{3}$ and 45°

SOL 1.43 The characteristic equation is

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

or $$1 + \frac{K(s^2 - 2s + 2)}{s^2 + 2s + 2} = 0$$

or $$s^2 + 2s + 2 + K(s^2 - 2s + 2) = 0$$

or $$K = -\frac{s^2 + 2s + 2}{s^2 - 2s + 2}$$

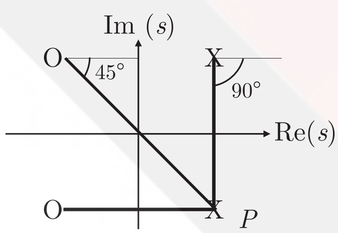
For break away & break in point differentiating above w.r.t. s we have

$$\frac{dK}{ds} = -\frac{(s^2 - 2s + 2)(2s + 2) - (s^2 + 2s + 2)(2s - 2)}{(s^2 - 2s + 2)^2} = 0$$

Thus $$(s^2 - 2s + 2)(2s + 2) - (s^2 + 2s + 2)(2s - 2) = 0$$

or $$s = \pm\sqrt{2}$$

Let θ_d be the angle of departure at pole P, then



$$-\theta_d - \theta_{p1} + \theta_{z1} + \theta_{z2} = 180^\circ$$

$$-\theta_d = 180^\circ - (-\theta_{p1} + \theta_{z1} + \theta_2)$$

$$= 180^\circ - (90^\circ + 180 - 45^\circ) = -45^\circ$$

Hence (B) is correct option.

MCQ 1.44 An LTI system having transfer function $\frac{s^2+1}{s^2+2s+1}$ and input $x(t) = \sin(t+1)$ is in steady state. The output is sampled at a rate ω_s rad/s to obtain the final output $\{x(k)\}$. Which of the following is true ?

(A) $y(.)$ is zero for all sampling frequencies ω_s

(B) $y(.)$ is nonzero for all sampling frequencies ω_s

(C) $y(.)$ is nonzero for $\omega_s > 2$, but zero for $\omega_s < 2$

(D) $y(.)$ is zero for $\omega_s > 2$, but nonzero for $\omega_2 < 2$

SOL 1.44 Hence (A) is correct answer.

MCQ 1.45 The unit step response of an under-damped second order system has steady state value of -2. Which one of the following transfer functions has theses properties ?

(A) $\frac{-2.24}{s^2+2.59s+1.12}$ (B) $\frac{-3.82}{s^2+1.91s+1.91}$

(C) $\frac{-2.24}{s^2-2.59s+1.12}$ (D) $\frac{-382}{s^2-1.91s+1.91}$

SOL 1.45 For under-damped second order response

$$T(s) = \frac{k\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2} \qquad \text{where } \xi < 1$$

Thus (A) or (B) may be correct

For option (A) $\omega_n = 1.12$ and $2\xi\omega_n = 2.59 \rightarrow \xi = 1.12$

For option (B) $\omega_n = 1.91$ and $2\xi\omega_n = 1.51 \rightarrow \xi = 0.69$

Hence (B) is correct option.

MCQ 1.46 A discrete random variable X takes values from 1 to 5 with probabilities as shown in the table. A student calculates the mean X as 3.5 and her teacher calculates the variance of X as 1.5. Which of the following statements is true ?

k	1	2	3	4	5
$P(X=k)$	0.1	0.2	0.3	0.4	0.5

(A) Both the student and the teacher are right
(B) Both the student and the teacher are wrong
(C) The student is wrong but the teacher is right
(D) The student is right but the teacher is wrong

SOL 1.46 Hence (B) is correct option.

The mean is

$$\begin{aligned}\overline{X} &= \Sigma x_i p_i(x)\\ &= 1\times0.1+2\times0.2+3\times0.4+4\times0.2+5\times0.1\\ &= 0.1+0.4+1.2+0.8+0.5 = 3.0\\ \overline{X^2} &= \Sigma x_i^2 p_i(x)\\ &= 1\times0.1+4\times0.2+9\times0.4+16\times0.2+25\times0.1\\ &= 0.1+0.8+3.6+3.2+2.5 = 10.2\end{aligned}$$

Variance $\sigma_x^2 = \overline{X^2} - (\overline{X})^2$

$= 10.2 - (3)^2 = 1.2$

MCQ 1.47 A message signal given by $m(t) = (\frac{1}{2})\cos\omega_1 t - (\frac{1}{2})\sin\omega_2 t$ amplitude - modulated with a carrier of frequency ω_C to generator $s(t)[1+m(t)]\cos\omega_c t$. What is the power efficiency achieved by this modulation scheme ?

(A) 8.33% (B) 11.11%

(C) 20% (D) 25%

SOL 1.47 Hence (C) is correct option.

$$m(t) = \frac{1}{2}\cos\omega_1 t - \frac{1}{2}\sin\omega_2 t$$

$$s_{AM}(t) = [1 + m(t)]\cos\omega_c t$$

Modulation index

$$= \frac{|m(t)|_{\max}}{V_c}$$

$$m = \sqrt{\left(\frac{1}{2}\right)^2 + \left(\frac{1}{2}\right)^2} = \frac{1}{\sqrt{2}}$$

$$\eta = \frac{m^2}{m^2+2}\times 100\% = \frac{\left(\frac{1}{\sqrt{2}}\right)^2}{\left(\frac{1}{\sqrt{2}}\right)^2 + 2}\times 100\% = 20\%$$

MCQ 1.48 A communication channel with AWGN operating at a signal to noise ration $SNR >> 1$ and bandwidth B has capacity C_1. If the SNR is doubled keeping constant, the resulting capacity C_2 is given by

(A) $C_2 \approx 2C_1$ (B) $C_2 \approx C_1 + B$

(C) $C_2 \approx C_1 + 2B$ (D) $C_2 \approx C_1 + 0.3B$

SOL 1.48 Hence (B) is correct option.

We have $$C_1 = B\log_2\left(1 + \frac{S}{N}\right)$$

$$\approx B\log_2\left(\frac{S}{N}\right) \qquad \text{As } \frac{S}{N} >> 1$$

If we double the $\frac{S}{N}$ ratio then

$$C_2 \approx B\log_2\left(\frac{2S}{N}\right)$$

$$\approx B\log_2 2 + B\log_2\frac{S}{N}$$

$$\approx B + C_1$$

MCQ 1.49 A magnetic field in air is measured to be

$$\vec{B} = B_0\left(\frac{x}{x^2+y^2}\hat{y} - \frac{y}{x^2+y^2}\hat{x}\right)$$

What current distribution leads to this field ?

[Hint : The algebra is trivial in cylindrical coordinates.]

(A) $\vec{J} = \frac{B_0\hat{z}}{\mu_0}\left(\frac{1}{x^2+y^2}\right), r \neq 0$ (B) $\vec{J} = -\frac{B_0\hat{z}}{\mu_0}\left(\frac{2}{x^2+y^2}\right), r \neq 0$

(C) $\vec{J} = 0, r \neq 0$ (D) $\vec{J} = \frac{B_0\hat{z}}{\mu_0}\left(\frac{1}{x^2+y^2}\right), r \neq 0$

SOL 1.49 Hence (C) is correct option.

We have $$\vec{B} = B_0\left(\frac{x}{x^2+y^2}a_y - \frac{y}{x^2+y^2}a_x\right) \qquad ...(1)$$

To convert in cylindrical substituting

$$x = r\cos\phi \text{ and } y = r\sin\phi$$

$$a_x = \cos\phi a_r - \sin\phi a_\phi$$

and $$a_y = \sin\phi a_r + \cos\phi a_\phi$$

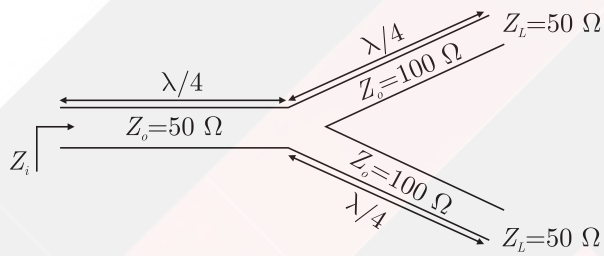
In (1) we have

$$\vec{B} = \vec{B}_0 a_\phi$$

Now $$\vec{H} = \frac{\vec{B}}{\mu_0} = \frac{\vec{B}_0 a_\phi}{\mu_0} \qquad \text{constant}$$

$$\vec{J} = \nabla\times\vec{H} = 0 \qquad \text{since } H \text{ is constant}$$

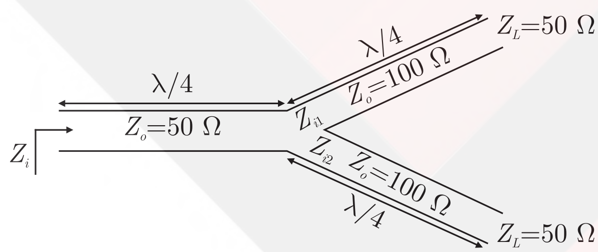
MCQ 1.50 A transmission line terminates in two branches, each of length $\frac{\lambda}{4}$, as shown. The branches are terminated by 50Ω loads. The lines are lossless and have the characteristic impedances shown. Determine the impedance Z_i as seen by the source.



(A) 200Ω (B) 100Ω

(C) 50Ω (D) 25Ω

SOL 1.50 The transmission line are as shown below. Length of all line is $\frac{\lambda}{4}$



$$Z_{i1} = \frac{Z_{01}^2}{Z_{L1}} = \frac{100^2}{50} = 200\Omega$$

$$Z_{i2} = \frac{Z_{02}^2}{Z_{L2}} = \frac{100^2}{50} = 200\Omega$$

$$Z_{L3} = Z_{i1}\| Z_{i2} = 200\Omega\| 200\Omega = 100\Omega$$

$$Z_i = \frac{Z_0^2}{Z_{L3}} = \frac{50^2}{100} = 25\Omega$$

Hence (D) is correct option.

Common Date for Question 51 and 52 :

Consider a silicon $p-n$ junction at room temperature having the following parameters:

Doping on the n-side $= 1 \times 10^{17}$ cm-3

Depletion width on the n-side $= 0.1 \mu m$

Depletion width on the p-side $= 1.0 \mu m$

Intrinsic carrier concentration $= 1.4 \times 10^{10}$ cm-3

Thermal voltage $= 26$ mV

Permittivity of free space $= 8.85 \times 10^{-14}$ F.cm-1

Dielectric constant of silicon $= 12$

MCQ 1.51 The built-in potential of the junction

(A) is 0.70 V

(B) is 0.76 V

(C) is 0.82 V

(D) Cannot be estimated from the data given

SOL 1.51 Hence option (B) is correct.

We know that

$$N_A W_P = N_D W_N$$

or $$N_A = \frac{N_D W_N}{W_P} = \frac{1 \times 10^{17} \times 0.1 \times 10^{-6}}{1 \times 10^{-6}} = 1 \times 10^{16}$$

The built-in potential is

$$V_{bi} = V_T \, 1\text{n}\left(\frac{N_A N_D}{n_i^2}\right)$$

$$= 26 \times 10^{-3} \ln\left(\frac{1 \times 10^{17} \times 1 \times 10^{16}}{(1.4 \times 10^{10})^2}\right) = 0.760$$

MCQ 1.52 The peak electric field in the device is

(A) 0.15 MV . cm-1, directed from p-region to n-region

(B) 0.15 MV . cm-1, directed from n-region to p-region

(C) 1.80 MV . cm-1, directed from p-retion to n-region

(D) 1.80 MV . cm-1, directed from n-region to p-region

SOL 1.52 The peak electric field in device is directed from p to n and is

$$E = -\frac{eN_D x_n}{\varepsilon_s} \qquad \text{from } p \text{ to } n$$

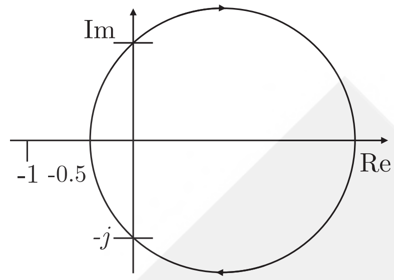
$$= \frac{eN_D x_n}{\varepsilon_s} \qquad \text{from } n \text{ to } p$$

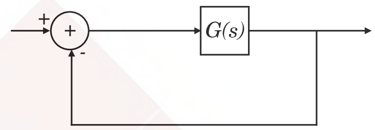
$$= \frac{1.6 \times 10^{-19} \times 1 \times 10^{17} \times 1 \times 10^{-5}}{8.85 \times 10^{-14} \times 12} = 0.15 \text{MV/cm}$$

Hence option (B) is correct.

Common Data for Questions 53 and 54 :

The Nyquist plot of a stable transfer function $G(s)$ is shown in the figure are interested in the stability of the closed loop system in the feedback configuration shown.





MCQ 1.53 Which of the following statements is true ?

(A) $G(s)$ is an all-pass filter

(B) $G(s)$ has a zero in the right-half plane

(C) $G(s)$ is the impedance of a passive network

(D) $G(s)$ is marginally stable

SOL 1.53 The plot has one encirclement of origin in clockwise direction. Thus $G(s)$ has a zero is in RHP.
Hence (B) is correct option.

MCQ 1.54 The gain and phase margins of $G(s)$ for closed loop stability are

(A) 6 dB and 180° (B) 3 dB and 180°

(C) 6 dB and 90° (D) 3 dB and 90°

SOL 1.54 The Nyzuist plot intersect the real axis ate - 0.5. Thus

$$\text{G. M.} = -20\log x = -20\log 0.5 = 6.020 \text{ dB}$$

And its phase margin is 90°.
Hence (C) is correct option.

Common data for Questions 55 & 56 :

The amplitude of a random signal is uniformly distributed between -5 V and 5 V.

MCQ 1.55 If the signal to quantization noise ratio required in uniformly quantizing the signal is 43.5 dB, the step of the quantization is approximately

(A) 0.033 V (B) 0.05 V

(C) 0.0667 V (D) 0.10 V

SOL 1.55 Hence (C) is correct option.
We have $SNR = 1.76 + 6n$

or $$43.5 = 1.76 + 6n$$
$$6n = 43.5 + 1.76$$
$$6n = 41.74 \longrightarrow n \approx 7$$

No. of quantization level is
$$2^7 = 128$$

Step size required is
$$= \frac{V_H - V_L}{128} = \frac{5-(-5)}{128} = \frac{10}{128}$$
$$= .078125$$
$$\approx .0667$$

MCQ 1.56 If the positive values of the signal are uniformly quantized with a step size of 0.05 V, and the negative values are uniformly quantized with a step size of 0.1 V, the resulting signal to quantization noise ration is approximately

(A) 46 dB (B) 43.8 dB

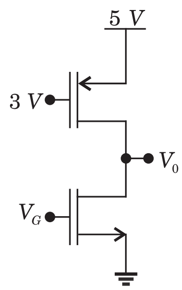
(C) 42 dB (D) 40 dB

SOL 1.56 For positive values step size
$$s_+ = 0.05 \text{ V}$$
For negative value step size
$$s_- = 0.1 \text{ V}$$
No. of quantization in $+ive$ is
$$= \frac{5}{s_+} = \frac{5}{0.05} = 100$$
Thus $$2^{n+} = 100 \longrightarrow n^+ = 7$$
No. of quantization in $-ve$
$$Q_1 = \frac{5}{s_-} = \frac{5}{0.1} = 50$$
Thus $$2^{n^-} = 50 \longrightarrow n^- = 6$$
$$\left(\frac{S}{N}\right)_+ = 1.76 + 6n^+ = 1.76 + 42 = 43.76 \text{ dB}$$
$$\left(\frac{S}{N}\right)_- = 1.76 + 6n^- = 1.76 + 36 = 37.76 \text{ dB}$$
Best $$\left(\frac{S}{N}\right)_0 = 43.76 \text{ dB}$$

Hence (B) is correct option.

Statement for Linked Answer Question 57 and 58 :

Consider for CMOS circuit shown, where the gate voltage v_0 of the n-MOSFET is increased from zero, while the gate voltage of the p $-$MOSFET is kept constant at 3 V. Assume, that, for both transistors, the magnitude of the threshold voltage is 1 V and the product of the trans-conductance parameter is 1mA. V^{-2}



MCQ 1.57 For small increase in V_G beyond 1V, which of the following gives the correct description of the region of operation of each MOSFET

(A) Both the MOSFETs are in saturation region

(B) Both the MOSFETs are in triode region

(C) n-MOSFETs is in triode and $p-$MOSFET is in saturation region

(D) n- MOSFET is in saturation and $p-$MOSFET is in triode region

SOL 1.57 For small increase in V_G beyond 1 V the $n-$ channel MOSFET goes into saturation as $V_{GS} \to +\,ive$ and $p-$ MOSFET is always in active region or triode region.
Hence (D) is correct option.

MCQ 1.58 Estimate the output voltage V_0 for $V_G = 1.5$ V. [Hints : Use the appropriate current-voltage equation for each MOSFET, based on the answer to Q.57]

(A) $4 - \frac{1}{\sqrt{2}}$ (B) $4 + \frac{1}{\sqrt{2}}$

(C) $4 - \frac{\sqrt{3}}{2}$ (D) $4 + \frac{\sqrt{3}}{2}$

SOL 1.58 Hence (C) is correct option.

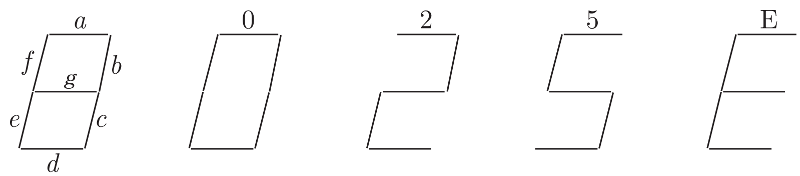
Statement for Linked Answer Question 59 & 60 :

Two products are sold from a vending machine, which has two push buttons P_1 and P_2.
When a buttons is pressed, the price of the corresponding product is displayed in a 7 - segment display. If no buttons are pressed, '0' is displayed signifying 'Rs 0'.
If only P_1 is pressed, '2' is displayed, signifying 'Rs. 2'

If only P_2 is pressed '5' is displayed, signifying 'Rs. 5'

If both P_1 and P_2 are pressed, 'E' is displayed, signifying 'Error'

The names of the segments in the 7 - segment display, and the glow of the display for '0', '2', '5' and 'E' are shown below.



Consider

(1) push buttons pressed/not pressed in equivalent to logic 1/0 respectively.

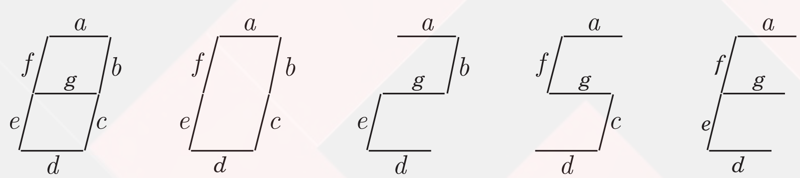
(2) a segment glowing/not glowing in the display is equivalent to logic 1/0 respectively.

MCQ 1.59 If segments a to g are considered as functions of P_1 and P_2, then which of the following is correct

(A) $g = \overline{P}_1 + P_2,\ d = c + e$ (B) $g = P_1 + P_2,\ d = c + e$

(C) $g = \overline{P}_1 + P_2,\ e = b + c$ (D) $g = P_1 + P_2,\ e = b + c$

SOL 1.59 The given situation is as follows



P_1=0, P_2=0 P_1=1 P_2=1 P_1=1, P_2=1

The truth table is as shown below

P_1	P_2	a	b	c	d	e	f	g
0	0	1	1	1	1	1	1	0
0	1	1	0	1	1	0	1	1
1	0	1	1	0	1	1	0	1
1	1	1	0	0	1	1	1	1

From truth table we can write

$$a = 1$$

$$b = \overline{P}_1\overline{P}_2 + P_1\overline{P}_2 = \overline{P}_2 \qquad \text{1 NOT Gate}$$

$$c = \overline{P}_1\overline{P}_2 + \overline{P}_1 P_2 = \overline{P}_1 \qquad \text{1 NOT Gate}$$

$$d = 1 = c + e$$

and

$$c = \overline{\overline{P}_1 P_2} = P_1 + \overline{P}_2 \qquad \text{1 OR GATE}$$

$$f = \overline{P_1\overline{P}_2} = \overline{P}_1 + P_2 \qquad \text{1 OR GATE}$$

$$g = \overline{\overline{P}_1\overline{P}_2} = P_1 + P_2 \qquad \text{1 OR GATE}$$

Thus we have $g = P_1 + P_2$ and $d = 1 = c + e$. It may be observed easily from figure that

Led g does not glow only when both P_1 and P_2 are 0. Thus

$$g = P_1 + P_2$$

LED d is 1 all condition and also it depends on

$$d = c + e$$

Hence (B) is correct answer.

MCQ 1.60 What are the minimum numbers of NOT gates and 2 - input OR gates required to design the logic of the driver for this 7 - Segment display

(A) 3 NOT and 4 OR
(B) 2 NOT and 4 OR
(C) 1 NOT and 3 OR
(D) 2 NOT and 3 OR

SOL 1.60 As shown in previous solution 2 NOT gates and 3-OR gates are required.
Hence (D) is correct answer.

Answer Sheet

1.	(B)	13.	(C)	25.	(A)	37.	(A)	49.	(C)
2.	(A)	14.	(A)	26.	(D)	38.	(C)	50.	(D)
3.	(B)	15.	(A)	27.	(B)	39.	(A)	51.	(B)
4.	(C)	16.	(D)	28.	(B)	40.	(A)	52.	(B)
5.	(C)	17.	(C)	29.	(C)	41.	(B)	53.	(B)
6.	(C)	18.	(C)	30.	(A)	42.	(D)	54.	(C)
7.	(A)	19.	(C)	31.	(A)	43.	(B)	55.	(C)
8.	(C)	20.	(D)	32.	(D)	44.	(A)	56.	(B)
9.	(*)	21.	(C)	33.	(A)	45.	(B)	57.	(D)
10.	(A)	22.	(D)	34.	(D)	46.	(B)	58.	(C)
11.	(C)	23.	(B)	35.	(D)	47.	(C)	59.	(B)
12.	(*)	24.	(B)	36.	(D)	48.	(B)	60.	(D)