GATE EC 2008

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

MCQ 1.1 All the four entries of the 2×2 matrix $=\begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix}$ are nonzero, and one of its eigenvalue is zero. Which of the following statements is true?

(A) $p_{11}p_{12} - p_{12}p_{21} = 1$ (B) $p_{11}p_{22} - p_{12}p_{21} = -1$

(C) $p_{11}p_{22} - p_{12}p_{21} = 0$ (D) $p_{11}p_{22} + p_{12}p_{21} = 0$

SOL 1.1 The product of Eigen value is equal to the determinant of the matrix. Since one of the Eigen value is zero, the product of Eigen value is zero, thus determinant of the matrix is zero.

Thus $p_{11}p_{22} - p_{12}p_{21} = 0$

Hence (C) is correct answer.

MCQ 1.2 The system of linear equations

$$4x + 2y = 7$$
$$2x + y = 6 \text{ has}$$

(A) a unique solution (B) no solution

(C) an infinite number of solutions (D) exactly two distinct solutions

SOL 1.2 The given system is

$$\begin{bmatrix} 4 & 2 \\ 2 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 7 \\ 6 \end{bmatrix}$$

We have $A = \begin{bmatrix} 4 & 2 \\ 2 & 1 \end{bmatrix}$

and $|A| = \begin{vmatrix} 4 & 2 \\ 2 & 1 \end{vmatrix} = 0$ Rank of matrix $\rho(A) < 2$

Now $C = \left[\begin{array}{cc|c} 4 & 2 & 7 \\ 2 & 1 & 6 \end{array}\right]$ Rank of matrix $\rho(C) = 2$

Since $\rho(A) \neq \rho(C)$ there is no solution.

Hence (B) is correct answer.

MCQ 1.3 The equation $\sin(z) = 10$ has

(A) no real or complex solution

(B) exactly two distinct complex solutions

(C) a unique solution

(D) an infinite number of complex solutions

SOL 1.3 $\sin z$ can have value between -1 to $+1$. Thus no solution.
Hence (A) is correct solution.

MCQ 1.4 For real values of x, the minimum value of the function
$f(x) = \exp(x) + \exp(-x)$ is

(A) 2 (B) 1

(C) 0.5 (D) 0

SOL 1.4 Hence (A) is correct answer.

We have $f(x) = e^x + e^{-x}$

For $x > 0$, $e^x > 1$ and $0 < e^{-x} < 1$

For $x < 0$, $0 < e^x < 1$ and $e^{-x} > 1$

Thus $f(x)$ have minimum values at $x = 0$ and that is $e^0 + e^{-0} = 2$.

MCQ 1.5 Which of the following functions would have only odd powers of x in its Taylor series expansion about the point $x = 0$?

(A) $\sin(x^3)$ (B) $\sin(x^2)$

(C) $\cos(x^3)$ (D) $\cos(x^2)$

SOL 1.5 Hence (A) is correct answer.

$$\sin x = x + \frac{x^3}{3!} + \frac{x^5}{5!} + \dots$$

$$\cos x = 1 + \frac{x^2}{2!} + \frac{x^4}{4!} + \dots$$

Thus only $\sin(x^3)$ will have odd power of x.

MCQ 1.6 Which of the following is a solution to the differential equation $\frac{dx(t)}{dt} + 3x(t) = 0$?

(A) $x(t) = 3e^{-t}$ (B) $x(t) = 2e^{-3t}$

(C) $x(t) = -\frac{3}{2}t^2$ (D) $x(t) = 3t^2$

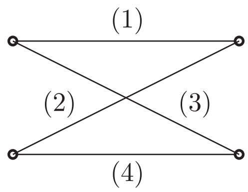
SOL 1.6 Hence (B) is correct answer.

We have $$\frac{dx(t)}{dt} + 3x(t) = 0$$

or $$(D+3)\,x(t) = 0$$

Since $m = -3$, $x(t) = Ce^{-3t}$ Thus only (B) may be solution.

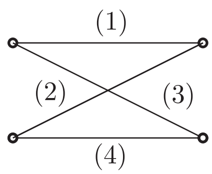
MCQ 1.7 In the following graph, the number of trees (P) and the number of cut-set (Q) are



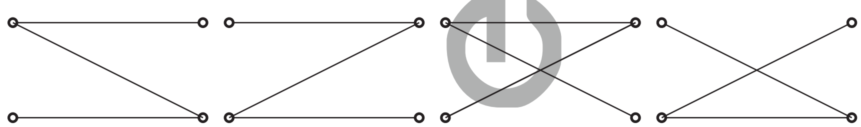
(A) $P = 2, Q = 2$ (B) $P = 2, Q = 6$

(C) $P = 4, Q = 6$ (D) $P = 4, Q = 10$

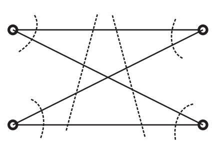
SOL 1.7 The given graph is



There can be four possible tree of this graph which are as follows:

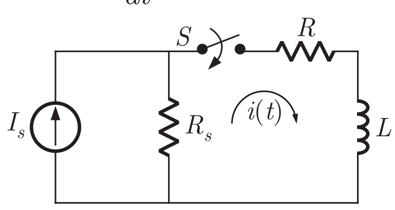


There can be 6 different possible cut-set.



Hence (C) is correct option.

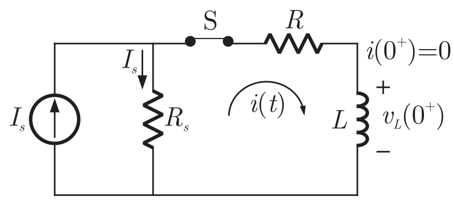
MCQ 1.8 In the following circuit, the switch S is closed at $t = 0$. The rate of change of current $\frac{di}{dt}(0^+)$ is given by



(A) 0 (B) $\frac{R_s I_s}{L}$

(C) $\frac{(R + R_s) I_s}{L}$ (D) ∞

SOL 1.8 Initially $i(0^-) = 0$ therefore due to inductor $i(0^+) = 0$. Thus all current I_s will flow in resistor R and voltage across resistor will be $I_s R_s$. The voltage across inductor will be equal to voltage across R_s as no current flow through R.



Thus $v_L(0^+) = I_s R_s$

but $v_L(0^+) = L\dfrac{di(0^+)}{dt}$

Thus $\dfrac{di(0^+)}{dt} = \dfrac{v_L(0^+)}{L} = \dfrac{I_s R_s}{L}$

Hence (B) is correct option.

MCQ 1.9 The input and output of a continuous time system are respectively denoted by $x(t)$ and $y(t)$. Which of the following descriptions corresponds to a causal system ?

(A) $y(t) = x(t-2) + x(t+4)$ (B) $y(t) = (t-4)\,x(t+1)$

(C) $y(t) = (t+4)\,x(t-1)$ (D) $y(t) = (t+5)\,x(t+5)$

SOL 1.9 The output of causal system depends only on present and past states only.
In option (A) $y(0)$ depends on $x(-2)$ and $x(4)$.
In option (B) $y(0)$ depends on $x(1)$.
In option (C) $y(0)$ depends on $x(-1)$.
In option (D) $y(0)$ depends on $x(5)$.
Thus only in option (C) the value of $y(t)$ at $t=0$ depends on $x(-1)$ past value. In all other option present value depends on future value.
Hence (C) is correct answer

MCQ 1.10 The impulse response $h(t)$ of a linear time invariant continuous time system is described by $h(t) = \exp(\alpha t)\,u(t) + \exp(\beta t)\,u(-t)$ where $u(-t)$ denotes the unit step function, and α and β are real constants. This system is stable if

(A) α is positive and β is positive

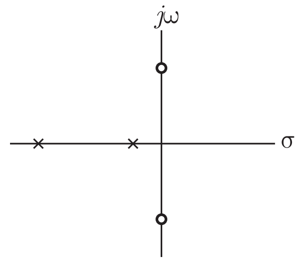
(B) α is negative and β is negative

(C) α is negative and β is negative

(D) α is negative and β is positive

SOL 1.10 Hence (D) is correct answer.
We have $h(t) = e^{\alpha t}u(t) + e^{\beta t}u(-t)$
This system is stable only when bounded input has bounded output For stability $\alpha t < 0$ for $t > 0$ that implies $\alpha < 0$ and $\beta t > 0$ for $t > 0$ that implies $\beta > 0$. Thus, α is negative and β is positive.

MCQ 1.11 The pole-zero given below correspond to a



(A) Law pass filter (B) High pass filter

(C) Band filter (D) Notch filter

SOL 1.11 Percent overshoot depends only on damping ratio, ξ.

$$M_p = e^{-\xi\pi\sqrt{1-\xi^2}}$$

If M_p is same then ξ is also same and we get

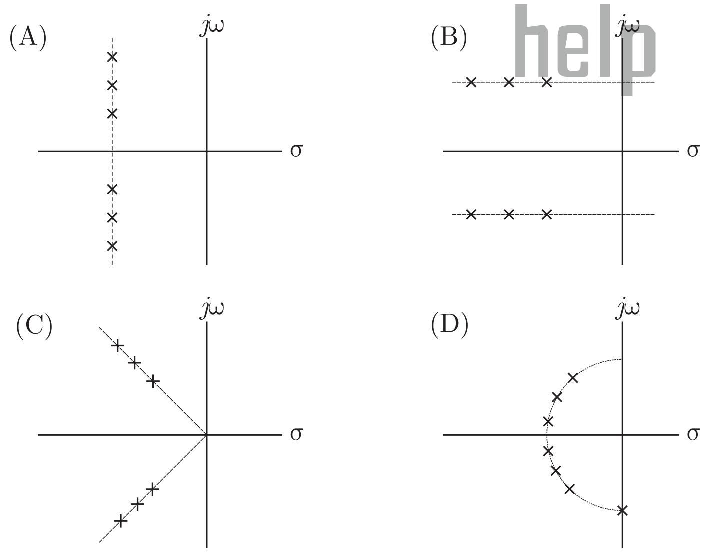
$$\xi = \cos\theta$$

Thus $\theta =$ constant

The option (C) only have same angle.

Hence (C) is correct option.

MCQ 1.12 Step responses of a set of three second-order underdamped systems all have the same percentage overshoot. Which of the following diagrams represents the poles of the three systems ?



SOL 1.12 Transfer function for the given pole zero plot is:

$$\frac{(s+Z_1)(s+Z_2)}{(s+P_1)(s+P_2)}$$

From the plot Re (P_1 and P_2)>(Z_1 and Z_2)

So, these are two lead compensator.

Hence both high pass filters and the system is high pass filter.

Hence (C) is correct option.

MCQ 1.13 Which of the following is NOT associated with a $p-n$ junction ?

(A) Junction Capacitance
(B) Charge Storage Capacitance
(C) Depletion Capacitance
(D) Channel Length Modulations

SOL 1.13 Channel length modulation is not associated with a $p-n$ junction. It is being associated with MOSFET in which effective channel length decreases, producing the phenomenon called channel length modulation.
Hence option (D) is correct.

MCQ 1.14 Which of the following is true?

(A) A silicon wafer heavily doped with boron is a p^+ substrate
(B) A silicon wafer lightly doped with boron is a p^+ substrate
(C) A silicon wafer heavily doped with arsenic is a p^+ substrate
(D) A silicon wafer lightly doped with arsenic is a p^+ substrate

SOL 1.14 Trivalent impurities are used for making $p-$ type semiconductors. So, Silicon wafer heavily doped with boron is a p^+ substrate.
Hence option (A) is correct

MCQ 1.15 For a Hertz dipole antenna, the half power beam width (HPBW) in the E-plane is

(A) 360°
(B) 180°
(C) 90°
(D) 45°

SOL 1.15 The beam-width of Hertizian dipole is 180° and its half power beam-width is 90°.
Hence (C) is correct option

MCQ 1.16 For static electric and magnetic fields in an inhomogeneous source-free medium, which of the following represents the correct form of Maxwell's equations ?

(A) $\nabla\cdot E=0$, $\nabla\times B=0$
(B) $\nabla\cdot E=0$, $\nabla\cdot B=0$
(C) $\nabla\times E=0$, $\nabla\times B=0$
(D) $\nabla\times E=0$, $\nabla\cdot B=0$

SOL 1.16 Maxwell equations

$$\nabla-\vec{B}=0$$
$$\nabla\cdot\vec{E}=\rho/E$$
$$\nabla\times\vec{E}=-\vec{B}$$
$$\nabla\times\hat{H}=\vec{D}+\vec{J}$$

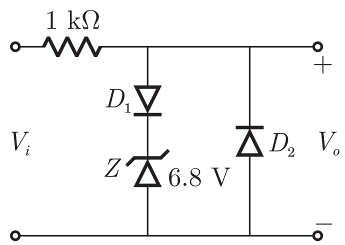
For static electric magnetic fields

$$\nabla\cdot\vec{B}=0$$
$$\nabla\cdot\vec{E}=\rho/E$$
$$\nabla\times\vec{E}=0$$
$$\nabla\times\widehat{H}=\vec{J}$$

Hence (D) is correct option

MCQ 1.17 In the following limiter circuit, an input voltage $V_i = 10 \sin 100\pi t$ is applied. Assume that the diode drop is 0.7 V when it is forward biased. When it is forward biased. The zener breakdown voltage is 6.8 V

The maximum and minimum values of the output voltage respectively are



(A) 6.1 V, – 0.7 V (B) 0.7 V, – 7.5 V

(C) 7.5 V, – 0.7 V (D) 7.5 V, – 7.5 V

SOL 1.17 For the positive half of V_i, the diode D_1 is forward bias, D_2 is reverse bias and the zener diode is in breakdown state because $V_i > 6.8$.

Thus output voltage is

$$V_0 = 0.7 + 6.8 = 7.5 \text{ V}$$

For the negative half of V_i, D_2 is forward bias thus

Then $V_0 = -0.7$ V

Hence (C) is correct option

MCQ 1.18 A silicon wafer has 100 nm of oxide on it and is furnace at a temperature above 1000° C for further oxidation in dry oxygen. The oxidation rate

(A) is independent of current oxide thickness and temperature

(B) is independent of current oxide thickness but depends on temperature

(C) slows down as the oxide grows

(D) is zero as the existing oxide prevents further oxidation

SOL 1.18 Oxidation rate is zero because the existing oxide prevent the further oxidation. Hence option (D) is correct.

MCQ 1.19 The drain current of MOSFET in saturation is given by $I_D = K(V_{GS} - V_T)^2$ where K is a constant.

The magnitude of the transconductance g_m is

(A) $\dfrac{K(V_{GS} - V_T)^2}{V_{DS}}$ (B) $2K(V_{GS} - V_T)$

(C) $\dfrac{I_d}{V_{GS} - V_{DS}}$ (D) $\dfrac{K(V_{GS} - V_T)^2}{V_{GS}}$

SOL 1.19 Hence option (B) is correct.

$$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{\partial}{\partial V_{GS}} K(V_{GS} - V_T)^2 = 2K(V_{GS} - V_T)$$

MCQ 1.20 Consider the amplitude modulated (AM) signal $A_c \cos \omega_c t + 2 \cos \omega_m t \cos \omega_c t$. For demodulating the signal using envelope detector, the minimum value of A_c should be

(A) 2 (B) 1

(C) 0.5 (D) 0

SOL 1.20 Hence (A) is correct option

We have
$$x_{AM}(t) = A_c \cos \omega_c + 2 \cos \omega_m t \cos \omega_c t$$
$$= A_C \left(1 + \frac{2}{A_c} \cos \omega_m t\right) \cos \omega_c t$$

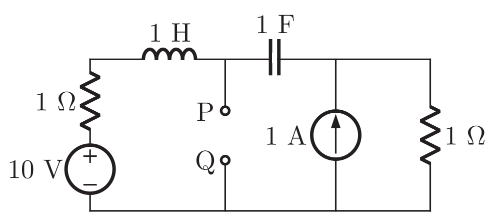
For demodulation by envelope demodulator modulation index must be less than or equal to 1.

Thus
$$\frac{2}{A_c} \leq 1$$
$$A_c \geq 2$$

Hence minimum value of $A_c = 2$

Q.21 to Q.75 carry two marks each

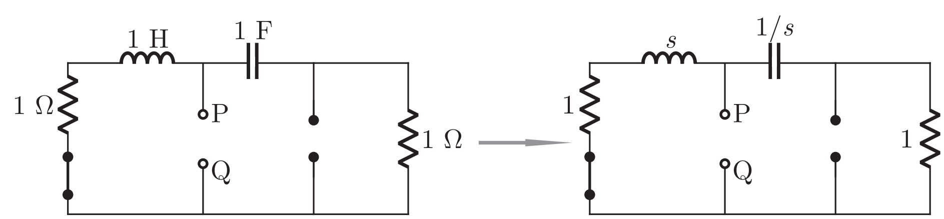
MCQ 1.21 The Thevenin equivalent impedance Z_{th} between the nodes P and Q in the following circuit is



(A) 1 (B) $1 + s + \frac{1}{s}$

(C) $2 + s + \frac{1}{s}$ (D) $\frac{s^2 + s + 1}{s^2 + 2s + 1}$

SOL 1.21 Killing all current source and voltage sources we have,



$$Z_{th} = (1 + s) \| (\tfrac{1}{s} + 1)$$
$$= \frac{(1 + s)(\frac{1}{s} + 1)}{(1 + s) + (\frac{1}{s} + 1)} = \frac{[\frac{1}{s} + 1 + 1 + s]}{s + \frac{1}{s} + 1 + 1}$$

or $\quad Z_{th} = 1$

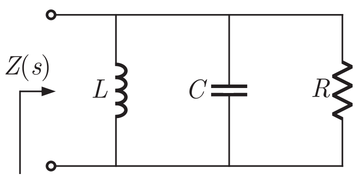
Alternative :

Here at DC source capacitor act as open circuit and inductor act as short circuit. Thus we can directly calculate thevenin Impedance as 1 Ω

Hence (A) is correct option.

MCQ 1.22 The driving point impedance of the following network is given by

$$Z(s) = \frac{0.2s}{s^2 + 0.1s + 2}$$



The component values are

(A) $L = 5\,\text{H}, R = 0.5\,\Omega, C = 0.1\,\text{F}$

(B) $L = 0.1\,\text{H}, R = 0.5\,\Omega, C = 5\,\text{F}$

(C) $L = 5\,\text{H}, R = 2\,\Omega, C = 0.1\,\text{F}$

(D) $L = 0.1\,\text{H}, R = 2\,\Omega, C = 5\,\text{F}$

SOL 1.22 Hence (D) is correct option.

$$Z(s) = R \left\| \frac{1}{sC} \right\| sL = \frac{\frac{s}{C}}{s^2 + \frac{s}{RC} + \frac{1}{LC}}$$

We have been given

$$Z(s) = \frac{0.2s}{s^2 + 0.1s + 2}$$

Comparing with given we get

$$\frac{1}{C} = 0.2 \text{ or } C = 5 \text{ F}$$

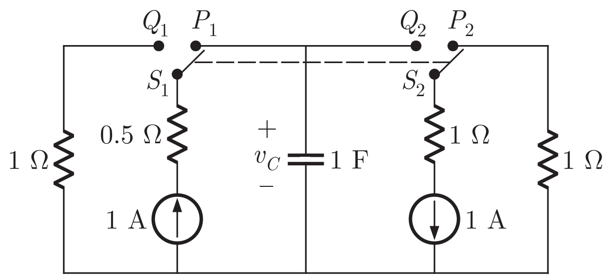
$$\frac{1}{RC} = 0.1 \text{ or } R = 2\,\Omega$$

$$\frac{1}{LC} = 2 \text{ or } L = 0.1 \text{ H}$$

MCQ 1.23 The circuit shown in the figure is used to charge the capacitor C alternately from two current sources as indicated. The switches S_1 and S_2 are mechanically coupled and connected as follows:

For $2nT \le t \le (2n+1)\,T$, $(n = 0,1,2,..)$ S_1 to P_1 and S_2 to P_2

For $(2n+1)\,T \le t \le (2n+2)\,T$, $(n = 0,1,2,...)$ S_1 to Q_1 and S_2 to Q_2



Assume that the capacitor has zero initial charge. Given that $u(t)$ is a unit step function , the voltage $v_c(t)$ across the capacitor is given by

(A) $\sum_{n=1}^{\infty}(-1)^n tu(t-nT)$

(B) $u(t)+2\sum_{n=1}^{\infty}(-1)^n u(t-nT)$

(C) $tu(t)+2\sum_{n=1}^{\infty}(-1)^n u(t-nT)(t-nT)$

(D) $\sum_{n=1}^{\infty}[0.5-e^{-(t-2nT)}+0.5e^{-(t-2nT)}-T]$

SOL 1.23 Voltage across capacitor is

$$V_c = \frac{1}{C}\int_0^t i dt$$

Here $C=1$ F and $i=1$ A. Therefore

$$V_c = \int_0^t dt$$

For $0<t<T$, capacitor will be charged from 0 V

$$V_c = \int_0^t dt = t$$

At $t=T, V_c = T$ Volts

For $T<t<2T$, capacitor will be discharged from T volts as

$$V_c = T - \int_T^t dt = 2T-t$$

At $t=2T, V_c=0$ volts

For $2T<t<3T$, capacitor will be charged from 0 V

$$V_c = \int_{2T}^t dt = t-2T$$

At $t=3T, V_c = T$ Volts

For $3T<t<4T$, capacitor will be discharged from T Volts

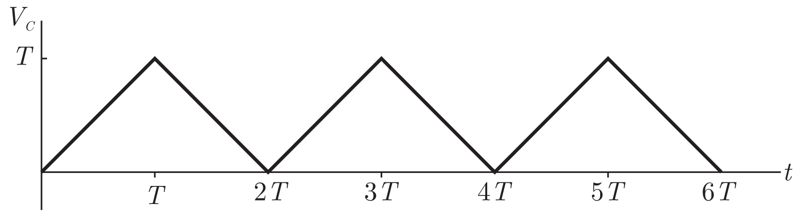
$$V_c = T - \int_{3T}^t dt = 4T-t$$

At $t=4T, V_c=0$ Volts

For $4T<t<5T$, capacitor will be charged from 0 V

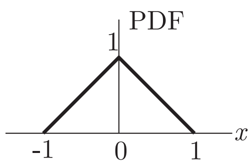
$$V_c = \int_{4T}^t dt = t-4T$$

At $t = 5T, V_c = T$ Volts
Thus the output waveform is

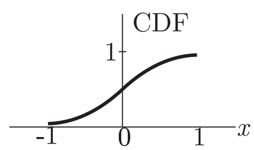


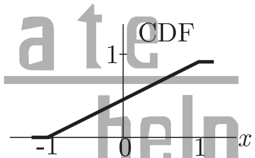
Only option C satisfy this waveform.
Hence (C) is correct option.

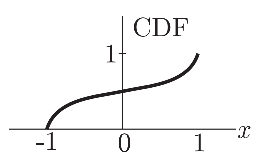
MCQ 1.24 The probability density function (pdf) of random variable is as shown below

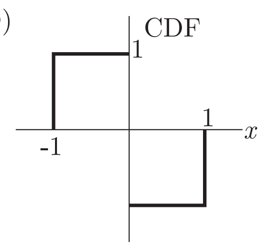


The corresponding commutative distribution function CDF has the form

(A)


(B)


(C)


(D)


SOL 1.24 CDF is the integration of PDF. Plot in option (A) is the integration of plot given in question.
Hence (A) is correct option.

MCQ 1.25 The recursion relation to solve $x = e^{-x}$ using Newton - Raphson method is

(A) $x_{n+1} = e^{-x_n}$

(B) $x_{n+1} = x_n - e^{-x_n}$

(C) $x_{n+1} = (1 + x_n)\dfrac{e^{-x_n}}{1 + e^{-x_n}}$

(D) $x_{n+1} = \dfrac{x_n^2 - e^{-x_n}(1 - x_n) - 1}{x_n - e^{-x_n}}$

SOL 1.25 Hence (C) is correct answer.

We have $x = e^{-x}$

or $f(x) = x - e^{-x}$

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

The Newton-Raphson iterative formula is

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

Now $\quad f(x_n) = x_n - e^{-x_n}$

$$f'(x_n) = 1 + e^{-x_n}$$

Thus $\quad x_{n+1} = x_n - \frac{x_n - e^{-x_n}}{1 + e^{-x_n}} = \frac{(1 + x_n)\, e^{-x_n}}{1 + e^{-x_n}}$

MCQ 1.26 The residue of the function $f(z) = \frac{1}{(z+2)^2(z-2)^2}$ at $z = 2$ is

(A) $-\frac{1}{32}$ (B) $-\frac{1}{16}$

(C) $\frac{1}{16}$ (D) $\frac{1}{32}$

SOL 1.26 Hence (A) is correct answer.

$$\text{Res } f(z)_{z=a} = \frac{1}{(n-1)!}\frac{d^{n-1}}{dz^{n-1}}[(z-a)^n f(z)]_{z=a}$$

Here we have $n = 2$ and $a = 2$

Thus $\quad \text{Res } f(z)_{z=2} = \frac{1}{(2-1)!}\frac{d}{dz}\left[(z-2)^2\frac{1}{(z-2)^2(z+2)^2}\right]_{z=a}$

$$= \frac{d}{dz}\left[\frac{1}{(z+2)^2}\right]_{z=a} = \left[\frac{-2}{(z+2)^3}\right]_{z=a}$$

$$= -\frac{2}{64} = -\frac{1}{32}$$

MCQ 1.27 Consider the matrix $P = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$. The value of e^p is

(A) $\begin{bmatrix} 2e^{-2} - 3e^{-1} & e^{-1} - e^{-2} \\ 2e^{-2} - 2e^{-1} & 5e^{-2} - e^{-1} \end{bmatrix}$ (B) $\begin{bmatrix} e^{-1} + e^{-1} & 2e^{-2} - e^{-1} \\ 2e^{-1} - 4e^{2} & 3e^{-1} + 2e^{-2} \end{bmatrix}$

(C) $\begin{bmatrix} 5e^{-2} - e^{-1} & 3e^{-1} - e^{-2} \\ 2e^{-2} - 6e^{-1} & 4e^{-2} + 6^{-1} \end{bmatrix}$ (D) $\begin{bmatrix} 2e^{-1} - e^{-2} & e^{-1} - e^{-2} \\ -2e^{-1} + 2e^{-2} & -e^{-1} + 2e^{-2} \end{bmatrix}$

SOL 1.27 Hence (D) is correct answer.

$$e^P = L^{-1}[(s\boldsymbol{I} - \boldsymbol{A})^{-1}]$$

$$= L^{-1}\left(\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\right)^{-1}$$

$$= L^{-1}\left(\begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix}^{-1}\right)$$

$$= L^{-1}\left(\begin{bmatrix} \frac{s+3}{(s+1)(s+2)} & \frac{1}{(s+1)(s+2)} \\ \frac{-2}{(s+1)(s+2)} & \frac{s}{(s+1)(s+2)} \end{bmatrix}\right)$$

$$= \begin{bmatrix} 2e^{-1} - e^{-2} & e^{-1} - e^{-2} \\ -2e^{-1} + 2e^{-2} & -e^{-1} + 2e^{-2} \end{bmatrix}$$

MCQ 1.28 In the Taylor series expansion of $\exp(x)+\sin(x)$ about the point $x=\pi$, the coefficient of $(x-\pi)^2$ is

(A) $\exp(\pi)$ (B) $0.5\exp(\pi)$

(C) $\exp(\pi)+1$ (D) $\exp(\pi)-1$

SOL 1.28 Taylor series is given as

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

For $x=\pi$ we have

Thus $$f(x) = f(\pi) + \frac{x-\pi}{1!}f'(\pi) + \frac{(x-\pi)^2}{2!}f''(x)\ldots$$

Now
$$f(x) = e^x + \sin x$$
$$f'(x) = e^x + \cos x$$
$$f''(x) = e^x - \sin x$$
$$f''(\pi) = e^\pi - \sin\pi = e^\pi$$

Thus the coefficient of $(x-\pi)^2$ is $\frac{f''(\pi)}{2!}$

Hence (B) is correct answer.

MCQ 1.29 $P_x(x) = M\exp(-2|x|) - N\exp(-3|x|)$ is the probability density function for the real random variable X, over the entire x axis, M and N are both positive real numbers. The equation relating M and N is

(A) $M-\frac{2}{3}N=1$ (B) $2M+\frac{1}{3}N=1$

(C) $M+N=1$ (D) $M+N=3$

SOL 1.29 Correct Option is ( )

MCQ 1.30 The value of the integral of the function $g(x,y) = 4x^3+10y^4$ along the straight line segment from the point $(0,0)$ to the point $(1,2)$ in the $x-y$ plane is

(A) 33 (B) 35

(C) 40 (D) 56

SOL 1.30 The equation of straight line from $(0,0)$ to $(1,2)$ is $y=2x$.

Now $g(x,y) = 4x^3+10y^4$

or, $g(x,2x) = 4x^3+160x^4$

Now $\int_0^1 g(x,2x) = \int_0^1 (4x^3+160x^4)\,dx$

$= [x^4+32x^5]_0^1 = 33$

Hence (A) is correct answer.

MCQ 1.31 A linear, time - invariant, causal continuous time system has a rational transfer function with simple poles at $s=-2$ and $s=-4$ and one simple zero at $s=-1$.

A unit step $u(t)$ is applied at the input of the system. At steady state, the output has constant value of 1. The impulse response of this system is

(A) $[\exp(-2t) + \exp(-4t)]\,u(t)$

(B) $[-4\exp(-2t) - 12\exp(-4t) - \exp(-t)]\,u(t)$

(C) $[-4\exp(-2t) + 12\exp(-4t)]\,u(t)$

(D) $[-0.5\exp(-2t) + 1.5\exp(-4t)]\,u(t)$

SOL 1.31 Hence (C) is correct answer.

$$G(s) = \frac{K(s+1)}{(s+2)(s+4)}, \text{ and } R(s) = \frac{1}{s}$$

$$C(s) = G(s)R(s) = \frac{K(s+1)}{s(s+2)(s+4)}$$

$$= \frac{K}{8s} + \frac{K}{4(s+2)} - \frac{3K}{8(s+4)}$$

Thus $\quad c(t) = K\left[\frac{1}{8} + \frac{1}{4}e^{-2t} - \frac{3}{8}e^{-4t}\right]u(t)$

At steady-state , $c(\infty) = 1$

Thus $\quad \frac{K}{8} = 1$ or $K = 8$

Then, $\quad G(s) = \frac{8(s+1)}{(s+2)(s+4)} = \frac{12}{(s+4)} - \frac{4}{(s+2)}$

$$h(t) = L^{-1}G(s) = (-4e^{-2t} + 12e^{-4t})\,u(t)$$

MCQ 1.32 The signal $x(t)$ is described by

$$x(t) = \begin{cases} 1 & \text{for} -1 \le t \le +1 \\ 0 & \text{otherwise} \end{cases}$$

Two of the angular frequencies at which its Fourier transform becomes zero are

(A) $\pi,\ 2\pi$

(B) $0.5\pi,\ 1.5\pi$

(C) $0,\ \pi$

(D) $2\pi,\ 2.5\pi$

SOL 1.32 Hence (A) is correct answer.

We have $x(t) = \begin{cases} 1 & \text{for} -1 \le t \le +1 \\ 0 & \text{otherwise} \end{cases}$

Fourier transform is

$$\int_{-\infty}^{\infty} e^{-j\omega t}x(t)\,dt = \int_{-1}^{1} e^{-j\omega t}1\,dt$$

$$= \frac{1}{-j\omega}\left[e^{-j\omega t}\right]_{-1}^{1}$$

$$= \frac{1}{-j\omega}(e^{-j\omega} - e^{j\omega}) = \frac{1}{-j\omega}(-2j\sin\omega)$$

$$= \frac{2\sin\omega}{\omega}$$

This is zero at $\omega = \pi$ and $\omega = 2\pi$

MCQ 1.33 A discrete time linear shift - invariant system has an impulse response $h[n]$ with $h[0] = 1, h[1] = -1, h[2] = 2$, and zero otherwise The system is given an input sequence $x[n]$ with $x[0] = x[2] = 1$, and zero otherwise. The number of nonzero samples in the output sequence $y[n]$, and the value of $y[2]$ are respectively

(A) 5, 2 (B) 6, 2

(C) 6, 1 (D) 5, 3

SOL 1.33 Hence (D) is correct answer.

Given
$$h(n) = [1, -1, 2]$$
$$x(n) = [1, 0, 1]$$
$$y(n) = x(n) * h(n)$$

The length of $y[n]$ is

$= L_1 + L_2 - 1 = 3 + 3 - 1 = 5$

$$y(n) = x(n) * h(n) = \sum_{k=-\infty}^{\infty} x(k)\,h(n-k)$$

$$y(2) = \sum_{k=-\infty}^{\infty} x(k)\,h(2-k)$$
$$= x(0)\,h(2-0) + x(1)\,h(2-1) + x(2)\,h(2-2)$$
$$= h(2) + 0 + h(0) = 1 + 2 = 3$$

There are 5 non zero sample in output sequence and the value of $y[2]$ is 3.

MCQ 1.34 Consider points P and Q in the $x-y$ plane, with $P = (1,0)$ and $Q = (0,1)$. The line integral $2\int_P^Q (xdx + ydy)$ along the semicircle with the line segment PQ as its diameter

(A) is -1

(B) is 0

(C) is 1

(D) depends on the direction (clockwise or anit-clockwise) of the semicircle

SOL 1.34 Hence (B) is correct answer.

$$I = 2\int_P^Q (xdx + ydy)$$
$$= 2\int_P^Q xdx + 2\int_P^Q ydy$$
$$= 2\int_1^0 xdx + 2\int_0^1 ydy = 0$$

MCQ 1.35 Let $x(t)$ be the input and $y(t)$ be the output of a continuous time system. Match the system properties P1, P2 and P3 with system relations R1, R2, R3, R4

Properties	Relations
P1 : Linear but NOT time - invariant	R1 : $y(t) = t^2 x(t)$
P2 : Time - invariant but NOT linear	R2 : $y(t) = t\lvert x(t)\rvert$

P3 : Linear and time - invariant

R3 : $y(t) = |x(t)|$
R4 : $y(t) = x(t-5)$

(A) (P1, R1), (P2, R3), (P3, R4)
(B) (P1, R2), (P2, R3), (P3, R4)
(C) (P1, R3), (P2, R1), (P3, R2)
(D) (P1, R1), (P2, R2), (P3, R3)

SOL 1.35 Mode function are not linear. Thus $y(t) = |x(t)|$ is not linear but this functions is time invariant. Option (A) and (B) may be correct.
The $y(t) = t|x(t)|$ is not linear, thus option (B) is wrong and (a) is correct. We can see that
R_1: $y(t) = t^2 x(t)$ Linear and time variant.
R_2: $y(t) = t|x(t)|$ Non linear and time variant.
R_3: $y(t) = x|(t)|$ Non linear and time invariant
R_4: $y(t) = x(t-5)$ Linear and time invariant
Hence (B) is correct answer.

MCQ 1.36 A memory less source emits n symbols each with a probability p. The entropy of the source as a function of n

(A) increases as $\log n$
(B) decreases as $\log\left(\frac{1}{n}\right)$
(C) increases as n
(D) increases as $n \log n$

SOL 1.36 The entropy is

$$H = \sum_{i=1}^{m} p_i \log_2 \frac{1}{p_i} \text{ bits}$$

Since $$p_1 = p_2 = \dots = p_n = \frac{1}{n}$$

$$H = \sum_{i=1}^{n} \frac{1}{n} \log n = \log n$$

Hence (A) is correct option.

MCQ 1.37 $\{x(n)\}$ is a real - valued periodic sequence with a period N. $x(n)$ and $X(k)$ form N-point Discrete Fourier Transform (DFT) pairs. The DFT $Y(k)$ of the sequence $y(n) = \frac{1}{N}\sum_{r=0}^{N-1} x(r)\, x(n+r)$ is

(A) $|X(k)|^2$
(B) $\frac{1}{N}\sum_{r=0}^{N-1} X(r)\, X(k+r)$
(C) $\frac{1}{N}\sum_{r=0}^{N-1} X(r)\, X(k+r)$
(D) 0

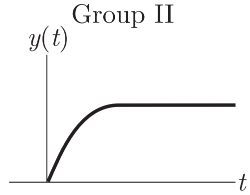
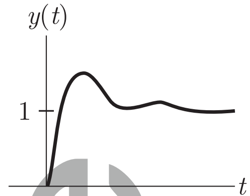
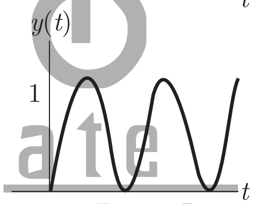
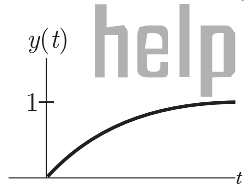
SOL 1.37 Hence (A) is correct answer.

Given : $$y(n) = \frac{1}{N}\sum_{r=0}^{N-1} x(r)\, x(n+r)$$

It is Auto correlation.

Hence $\quad y(n) = r_{xx}(n) \xrightarrow{DFT} |X(k)|^2$

MCQ 1.38 Group I lists a set of four transfer functions. Group II gives a list of possible step response $y(t)$. Match the step responses with the corresponding transfer functions.

Group I	Group II
$P = \frac{25}{s^2 + 25}$	(1) 
$Q = \frac{36}{s^2 + 20s + 36}$	(2) 
$R = \frac{36}{s^2 + 12s + 36}$	(3) 
$S = \frac{49}{s^2 + 7s + 49}$	(4) 

(A) $P-3, Q-1, R-4, S-2$ (B) $P-3, Q-2, R-4, S-1$

(C) $P-2, Q-1, R-4, S-2$ (D) $P-3, Q-4, R-1, S-2$

SOL 1.38 Hence (D) is correct option.

$P = \frac{25}{s^2 + 25}$ $\quad 2\xi\omega_n = 0, \xi = 0 \rightarrow$ Undamped $\quad$ Graph 3

$Q = \frac{6^2}{s^2 + 20s + 6^2}$ $\quad 2\xi\omega_n = 20, \xi > 1 \rightarrow$ Overdamped $\quad$ Graph 4

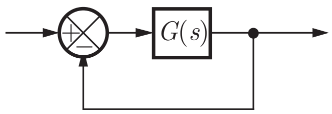
$R = \frac{6^2}{s^2 + 12s + 6^2}$ $\quad 2\xi\omega_n = 12, \xi = 1 \rightarrow$ Critically $\quad$ Graph 1

$S = \frac{7^2}{s^2 + 7s + 7^2}$ $\quad 2\xi\omega_n = 7, \xi < 1 \rightarrow$ underdamped $\quad$ Graph 2

MCQ 1.39 A certain system has transfer function

$$G(s) = \frac{s + 8}{s^2 + \alpha s - 4}$$

where α is a parameter. Consider the standard negative unity feedback configuration as shown below



Which of the following statements is true?

(A) The closed loop systems is never stable for any value of α

(B) For some positive value of α, the closed loop system is stable, but not for all positive values.

(C) For all positive values of α, the closed loop system is stable.

(D) The closed loop system stable for all values of α, both positive and negative.

SOL 1.39 Hence (C) is correct option.

The characteristic equation of closed lop transfer function is

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

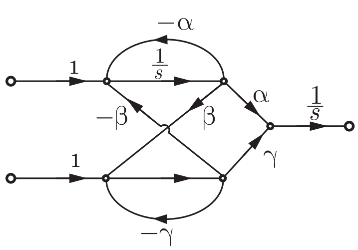
$$1 + \frac{s+8}{s^2 + \alpha s - 4} = 0$$

or $$s^2 + \alpha s - 4 + s + 8 = 0$$

or $$s^2 + (\alpha + 1)s + 4 = 0$$

This will be stable if $(\alpha + 1) > 0 \to \alpha > -1$. Thus system is stable for all positive value of α.

MCQ 1.40 A signal flow graph of a system is given below



The set of equalities that corresponds to this signal flow graph is

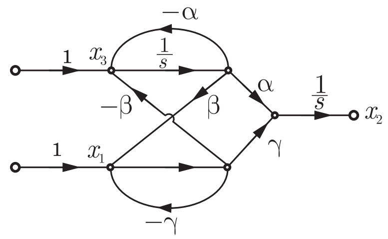
(A) $\frac{d}{dt}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{bmatrix} \beta & -\gamma & 0 \\ \gamma & \alpha & 0 \\ -\alpha & \beta & 0 \end{bmatrix}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 1 \\ 1 & 0 \end{bmatrix}\begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$

(B) $\frac{d}{dt}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{bmatrix} 0 & \alpha & \gamma \\ 0 & -\alpha & -\gamma \\ 0 & \beta & -\beta \end{bmatrix}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}\begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$

(C) $\frac{d}{dt}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{bmatrix} -\alpha & \beta & 0 \\ -\beta & -\gamma & 0 \\ \alpha & \gamma & 0 \end{bmatrix}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}\begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$

(D) $\frac{d}{dt}\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{bmatrix} -\alpha & 0 & \beta \\ \gamma & 0 & \alpha \\ -\beta & 0 & -\alpha \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}\begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$

SOL 1.40 We labeled the given SFG as below :



From this SFG we have

$$\dot{x}_1 = -\gamma x_1 + \beta x_3 + \mu_1$$
$$\dot{x}_2 = \gamma x_1 + \alpha x_3$$
$$\dot{x}_3 = -\beta x_1 - \alpha x_3 + u_2$$

Thus $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -\gamma & 0 & \beta \\ \gamma & 0 & \alpha \\ -\beta & 0 & -\alpha \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 & 1 \\ 0 & 0 \\ 1 & 0 \end{bmatrix}\begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$

Hence (C) is correct option.

MCQ 1.41 The number of open right half plane of

$$G(s) = \frac{10}{s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3} \text{ is}$$

(A) 0 (B) 1

(C) 2 (D) 3

SOL 1.41 The characteristic equation is

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

or $s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3 = 0$

Substituting $s = \frac{1}{z}$ we have

$$3z^5 + 5z^4 + 6z^3 + 3z^2 + 2z + 1 = 0$$

The routh table is shown below. As there are tow sign change in first column, there are two RHS poles.

z^5	3	6	2
z^4	5	3	1
z^3	$\frac{21}{5}$	$\frac{7}{5}$	
z^2	$\frac{4}{3}$	3	
z^1	$-\frac{7}{4}$		
z^0	1		

Hence (C) is correct option.

MCQ 1.42 The magnitude of frequency responses of an underdamped second order system is 5 at 0 rad/sec and peaks to $\frac{10}{\sqrt{3}}$ at $5\sqrt{2}$ rad/sec. The transfer function of the system is

(A) $\frac{500}{s^2 + 10s + 100}$

(B) $\frac{375}{s^2 + 5s + 75}$

(C) $\frac{720}{s^2 + 12s + 144}$

(D) $\frac{1125}{s^2 + 25s + 225}$

SOL 1.42 For underdamped second order system the transfer function is

$$T(s) = \frac{K\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

It peaks at resonant frequency. Therefore

Resonant frequency $\omega_r = \omega_n\sqrt{1 - 2\xi^2}$

and peak at this frequency

$$\mu_r = \frac{5}{2\xi\sqrt{1 - \xi^2}}$$

We have $\omega_r = 5\sqrt{2}$, and $\mu_r = \frac{10}{\sqrt{3}}$. Only options (A) satisfy these values.

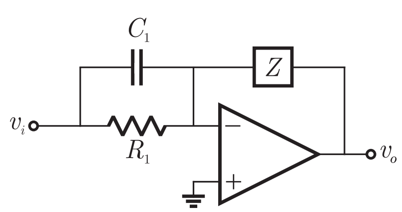
$$\omega_n = 10,\ \xi = \frac{1}{2}$$

where $\omega_r = 10\sqrt{1 - 2\left(\frac{1}{4}\right)} = 5\sqrt{2}$

and $\mu_r = \frac{5}{2\frac{1}{2}\sqrt{1 - \frac{1}{4}}} = \frac{10}{\sqrt{3}}$ Hence satisfied

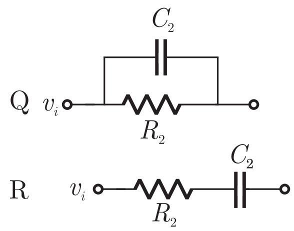
Hence (C) is correct option.

MCQ 1.43 Group I gives two possible choices for the impedance Z in the diagram. The circuit elements in Z satisfy the conditions $R_2 C_2 > R_1 C_1$. The transfer functions $\frac{V_0}{V_i}$ represents a kind of controller.



Match the impedances in Group I with the type of controllers in Group II

Group I | Group I



1. PID controller
2. Lead Compensator
3. Lag Compensator

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

SOL 1.43 The given circuit is a inverting amplifier and transfer function is

$$\frac{V_o}{V_i} = \frac{-Z}{\frac{R_1}{sC_1R_1+1}} = \frac{-Z(sC_1R_1+1)}{R_1}$$

For Q, $$Z = \frac{(sC_2R_2+1)}{sC_2}$$

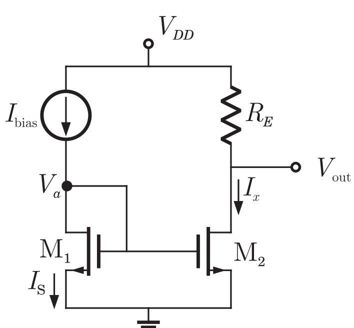
$$\frac{V_o}{V_i} = -\frac{(sC_2R_2+1)}{sC_2}\times\frac{(sC_1R_1+1)}{R_1}$$ PID Controller

For R, $$Z = \frac{R_2}{(sC_2R_2+1)}$$

$$\frac{V_o}{V_i} = -\frac{R_2}{(sC_2R_2+1)}\times\frac{(sC_1R_1+1)}{R_1}$$

Since $R_2C_2 > R_1C_1$, it is lag compensator.
Hence (B) is correct option.

MCQ 1.44 For the circuit shown in the following figure, transistor $M1$ and $M2$ are identical $NMOS$ transistors. Assume the $M2$ is in saturation and the output is unloaded.



The current I_x is related to I_{bias} as

(A) $I_x = I_{bias} + I_s$ (B) $I_x = I_{bias}$
(C) $I_x = I_{bias} - \left(V_{DD} - \frac{V_{out}}{R_E}\right)$ (D) $I_x = I_{bias} - I_s$

SOL 1.44 By Current mirror,

$$I_x = \frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1} I_{bias}$$

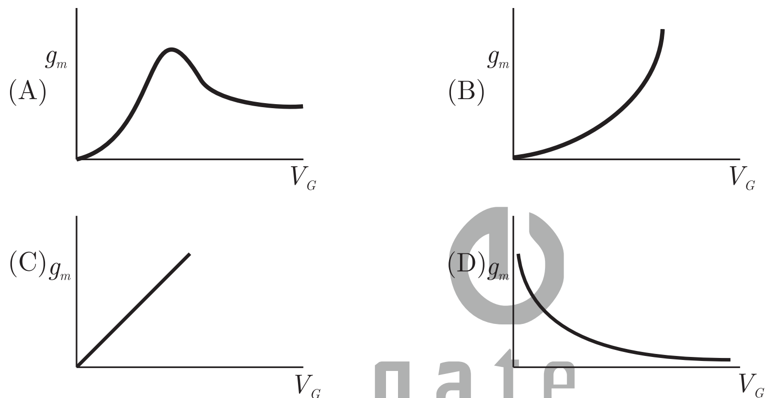
Since MOSFETs are identical,

Thus $\left(\frac{W}{L}\right)_2 = \left(\frac{W}{L}\right)_2$

Hence $I_x = I_{bias}$

Hence (B) is correct option.

MCQ 1.45 The measured trans conductance g_m of an NMOS transistor operating in the linear region is plotted against the gate voltage V_G at a constant drain voltage V_D. Which of the following figures represents the expected dependence of g_m on V_G ?

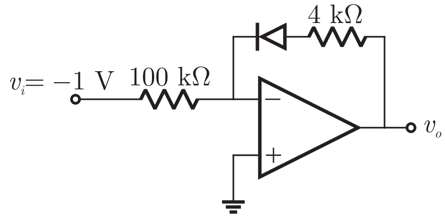


SOL 1.45 Hence option (C) is correct.

As $V_D = \text{constant}$

Thus $g_m \propto (V_{GS} - V_T)$ Which is straight line.

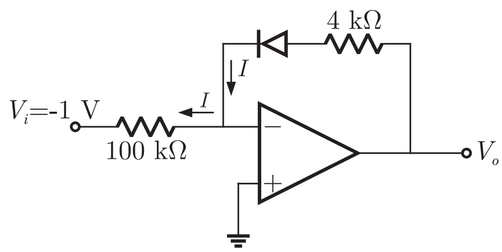
MCQ 1.46 Consider the following circuit using an ideal OPAMP. The I-V characteristic of the diode is described by the relation $I = I_0\left(e^{\frac{V}{V_t}-1}\right)$ where $V_T = 25$ mV, $I_0 = 1\mu$A and V is the voltage across the diode (taken as positive for forward bias). For an input voltage $V_i = -1$ V, the output voltage V_0 is



(A) 0 V (B) 0.1 V

(C) 0.7 V (D) 1.1 V

SOL 1.46 The circuit is using ideal OPAMP. The non inverting terminal of OPAMP is at ground, thus inverting terminal is also at virtual ground.



Thus current will flow from -ive terminal (0 Volt) to -1 Volt source. Thus the current I is

$$I = \frac{0-(-1)}{100k} = \frac{1}{100k}$$

The current through diode is

$$I = I_0\left(e^{\frac{V}{V_t}} - 1\right)$$

Now $V_T = 25$ mV and $I_0 = 1$ μA

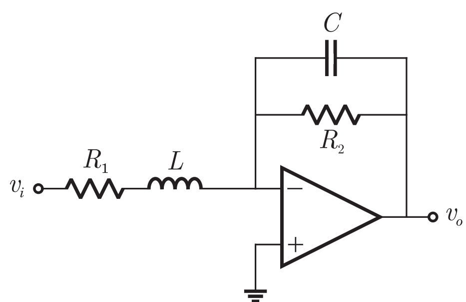
Thus $$I = 10^{-6}\left[e^{\frac{V}{25\times 10^{-3}}} - 1\right] = \frac{1}{10^5}$$

or $$V = 0.06 \text{ V}$$

Now $$V_0 = I \times 4\text{k} + V = \frac{1}{100k}\times 4k + 0.06 = 0.1 \text{ V}$$

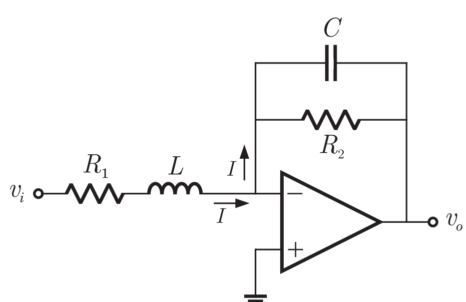
Hence (B) is correct option.

MCQ 1.47 The OPAMP circuit shown above represents a



(A) high pass filter (B) low pass filter
(C) band pass filter (D) band reject filter

SOL 1.47 The circuit is using ideal OPAMP. The non inverting terminal of OPAMP is at ground, thus inverting terminal is also at virtual ground.



Thus we can write

$$\frac{v_i}{R_1 + sL} = \frac{-v}{\frac{R_2}{sR_2C_2 + 1}}$$

or $$\frac{v_0}{v_i} = -\frac{R_2}{(R_1 + sL)(sR_2C_2 + 1)}$$

and from this equation it may be easily seen that this is the standard form of T.F. of low pass filter

$$H(s) = \frac{K}{(R_1 + sL)(sR_2C_2 + 1)}$$

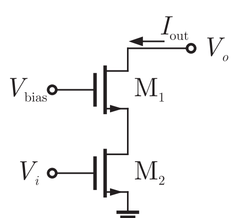
and form this equation it may be easily seen that this is the standard form of T.F. of low pass filter

$$H(s) = \frac{K}{as^2 + bs + b}$$

Hence (B) is correct option.

MCQ 1.48 Two identical NMOS transistors $M1$ and $M2$ are connected as shown below. V_{bias} is chosen so that both transistors are in saturation. The equivalent g_m of the pair is defied to be $\frac{\partial I_{out}}{\partial V_i}$ at constant V_{out}

The equivalent g_m of the pair is



(A) the sum of individual g_m's of the transistors

(B) the product of individual g_m's of the transistors

(C) nearly equal to the g_m of $M1$

(D) nearly equal to $\frac{g_m}{g_0}$ of $M2$

SOL 1.48 The current in both transistor are equal. Thus g_m is decide by M_1.
Hence (C) is correct option.

MCQ 1.49 An 8085 executes the following instructions

2710 LXI H, 30A0 H
2713 DAD H
2414 PCHL

All address and constants are in Hex. Let PC be the contents of the program counter and HL be the contents of the HL register pair just after executing PCHL. Which of the following statements is correct ?

(A) PC = 2715H, HL = 30A0H

(B) PC = 30A0H, HL = 2715H

(C) PC = 6140H
HL = 6140H

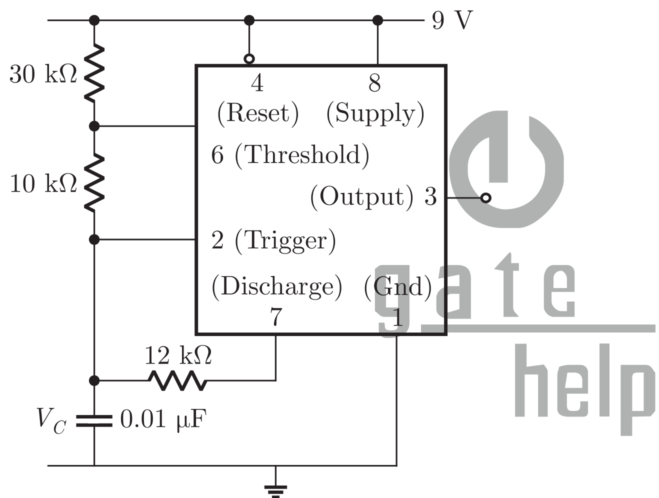
(D) PC = 6140H
HL = 2715H

SOL 1.49 2710H LXI H, 30A0H ; Load 16 bit data 30A0 in HL pair
2713H DAD H ; 6140H → HL
2714H PCHL ; Copy the contents 6140H of HL in PC

Thus after execution above instruction contests of PC and HL are same and that is 6140H

Hence (C) is correct answer.

MCQ 1.50 An astable multivibrator circuit using IC 555 timer is shown below. Assume that the circuit is oscillating steadily.



The voltage V_c across the capacitor varies between

(A) 3 V to 5 V (B) 3 V to 6 V

(C) 3.6 V to 6 V (D) 3.6 V to 5 V

SOL 1.50 Correct Option is ( )

MCQ 1.51 Silicon is doped with boron to a concentration of 4×10^{17} atoms cm^3. Assume the intrinsic carrier concentration of silicon to be $1.5\times10^{10}/\text{cm}^3$ and the value of kT/q to be 25 mV at 300 K. Compared to undopped silicon, the fermi level of doped silicon

(A) goes down by 0.31 eV (B) goes up by 0.13 eV

(C) goes down by 0.427 eV (D) goes up by 0.427 eV

SOL 1.51 Hence option (C) is correct.

$$E_2 - E_1 = kT\ln\frac{N_A}{n_i}$$

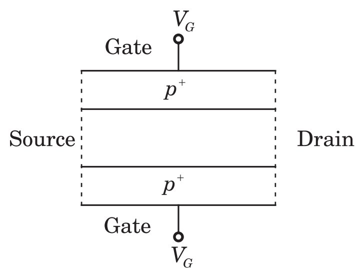
$$N_A = 4\times10^{17}$$

$$n_i = 1.5 \times 10^{10}$$

$$E_2 - E_1 = 25 \times 10^{-3} e \ln \frac{4 \times 10^{17}}{1.5 \times 10^{10}} = 0.427 \text{ eV}$$

Hence fermi level goes down by 0.427 eV as silicon is doped with boron.

MCQ 1.52 The cross section of a JFET is shown in the following figure. Let V_c be -2 V and let V_P be the initial pinch -off voltage. If the width W is doubled (with other geometrical parameters and doping levels remaining the same), then the ratio between the mutual trans conductances of the initial and the modified JFET is



(A) 4

(B) $\frac{1}{2}\left(\frac{1-\sqrt{2/V_p}}{1-\sqrt{1/2V_p}}\right)$

(C) $\left(\frac{1-\sqrt{2/V_p}}{1-\sqrt{1/2V_p}}\right)$

(D) $\frac{1-(2-\sqrt{V_p})}{1-[1(2\sqrt{V_p})]}$

SOL 1.52 Hence option (C) is correct

Pinch off voltage $V_P = \frac{eW^2 N_D}{\varepsilon s}$

Let $V_P = V_{P1}$

Now $\frac{V_{P1}}{V_{P2}} = \frac{W_1^2}{W_2^2} = \frac{W^2}{(2W)^2}$

or $4V_{P1} = V_{P2}$

Initial transconductance

$$g_m = K_n\left[1 - \sqrt{\frac{V_{bi} - V_{GS}}{V_p}}\right]$$

For first condition $g_{m1} = K_n\left[1 - \sqrt{\frac{0-(-2)}{V_{P1}}}\right] = K_n\left[1 - \sqrt{\frac{2}{V_{P1}}}\right]$

For second condition

$$g_{m2} = K_n\left[1 - \sqrt{\frac{0-(-2)}{V_{P2}}}\right] = K_2\left[1 - \sqrt{\frac{2}{4V_{P1}}}\right]$$

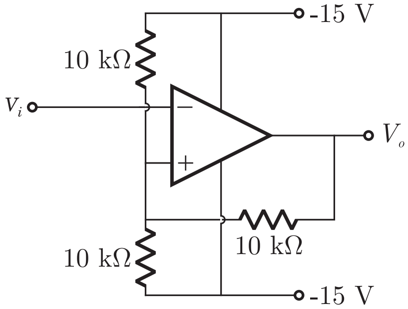
Dividing $\frac{g_{m1}}{g_{m2}} = \left(\frac{1-\sqrt{2/V_{P1}}}{1-\sqrt{1/(2V_{P1})}}\right)$

Hence $V_P = V_{P1}$

MCQ 1.53 Consider the Schmidt trigger circuit shown below

A triangular wave which goes from -12 to 12 V is applied to the inverting input of

OPMAP. Assume that the output of the OPAMP swings from +15 V to -15 V. The voltage at the non-inverting input switches between



(A) $-12\,V$ to +12 V (B) -7.5 V to 7.5 V

(C) -5 V to +5 V (D) 0 V and 5 V

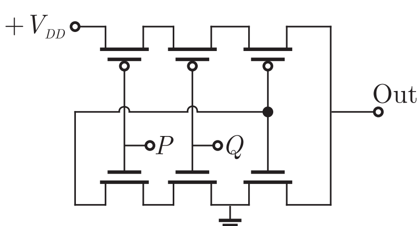
SOL 1.53 Let the voltage at non inverting terminal be V_1, then after applying KCL at non inverting terminal side we have

$$\frac{15 - V_1}{10} + \frac{V_0 - V_1}{10} = \frac{V_1 - (-15)}{10}$$

or $$V_1 = \frac{V_0}{3}$$

If V_0 swings from -15 to +15 V then V_1 swings between -5 V to +5 V.
Hence (C) is correct option.

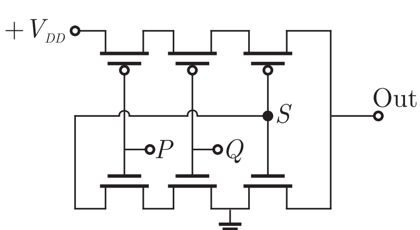
MCQ 1.54 The logic function implemented by the following circuit at the terminal OUT is



(A) P NOR Q (B) P NAND Q

(C) P OR Q (D) P AND Q

SOL 1.54 From the figure shown below it may be easily seen upper MOSFET are shorted and connected to V_{dd} thus OUT is 1 only when the node S is 0,



Since the lower MOSFETs are shorted to ground, node S is 0 only when input P

and Q are 1. This is the function of AND gate.
Hence (D) is correct answer.

MCQ 1.55 Consider the following assertions.

S1 : For Zener effect to occur, a very abrupt junction is required.

S2 : For quantum tunneling to occur, a very narrow energy barrier is required.

Which of the following is correct ?

(A) Only S2 is true

(B) S1 and S2 are both true but S2 is not a reason for S1

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

(D) Both S1 and S2 are false

SOL 1.55 Hence option (A) is correct.

MCQ 1.56 The two numbers represented in signed 2's complement form are $P + 11101101$ and $Q = 11100110$. If Q is subtracted from P, the value obtained in signed 2's complement is

(A) 1000001111 (B) 00000111

(C) 11111001 (D) 111111001

SOL 1.56 MSB of both number are 1, thus both are negative number. Now we get

$$11101101 = (-19)_{10}$$

and $11100110 = (-26)_{10}$

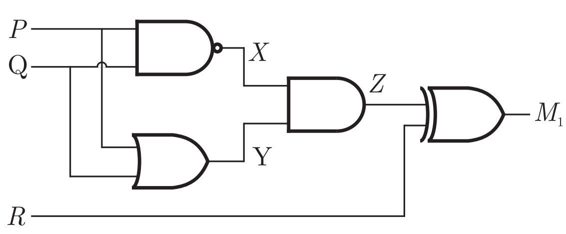
$$P - Q = (-19) - (-26) = 7$$

Thus 7 signed two's complements form is

$$(7)_{10} = 00000111$$

Hence (B) is correct answer.

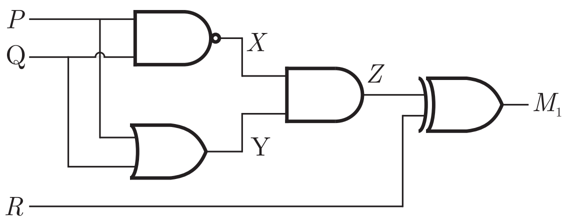
MCQ 1.57 Which of the following Boolean Expressions correctly represents the relation between P, Q, R and M_1



(A) $M_1 = (P \text{ OR } Q) \text{ XOR } R$ (B) $M_1 = (P \text{ AND } Q) X \text{ OR } R$

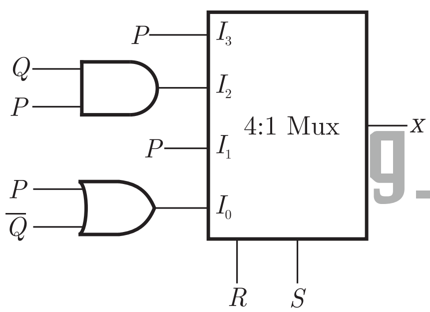
(C) $M_1 = (P \text{ NOR } Q) X \text{ OR } R$ (D) $M_1 = (P \text{ XOR } Q) \text{ XOR } R$

SOL 1.57 The circuit is as shown below



$$X = \overline{PQ}$$
$$Y = (P + Q)$$
So $$Z = \overline{PQ}(P + Q)$$
$$= (\overline{P} + \overline{Q})(P + Q) = \overline{P}Q + P\overline{Q} = P \oplus Q$$
and $$M_1 = Z \oplus R = (P \oplus Q) \oplus R$$
Hence (D) is correct answer

MCQ 1.58 For the circuit shown in the following, $I_0 - I_3$ are inputs to the 4:1 multiplexers, R (MSB) and S are control bits.
The output Z can be represented by



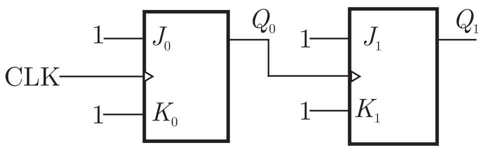
(A) $PQ + P\overline{Q}S + \overline{Q}\,\overline{R}\,\overline{S}$
(B) $P\overline{Q} + PQ\overline{R} + \overline{P}\,\overline{Q}\,\overline{S}$
(C) $P\overline{Q}\,\overline{R} + \overline{P}QR + PARS + \overline{Q}\,\overline{R}\,\overline{S}$
(D) $PQ\overline{R} + PQR\overline{S} + P\overline{Q}RS + \overline{Q}\,\overline{R}\,\overline{S}$

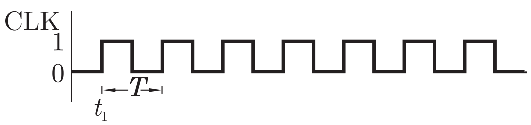
SOL 1.58 Hence (A) is correct answer.
$$Z = I_0\overline{R}\,\overline{S} + I_1\overline{R}S + I_2R\overline{S} + I_3RS$$
$$= (P + \overline{Q})\,\overline{R}\,\overline{S} + P\overline{R}S + PQR\overline{S} + PRS$$
$$= P\overline{R}\,\overline{S} + \overline{Q}\,\overline{R}\,\overline{S} + P\overline{R}S + PQR\overline{S} + PRS$$
The $k-$ Map is as shown below

PQ \ RS	00	01	11	10
00	1			
01				
11	1	1	1	1
10	1	1	1	

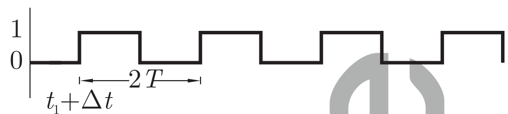
$$Z = PQ + P\overline{Q}S + \overline{Q}\overline{R}\overline{S}$$

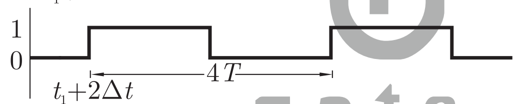
MCQ 1.59 For each of the positive edge-triggered $J-K$ flip flop used in the following figure, the propagation delay is $\triangle t$.

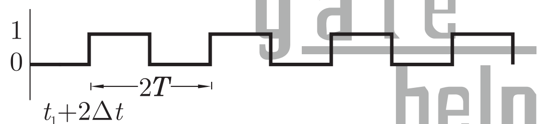


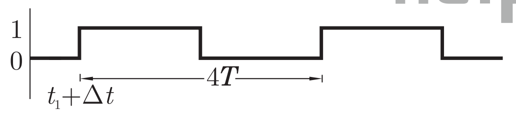


Which of the following wave forms correctly represents the output at Q_1 ?

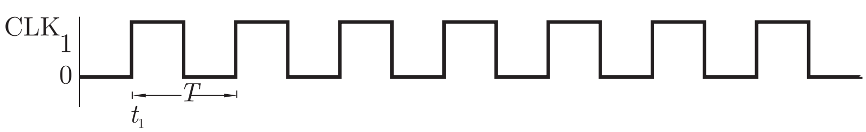
(A)


(B)


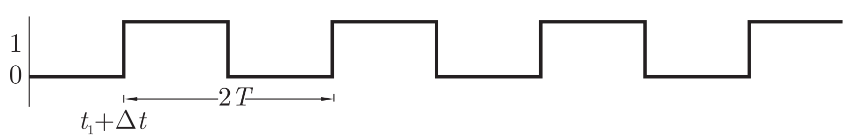
(C)


(D)


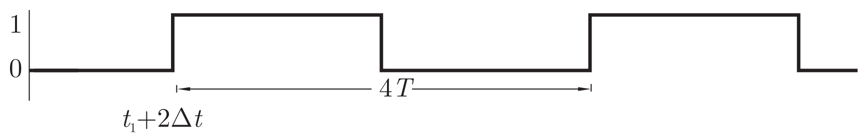
SOL 1.59 Since the input to both JK flip-flop is 11, the output will change every time with clock pulse. The input to clock is



The output Q_0 of first FF occurs after time $\triangle T$ and it is as shown below

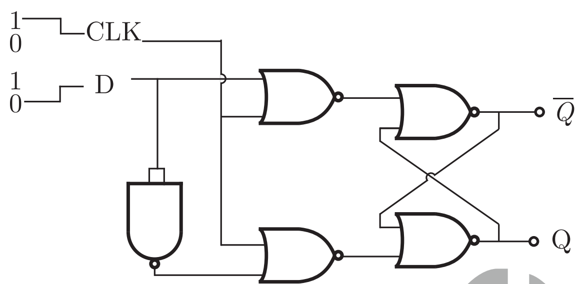


The output Q_1 of second FF occurs after time $\triangle T$ when it gets input (i.e. after $\triangle T$ from t_1) and it is as shown below



Hence (B) is correct answer.

MCQ 1.60 For the circuit shown in the figure, D has a transition from 0 to 1 after CLK changes from 1 to 0. Assume gate delays to be negligible
Which of the following statements is true



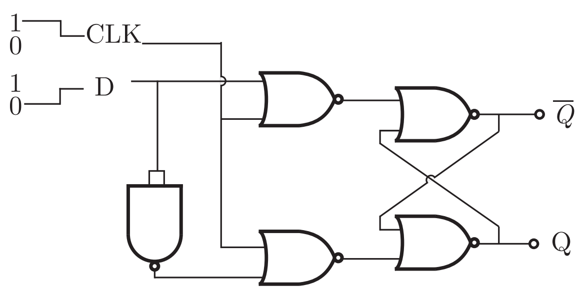
(A) Q goes to 1 at the CLK transition and stays at 1

(B) Q goes to 0 at the CLK transition and stays 0

(C) Q goes to 1 at the CLK tradition and goes to 0 when D goes to 1

(D) Q goes to 0 at the CLK transition and goes to 1 when D goes to 1

SOL 1.60 The circuit is as shown below



The truth table is shown below. When CLK make transition Q goes to 1 and when D goes to 1, Q goes to 0
Hence (A) is correct answer.

MCQ 1.61 A rectangular waveguide of internal dimensions ($a = 4$ cm and $b = 3$ cm) is to be operated in TE_{11} mode. The minimum operating frequency is

(A) 6.25 GHz (B) 6.0 GHz

(C) 5.0 GHz (D) 3.75 GHz

SOL 1.61 Cut-off Frequency is

$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

For TE_{11} mode,

$$f_c = \frac{3\times10^{10}}{2}\sqrt{\left(\frac{1}{4}\right)^2+\left(\frac{1}{3}\right)^2} = 6.25 \text{ GHz}$$

Hence (A) is correct option.

MCQ 1.62 One end of a loss-less transmission line having the characteristic impedance of 75Ω and length of 1 cm is short-circuited. At 3 GHz, the input impedance at the other end of transmission line is

(A) 0 (B) Resistive

(C) Capacitive (D) Inductive

SOL 1.62 Hence (D) is correct option.

$$Z_{in} = Z_o\frac{Z_L + iZ_o\tan(\beta l)}{Z_o + iZ_L\tan(\beta l)}$$

For $Z_L = 0, Z_{in} = iZ_o\tan(\beta l)$

The wavelength is

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{3\times10^9} = 0.1 \text{ m or } 10 \text{ cm}$$

$$\beta l = \frac{2\pi}{\lambda}l = \frac{2\pi}{10}\times1 = \frac{\pi}{5}$$

Thus $$Z_{in} = iZ_o\tan\frac{\pi}{5}$$

Thus Z_{in} is inductive because $Z_o\tan\frac{\pi}{5}$ is positive

MCQ 1.63 A uniform plane wave in the free space is normally incident on an infinitely thick dielectric slab (dielectric constant $\varepsilon = 9$). The magnitude of the reflection coefficient is

(A) 0 (B) 0.3

(C) 0.5 (D) 0.8

SOL 1.63 Hence (C) is correct option.

We have $$\eta = \sqrt{\frac{\mu}{\varepsilon}}$$

Reflection coefficient

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

Substituting values for η_1 and η_2 we have

$$\tau = \frac{\sqrt{\frac{\mu_o}{\varepsilon_o\varepsilon_r}} - \sqrt{\frac{\mu_o}{\varepsilon_o}}}{\sqrt{\frac{\mu_o}{\varepsilon_o\varepsilon_r}} + \sqrt{\frac{\mu_o}{\varepsilon_o}}} = \frac{1-\sqrt{\varepsilon_r}}{1+\sqrt{\varepsilon_r}} = \frac{1-\sqrt{9}}{1+\sqrt{9}} \qquad \text{since } \varepsilon_r = 9$$

$$= -0.5$$

MCQ 1.64 In the design of a single mode step index optical fibre close to upper cut-off, the single-mode operation is not preserved if

(A) radius as well as operating wavelength are halved

(B) radius as well as operating wavelength are doubled

(C) radius is halved and operating wavelength is doubled

(D) radius is doubled and operating wavelength is halved

SOL 1.64 In single mode optical fibre, the frequency of limiting mode increases as radius decreases

Hence $r \propto \frac{1}{f}$

So. if radius is doubled, the frequency of propagating mode gets halved, while in option (D) it is increased by two times.
Hence (C) is correct option.

MCQ 1.65 At 20 GHz, the gain of a parabolic dish antenna of 1 meter and 70% efficiency is

(A) 15 dB (B) 25 dB

(C) 35 dB (D) 45 dB

SOL 1.65 Hence (D) is correct option.

$$\lambda = \frac{c}{f} = \frac{3\times 10^8}{20\times 10^9} = \frac{3}{200}$$

Gain $$G_p = \eta\pi^2\left(\frac{D}{\lambda}\right)^2 = 0.7\times\pi^2\left(\frac{1}{\frac{3}{100}}\right)^2 = 30705.4$$

$$= 44.87 \text{ dB}$$

MCQ 1.66 Noise with double-sided power spectral density on K over all frequencies is passed through a RC low pass filter with 3 dB cut-off frequency of f_c. The noise power at the filter output is

(A) K (B) Kf_c

(C) $k\pi f_c$ (D) ∞

SOL 1.66 Hence (C) is correct option.

PSD of noise is $\frac{N_0}{2} = K$ ...(1)

The 3-dB cut off frequency is

$$f_c = \frac{1}{2\pi RC} \quad ...(2)$$

Output noise power is

$$= \frac{N_0}{4RC} = \left(\frac{N_0}{2}\right)\frac{1}{2RC} = K\pi f_c$$

MCQ 1.67 Consider a Binary Symmetric Channel (BSC) with probability of error being p. To transmit a bit, say 1, we transmit a sequence of three 1s. The receiver will interpret the received sequence to represent 1 if at least two bits are 1. The probability that the transmitted bit will be received in error is

(A) $p^3 + 3p^2(1-p)$ (B) p^3

(C) $(1-p^3)$ (D) $p^3+p^2(1-p)$

SOL 1.67 At receiving end if we get two zero or three zero then its error.

Let p be the probability of 1 bit error, the probability that transmitted bit error is

$$= \text{Three zero} + \text{two zero and single one}$$
$$= {}^3C_3p^3 + 3C_2p^2(1-p)$$
$$= p^3 + p^2(1-p)$$

Hence (D) is correct option.

MCQ 1.68 Four messages band limited to W, $W, 2W$ and $3W$ respectively are to be multiplexed using Time Division Multiplexing (TDM). The minimum bandwidth required for transmission of this TDM signal is

(A) W (B) $3W$

(C) $6W$ (D) $7W$

SOL 1.68 Bandwidth of TDM is

$$= \frac{1}{2}\text{ (sum of Nyquist Rate)}$$
$$= \frac{1}{2}[2W+2W+4W+6W] = 7W$$

Hence (D) is correct option.

MCQ 1.69 Consider the frequency modulated signal

$10\cos[2\pi\times10^5t + 5\sin(2\pi\times1500t) + 7.5\sin(2\pi\times1000t)]$

with carrier frequency of 10^5 Hz. The modulation index is

(A) 12.5 (B) 10

(C) 7.5 (D) 5

SOL 1.69 Hence (B) is correct option.

We have $\theta_i = 2\pi10^5t + 5\sin(2\pi1500t) + 7.5\sin(2\pi1000t)$

$$\omega_i = \frac{d\theta_i}{dt} = 2\pi10^5 + 10\pi1500\cos(2\pi1500t) + 15\pi1000\cos(2\pi1000t)$$

Maximum frequency deviation is

$$\triangle\omega_{\max} = 2\pi(5\times1500 + 7.5\times1000)$$
$$\triangle f_{\max} = 15000$$

Modulation index is $= \dfrac{\triangle f_{\max}}{f_m} = \dfrac{15000}{1500} = 10$

MCQ 1.70 The signal $\cos\omega_ct + 0.5\cos\omega_mt\sin\omega_ct$ is

(A) FM only (B) AM only

(C) both AM and FM (D) neither AM nor FM

SOL 1.70 Hence (C) is correct option.

Common Data for Questions 71, 72 and 73 :

A speed signal, band limited to 4 kHz and peak voltage varying between +5 V and −5 V, is sampled at the Nyquist rate. Each sample is quantized and represented by 8 bits.

MCQ 1.71 If the bits 0 and 1 are transmitted using bipolar pulses, the minimum bandwidth required for distortion free transmission is

(A) 64 kHz (B) 32 kHz

(C) 8 kHz (D) 4 kHz

SOL 1.71 Hence (B) is correct option.

$$f_m = 4 \text{ KHz}$$

$$f_s = 2f_m = 8 \text{ kHz}$$

Bit Rate $R_b = nf_s = 8 \times 8 = 64$ kbps

The minimum transmission bandwidth is

$$BW = \frac{R_b}{2} = 32 \text{ kHz}$$

MCQ 1.72 Assuming the signal to be uniformly distributed between its peak to peak value, the signal to noise ratio at the quantizer output is

(A) 16 dB (B) 32 dB

(C) 48 dB (D) 4 kHz

SOL 1.72 Hence (C) is correct option.

$$\left(\frac{S_0}{N_0}\right) = 1.76 + 6n \text{ dB}$$

$$= 1.76 + 6 \times 8 = 49.76 \text{ dB}$$ We have $n = 8$

MCQ 1.73 The number of quantization levels required to reduce the quantization noise by a factor of 4 wo

(A) 1024 (B) 512

(C) 256 (D) 64

SOL 1.73 Hence (B) is correct option.

As $\text{Noise} \propto \frac{1}{L^2}$

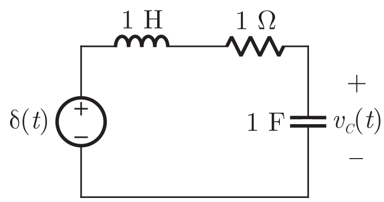
To reduce quantization noise by factor 4, quantization level must be two times i.e. $2L$.

Now $L = 2^n = 2^8 = 256$

Thus $2L = 512$

Common data for questions 74 & 75 :

The following series RLC circuit with zero conditions is excited by a unit impulse functions $\delta(t)$.



MCQ 1.74 For $t > 0$, the output voltage $v_C(t)$ is

(A) $\frac{2}{\sqrt{3}}(e^{\frac{-1}{2}t} - e^{\frac{\sqrt{3}}{2}t})$

(B) $\frac{2}{\sqrt{3}} te^{\frac{-1}{2}t} t$

(C) $\frac{2}{\sqrt{3}} e^{\frac{-1}{2}t} \cos\left(\frac{\sqrt{3}}{2}t\right)$

(D) $\frac{2}{\sqrt{3}} e^{\frac{-1}{2}t} \sin\left(\frac{\sqrt{3}}{2}t\right)$

SOL 1.74 Writing in transform domain we have

$$\frac{V_c(s)}{V_s(s)} = \frac{\frac{1}{s}}{(\frac{1}{s} + s + 1)} = \frac{1}{(s^2 + s + 1)}$$

Since $V_s(t) = \delta(t) \rightarrow V_s(s) = 1$ and

$$V_c(s) = \frac{1}{(s^2 + s + 1)}$$

or $$V_c(s) = \frac{2}{\sqrt{3}}\left[\frac{\frac{\sqrt{3}}{2}}{(s + \frac{1}{2})^2 + \frac{3}{4}}\right]$$

Taking inverse laplace transform we have

$$V_t = \frac{2}{\sqrt{3}} e^{-\frac{t}{2}} \sin\left(\frac{\sqrt{3}}{2}t\right)$$

Hence (D) is correct option.

MCQ 1.75 For $t > 0$, the voltage across the resistor is

(A) $\frac{1}{\sqrt{3}}\left(e^{\frac{\sqrt{3}}{2}t} - e^{-\frac{1}{2}t}\right)$

(B) $e^{\frac{-1}{2}t}\left[\cos\left(\frac{\sqrt{3}}{2}t\right) - \frac{1}{\sqrt{3}}\sin\left(\frac{\sqrt{3}\,t}{2}\right)\right]$

(C) $\frac{2}{\sqrt{3}} e^{\frac{-1}{2}t} \sin\left(\frac{\sqrt{3}\,t}{2}\right)$

(D) $\frac{2}{\sqrt{3}} e^{\frac{-1}{2}t} \cos\left(\frac{\sqrt{3}}{2}t\right)$

SOL 1.75 Let voltage across resistor be v_R

$$\frac{V_R(s)}{V_S(s)} = \frac{1}{(\frac{1}{s} + s + 1)} = \frac{s}{(s^2 + s + 1)}$$

Since $v_s = \delta(t) \rightarrow V_s(s) = 1$ we get

$$V_R(s) = \frac{s}{(s^2 + s + 1)} = \frac{s}{(s + \frac{1}{2})^2 + \frac{3}{4}}$$

$$= \frac{(s+\frac{1}{2})}{(s+\frac{1}{2})^2+\frac{3}{4}} - \frac{\frac{1}{2}}{(s+\frac{1}{2})^2+\frac{3}{4}}$$

or $$v_R(t) = e^{-\frac{1}{2}}\cos\frac{\sqrt{3}}{2}t - \frac{1}{2}\times\frac{2}{\sqrt{3}}e^{-\frac{1}{2}}\sin\frac{\sqrt{3}}{2}t$$

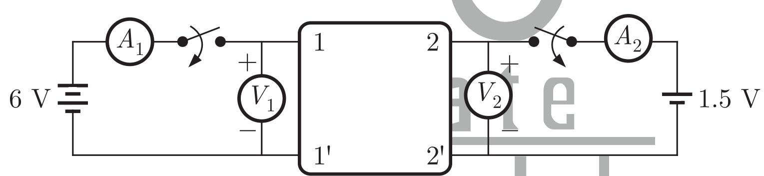
$$= e^{-\frac{t}{2}}\left[\cos\frac{\sqrt{3}}{2}t - \frac{1}{\sqrt{3}}\sin\frac{\sqrt{3}}{2}t\right]$$

Hence (B) is correct option.

Linked Answer Questions : Q. 76 to Q.85 carry two marks each.

Statement for linked Answers Questions 76 & 77:

A two-port network shown below is excited by external DC source. The voltage and the current are measured with voltmeters V_1, V_2 and ammeters. A_1, A_2 (all assumed to be ideal), as indicated



Under following conditions, the readings obtained are:

(1) S_1 -open, S_2 - closed $A_1 = 0, V_1 = 4.5$ V, $V_2 = 1.5$ V, $A_2 = 1$ A

(2) S_1 -open, S_2 - closed $A_1 = 4$ A, $V_1 = 6$ V, $V_2 = 6$ V, $A_2 = 0$

MCQ 1.76 The z-parameter matrix for this network is

(A) $\begin{bmatrix} 1.5 & 1.5 \\ 4.5 & 1.5 \end{bmatrix}$ (B) $\begin{bmatrix} 1.5 & 4.5 \\ 1.5 & 4.5 \end{bmatrix}$

(C) $\begin{bmatrix} 1.5 & 4.5 \\ 1.5 & 1.5 \end{bmatrix}$ (D) $\begin{bmatrix} 4.5 & 1.5 \\ 1.5 & 4.5 \end{bmatrix}$

SOL 1.76 From the problem statement we have

$$z_{11} = \frac{v_1}{i_1}\bigg|_{i_2=0} = \frac{6}{4} = 1.5\Omega$$

$$z_{12} = \frac{v_1}{i_2}\bigg|_{i_1=0} = \frac{4.5}{1} = 4.5\Omega$$

$$z_{21} = \frac{v_2}{i_1}\bigg|_{i_2=0} = \frac{6}{4} = 1.5\Omega$$

$$z_{22} = \frac{v_2}{i_2}\bigg|_{i_2=0} = \frac{1.5}{1} = 1.5\Omega$$

Thus z-parameter matrix is

$$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} 1.5 & 4.5 \\ 1.5 & 1.5 \end{bmatrix}$$

Hence (C) is correct option.

MCQ 1.77 The h-parameter matrix for this network is

(A) $\begin{bmatrix} -3 & 3 \\ -1 & 0.67 \end{bmatrix}$ (B) $\begin{bmatrix} -3 & -1 \\ 3 & 0.67 \end{bmatrix}$

(C) $\begin{bmatrix} 3 & 3 \\ 1 & 0.67 \end{bmatrix}$ (D) $\begin{bmatrix} 3 & 1 \\ -3 & -0.67 \end{bmatrix}$

SOL 1.77 From the problem statement we have

$$h_{12} = \frac{v_1}{v_2}\Big|_{i_1=0} = \frac{4.5}{1.5} = 3$$

$$h_{22} = \frac{i_2}{v_2}\Big|_{i_1=0} = \frac{1}{1.5} = 0.67$$

From z matrix, we have

$$v_1 = z_{11} i_1 + z_{12} i_2$$

$$v_2 = z_{21} i_1 + z_{22} i_2$$

If $v_2 = 0$

Then $\frac{i_2}{i_1} = \frac{-z_{21}}{z_{22}} = \frac{-1.5}{1.5} = -1 = h_{21}$

or $i_2 = -i_1$

Putting in equation for v_1, we get

$$v_1 = (z_{11} - z_{12})\, i_1$$

$$\frac{v_1}{i_1}\Big|_{v_2=0} = h_{11} = z_{11} - z_{12} = 1.5 - 4.5 = -3$$

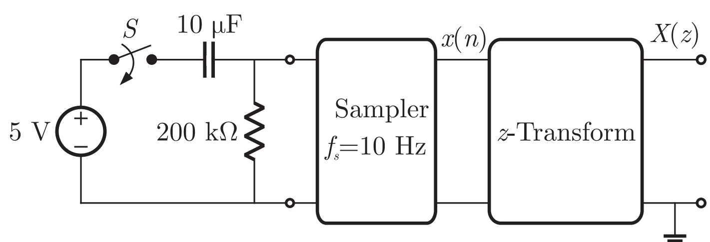
Hence h −parameter will be

$$\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} -3 & 3 \\ -1 & 0.67 \end{bmatrix}$$

Hence (A) is correct option.

Statement for Linked Answer Question 78 and 79 :

In the following network, the switch is closed at $t = 0^-$ and the sampling starts from $t = 0$. The sampling frequency is 10 Hz.



MCQ 1.78 The samples $x(n),\ n = (0, 1, 2, ...)$ are given by

(A) $5(1 - e^{-0.05n})$ (B) $5e^{-0.05n}$

(C) $5(1 - e^{-5n})$ (D) $5e^{-5n}$

SOL 1.78 Current through resistor (i.e. capacitor) is

$$I = I(0^+)\, e^{-t/RC}$$

Here, $I(0^+) = \frac{V}{R} = \frac{5}{200k} = 25\mu\text{A}$

$$RC = 200k \times 10\mu = 2\,\text{sec}$$

$$I = 25e^{-\frac{t}{2}}\,\mu\text{A}$$

$$= V_R \times R = 5e^{-\frac{t}{2}}\ \text{V}$$

Here the voltages across the resistor is input to sampler at frequency of 10 Hz. Thus

$$x(n) = 5e^{\frac{-n}{2\times 10}} = 5e^{-0.05n} \text{ For } t > 0$$

Hence (B) is correct answer.

MCQ 1.79 The expression and the region of convergence of the $z-$transform of the sampled signal are

(A) $\frac{5z}{z - e^5},\ |z| < e^{-5}$ (B) $\frac{5z}{z - e^{-0.05}},\ |z| < e^{-0.05}$

(C) $\frac{5z}{z - e^{-0.05}},\ |z| > e^{-0.05}$ (D) $\frac{5z}{z - e^{-5}},\ |z| > e^{-5}$

SOL 1.79 Hence (C) is correct answer.

Since $x(n) = 5e^{-0.05n}u(n)$ is a causal signal

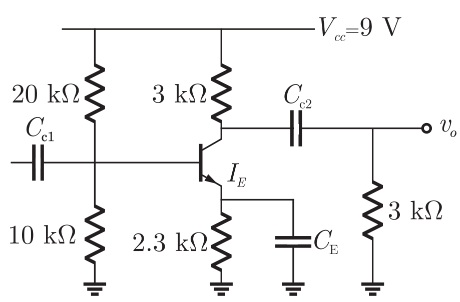
Its z transform is

$$X(z) = 5\left[\frac{1}{1 - e^{-0.05}z^{-1}}\right] = \frac{5z}{z - e^{-0.05}}$$

Its ROC is $|e^{-0.05}z^{-1}| > 1 \rightarrow |z| > e^{-0.05}$

Statement for Linked Answer Questions 80 and 81:

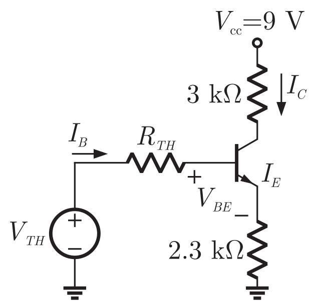
In the following transistor circuit, $V_{BE} = 0.7$ V, $r_3 = 25$ mV$/I_E$, and β and all the capacitances are very large



MCQ 1.80 The value of DC current I_E is

(A) 1 mA (B) 2 mA
(C) 5 mA (D) 10 mA

SOL 1.80 For the given DC values the Thevenin equivalent circuit is as follows



The thevenin resistance and voltage are

$$V_{TH} = \frac{10}{10+20} \times 9 = 3 \text{ V}$$

and total $R_{TH} = \frac{10k \times 20k}{10k + 20k} = 6.67 \text{ k}\Omega$

Since β is very large, therefore I_B is small and can be ignored

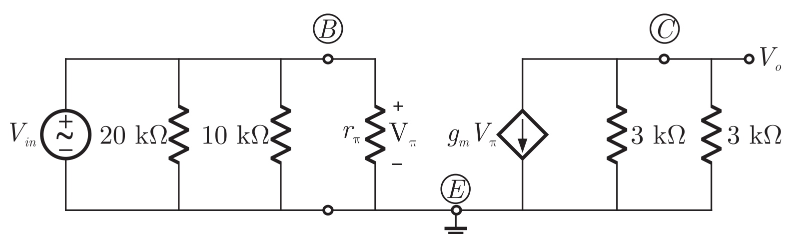
Thus $I_E = \frac{V_{TH} - V_{BE}}{R_E} = \frac{3-0.7}{2.3k} = 1 \text{ mA}$

Hence (A) is correct option.

MCQ 1.81 The mid-band voltage gain of the amplifier is approximately

(A) -180 (B) -120
(C) -90 (D) -60

SOL 1.81 The small signal model is shown in fig below



$$g_m = \frac{|I_C|}{V_T} = \frac{1m}{25m} = \frac{1}{25} \text{ A/V} \qquad I_C \approx I_E$$

$$V_o = -g_m V_\pi \times (3k \| 3k)$$

$$= -\frac{1}{25} V_{in} (1.5k) \qquad V_\pi = V_{in}$$

$$= -60 V_{in}$$

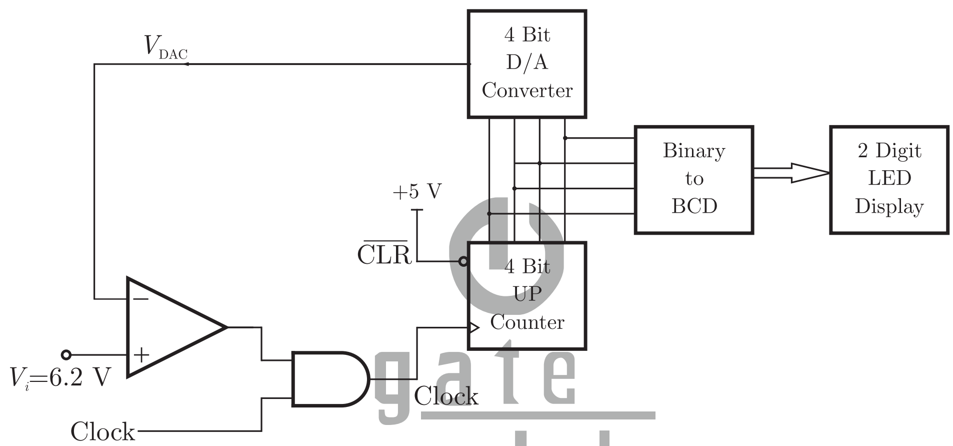
or $A_m = \frac{V_o}{V_{in}} = -60$

Hence (D) is correct option.

Statement For Linked Answer Question 82 & 83 :

In the following circuit, the comparators output is logic "1" if $V_1 > V_2$ and is logic "0" otherwise. The D/A conversion is done as per the relation $V_{DAC} = \sum_{n=0}^{3} 2^{n-1} b_n$ Volts, where b_3

(MSB), b_1, b_2 and b_0 (LSB) are the counter outputs. The counter starts from the clear state.



MCQ 1.82 The stable reading of the LED displays is

(A) 06 (B) 07

(C) 12 (D) 13

SOL 1.82 Hence (D) is correct answer.

We have

$$V_{DAC} = \sum_{n=0}^{3} 2^{n-1} b_n = 2^{-1} b_0 + 2^0 b_1 + 2^1 b_2 + 2^2 b_3$$

or $$V_{DAC} = 0.5 b_0 + b_1 + 2 b_2 + 4 b_3$$

The counter outputs will increase by 1 from 0000 till $V_{th} > V_{DAC}$. The output of counter and V_{DAC} is as shown below

Clock	$b_3 b_3 b_2 b_0$	V_{DAC}
1	0001	0
2	0010	0.5
3	0011	1
4	0100	1.5
5	0101	2

6	0110	2.5
7	0111	3
8	1000	3.5
9	1001	4
10	1010	4.5
11	1011	5
12	1100	5.5
13	1101	6
14	1110	6.5

and when $V_{ADC} = 6.5$ V (at 1101), the output of AND is zero and the counter stops. The stable output of LED display is 13.

MCQ 1.83 The magnitude of the error between V_{DAC} and V_{in} at steady state in volts is

(A) 0.2 (B) 0.3

(C) 0.5 (D) 1.0

SOL 1.83 Hence (B) is correct answer.

The $V_{ADC} - V_{in}$ at steady state is

$$= 6.5 - 6.2 = 0.3V$$

Statement for Linked Answer Question 84 & 85 :

The impulse response $h(t)$ of linear time - invariant continuous time system is given by $h(t) = \exp(-2t)\,u(t)$, where $u(t)$ denotes the unit step function.

MCQ 1.84 The frequency response $H(\omega)$ of this system in terms of angular frequency ω, is given by $H(\omega)$

(A) $\frac{1}{1 + j2\omega}$ (B) $\frac{\sin\omega}{\omega}$

(C) $\frac{1}{2 + j\omega}$ (D) $\frac{j\omega}{2 + j\omega}$

SOL 1.84 Hence (C) is correct answer.

$$h(t) = e^{-2t}u(t)$$

$$H(j\omega) = \int_{-\infty}^{\infty} h(t)\,e^{-j\omega t}\,dt$$

$$= \int_0^{\infty} e^{-2t}e^{-j\omega t}\,dt = \int_0^{\infty} e^{-(2+j\omega)t}\,dt = \frac{1}{(2 + j\omega)}$$

MCQ 1.85 The output of this system, to the sinusoidal input $x(t) = 2\cos 2t$ for all time t, is

(A) 0 (B) $2^{-0.25}\cos(2t - 0.125\pi)$

(C) $2^{-0.5}\cos(2t - 0.125\pi)$ (D) $2^{-0.5}\cos(2t - 0.25\pi)$

SOL 1.85 Hence (D) is correct answer.

$$H(j\omega) = \frac{1}{(2+j\omega)}$$

The phase response at $\omega = 2$ rad/sec is

$$\angle H(j\omega) = -\tan^{-1}\frac{\omega}{2} = -\tan^{-1}\frac{2}{2} = -\frac{\pi}{4} = -0.25\pi$$

Magnitude respone at $\omega = 2$ rad/sec is

$$|H(j\omega)| = \sqrt{\frac{1}{2^2+w^2}} = \frac{1}{2\sqrt{2}}$$

Input is $x(t) = 2\cos(2t)$

Output i $= \frac{1}{2\sqrt{2}} \times 2\cos(2t - 0.25\pi)$

$$= \frac{1}{\sqrt{2}}\cos[2t - 0.25\pi]$$

Answer Sheet

1.	(C)	19.	(B)	37.	(A)	55.	(A)	73.	(B)
2.	(B)	20.	(A)	38.	(D)	56.	(B)	74.	(D)
3.	(A)	21.	(A)	39.	(C)	57.	(D)	75.	(B)
4.	(A)	22.	(D)	40.	(C)	58.	(A)	76.	(C)
5.	(A)	23.	(C)	41.	(C)	59.	(B)	77.	(A)
6.	(B)	24.	(A)	42.	(C)	60.	(A)	78.	(B)
7.	(C)	25.	(C)	43.	(B)	61.	(A)	79.	(C)
8.	(B)	26.	(A)	44.	(B)	62.	(D)	80.	(A)
9.	(C)	27.	(D)	45.	(C)	63.	(C)	81.	(D)
10.	(D)	28.	(B)	46.	(B)	64.	(C)	82.	(D)
11.	(C)	29.	(*)	47.	(B)	65.	(D)	83.	(B)
12.	(C)	30.	(A)	48.	(C)	66.	(C)	84.	(C)
13.	(D)	31.	(C)	49.	(C)	67.	(D)	85.	(D)
14.	(A)	32.	(A)	50.	(*)	68.	(D)		
15.	(C)	33.	(D)	51.	(C)	69.	(B)		
16.	(D)	34.	(B)	52.	(C)	70	(C)		
17.	(C)	35.	(B)	53.	(C)	71	(B)		
18.	(D)	36.	(A)	54.	(D)	72	(C)		