1. The given differential equation

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

Order of differential equation

= highest derivative present in the differential equation

= 2

Degree is the maximum power of highest derivative.

Here degree = 1.

Hence there is no alternative correct out of the given choices.

2. (C) Fourier series is defined for a periodic function only. Here in alternative (C) term $e^{-|t|}$ makes a non-periodic function.

Hence alternative (C) is the correct choice.

3. (D) Probability of an odd number $= \frac{N(E)}{N(S)} = \frac{3}{6} = \frac{1}{2}$

Probability of an even number $= \frac{N(E)}{N(S)} = \frac{3}{6} = \frac{1}{2}$

since both the events are independent, therefore

$$P(\text{odd/even}) = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$$

4. (B) Given differential equation

$$\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = 0$$

$\therefore$ Auxiliary equation is

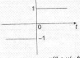
$$D^2 - 5D + 6 = 0$$

or $$(D-2)(D-3) = 0$$

or $$D = 2, 3$$

Hence, solution is, $$y = e^{2x} + e^{3x}$$

5. (A) Even and odd parts of a unit-step function $u(t)$ can be given by



$$\text{Even part} = \frac{u(t) + u(-t)}{2}$$

We know that

$$u(t) = \begin{cases} 1 & \text{for } t \geq 0 \\ 0 & \text{for } t < 0 \end{cases}$$

$$u(-t) = \begin{cases} 1 & \text{for } -t \geq 0 \\ 0 & \text{for } -t < 0 \end{cases}$$

Now, $$\frac{u(t) + u(-t)}{2} = \begin{cases} \frac{1}{2} & \text{for } t \leq 0 \\ \frac{1}{2} & \text{for } t > 0 \end{cases}$$

so, Even part of $u(t) = \frac{1}{2}$

and $$\text{Odd part} = \frac{u(t) - u(-t)}{2}$$

$$= \frac{x(t)}{2} \quad \text{[from given figure]}$$

6. (C) Given $$x(n) = \left(\frac{5}{6}\right)^n u(n) - \left(\frac{6}{5}\right)^n u(-n-1)$$

Here in the given signal $x(n)$ first sequence is causal sequence while the second sequence is non-causal sequence.

If $$a^n u(n) \overset{z}{\longleftrightarrow} \frac{z}{z-a}; |z| > |a|$$

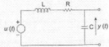
then $$\left(\frac{5}{6}\right)^n u(n) \overset{z}{\longleftrightarrow} \frac{z}{z-\frac{5}{6}}; |z| > \frac{5}{6}$$

If $\quad a^n\, u(-n-1) \overset{z}{\longleftrightarrow} -\dfrac{z}{z-a};\, |z| < |a|$

then $\quad \left(\dfrac{6}{5}\right)^n u(-n-1) \overset{z}{\longleftrightarrow} \dfrac{z}{z-\dfrac{6}{5}};\, |z| > \dfrac{6}{5}$

Hence, region of convergence of the sequence $x(n)$ must be $\dfrac{5}{6} < |z| < \dfrac{6}{5}$.

7. (C) Given, $\quad u(t) = \begin{cases} 1 & \text{for } t \geq 0 \\ 0 & \text{for } t \neq 0 \end{cases}$



from figure

$$y(t) = \frac{1}{C}\int i\,dt$$

$$y(s) = \frac{1}{Cs} I(s)$$

$$I(s) = \frac{L\,[u(t)]}{R + Ls + \dfrac{1}{Cs}}$$

$$= \frac{1}{s\left(R + Ls + \dfrac{1}{Cs}\right)} \quad \left[\because L\{u(t)\} = \frac{1}{s}\right]$$

Now, $\quad Y(s) = \dfrac{1}{LCs^2 + RCs + 1}$

or $\quad Y(s) = \dfrac{\dfrac{1}{LC}}{s^2 + \dfrac{R}{L}s + \dfrac{1}{LC}}$

On comparing A.E. $s^2 + \dfrac{R}{L}s + \dfrac{1}{LC} = 0$ with standard equation.

$$s^2 + 2\xi\omega_n s + \omega_n^2 = 0,$$

we get $\quad 2\,\xi\omega_n = \dfrac{R}{L}$

$$\omega_n^2 = \frac{1}{LC}$$

or $\quad \omega_n = \dfrac{1}{\sqrt{LC}}$

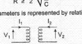
$\therefore \quad \xi = \dfrac{R}{2\omega_n L} = \dfrac{R}{2}\sqrt{\dfrac{C}{L}}$

for no oscillations, $\xi \geq 1$

or $\quad \dfrac{R}{2}\sqrt{\dfrac{C}{L}} \geq 1$

$$R \geq 2\sqrt{\frac{L}{C}}$$

8. (B) ABCD parameters is represented by relation



$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix} \qquad \text{...(i)}$$

from given figure, we have turns ratio, *i.e.*

$$\frac{V_1}{V_2} = \frac{I_2}{I_1}\,\frac{N_1}{N_2} = n \qquad \text{...(ii)}$$

from relation (i) and (ii)

$$I_1 = CV_2 + DI_2$$

$$D = X = \left.\frac{I_1}{I_2}\right|_{V_2 = 0} = \frac{1}{n} \qquad \left(\because \frac{I_2}{I_1} = n\right)$$

9. (B) Given $\quad R = 2\text{k}\Omega$

$\quad L = 1\text{H}$

$\quad C = \dfrac{1}{400}\,\mu\text{F}$

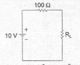
resonant frequency is series RLC circuit is given by

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{1 \times \dfrac{10^{-6}}{400}}}$$

$$= \frac{1}{\pi} \times 10^4 \text{ Hz.}$$

10. (C) According to maximum power transfer theorem, the maximum power will transfer to the load when $R_{th} = R_L = 100\Omega$ (Here) and it is given by



$$P_{max} = \frac{V^2}{4R_{th}} \text{ or } \frac{V^2}{4R_L}$$

$$= \frac{10^2}{4 \times 100} = \frac{1}{4} = 0{\cdot}25 \text{ W}$$

11. (C) Refer synopsis.

12. (B) Temperature dependency of reverse saturation current is given by relation

$$I_0(T) = I_0\, 2^{\frac{(T - T_1)}{10}}$$

where, $I_0(T)$ = saturation current at temp. T

I_0 = saturation current at temperature T_1

Here given, I_0 at $t = T_1 = 20°$ is 10PA at $t = 40° = T$.

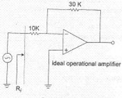
$$I_0 = ?$$

so, $\quad I_0(40°) = 10 \times 2^{\frac{40-20}{10}} = 10 \times 2^2 = 40\text{pA}.$

13. (C) The primary reason for the widespread use of silicon in semiconductor device technology is the favourable properties of silicon-dioxide (SiO_2).

14. (C) A current shunt feedback in an amplifier is used to decrease the input resistance and to increase the output resistance.

15. (B) Input Impedance for the given figure is calculated by shorting all voltage sources (*i.e.* input supply)



So, $R_i = 10k\Omega$

16. (D)
17. (B) The cascade amplifier is a multistage configuration of CE – CB.
18. (B)

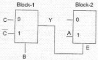
	2
16	43
	32
	11 → B

$(43)_{10} = (2B)_{16}$

and $(43) = 01000011$ (BCD system).

19. Let the output from block 1 as shown below is *y*.

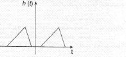
$$y = \overline{B}C + B\overline{C}$$



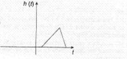
Since 1 input is not given in block-2. So it cannot be solved further due to data insufficiency.

20. (B) From the given options alternative (B) is the correct choice. Since the cansal system has non-zero value for $t \geq 0$ only.

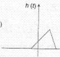
(A)



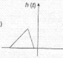
(B)



(C)



(D)



21. (A) Given $x(n) = \left(\frac{1}{2}\right)^n u(n)$

$$y(n) = x^2 n = \left(\frac{1}{2}\right)^{2n} u^2(n)$$

or $$y(n) = \left[\left(\frac{1}{2}\right)^2\right]^n u(n)$$

$$y(n) = \left(\frac{1}{4}\right)^n u(n)$$

Now, $x(e^{j0}) = \frac{1}{4}$

22. (D)

- $\{1 + k\,m(t)\}\,A \sin(\omega_c t) \rightarrow$ Amplitude modulation
- $k\,m(t)\,A \sin(\omega_c t) \rightarrow$ D SB-SC modulation
- $A \sin[\omega_c + k\,m(t)] \rightarrow$ phase modulation
- $A \sin\left\{\omega_c t + k \int_{-\infty}^{t} m(\tau)\,d\tau\right\} \rightarrow$ Frequency modulation

23. (A) The power present in the signal

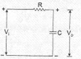
$$s(t) = 8\cos\left(20\pi t - \frac{\pi}{2}\right) + 4\sin(15\pi t)$$

$$= \frac{8^2}{2} + \frac{4^2}{2}$$

$$= 40$$

24. (C) SSB analog modulation scheme requires the minimum transmitted power and minimum channel bandwidth.
25. (C)
26. (D) Lag network is an RC network

$$\text{T.F.} = \frac{1/CS}{\frac{1}{CS} + R}$$



or $\text{T.F.} = \frac{1}{1 + RCS}$

or $\text{T.F.} = \frac{1}{1 + ST}$

(where T = RC = time constant)

or $\text{T.F.} = \frac{1}{1 + j\omega T}$

or $\text{T.F.} = \frac{1}{\sqrt{1 + \omega^2 T^2}} \angle -\tan^{-1}(\omega T)$

$= M \angle \phi$

where M = magnitude of the T.F.

$\angle \phi$ = phase of the T.F.

when $\omega = 0$, $M = 1$ and $\phi = 0°$.

The phasor at $\omega = 0$ has unit length and lies along the positive real axis.

As ω increase M decreases and phase angle increases negatively

when $\omega = \frac{1}{T}$, $M = \frac{1}{\sqrt{2}}$, $\phi = -45°$

and as $\omega \to \infty$, $M \to 0$, $\phi = -90°$

27. (A) Despite the presence of negative feedback, control systems still have problems of instability because the negative feedback increases the number of components of the system, thereby increasing its complexity as well as non linearities.

28. (C) Given

$\vec{H}(x, y, z, t) = 10 \sin(50000\, t + 0{\cdot}004\, x + 30)\, \hat{a}_y$ ...(A)

on comparing given equation (A) with the standard equation

$H = M_0 \sin(\omega t - \beta x)$ ...(B)

The phase velocity

$$v_p = \frac{\omega}{\beta} = \frac{50000}{-0{\cdot}004} = -1{\cdot}25 \times 10^7 \text{ m/s.}$$

29. (B) Refer synopsis.

30. (C) Given $n_g = 1{\cdot}5$

$f = 10^{14}$ Hz

$v = 3 \times 10^8$ m/s

$\lambda = ?$

Velocity of light in glass $= \frac{v}{n_g} = \frac{3 \times 10^8}{1{\cdot}5} = 2 \times 10^8$ m/s.

From relation $v = f\lambda$

or $2 \times 10^8 = 10^{14}\lambda$

or $\lambda = 2 \times 10^{-6}$ m

or $\lambda = 2\mu$m

31. (A) Given, $f(t) = e^{(a+2)t+5}$

or $f(t) = e^5 . e^{(a+2)t}$

In order to make the real part of Laplace transform of the function $f(t)$ to be exist

$\text{Re}(s) > a + 2$

32. (C) Given $A = \begin{bmatrix} -4 & 2 \\ 4 & 3 \end{bmatrix}$

A.E. is given by

$A - \lambda I = 0$ where, I is the identity matrix

or $\begin{bmatrix} -4 & 2 \\ 4 & 3 \end{bmatrix} - \lambda \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = 0$

or $\begin{bmatrix} -4 & 2 \\ 4 & 3 \end{bmatrix} - \begin{bmatrix} \lambda & 0 \\ 0 & \lambda \end{bmatrix} = 0$

or $(-4 - \lambda)(3 - \lambda) - 2 \times 4 = 0$

or $-12 - 3\lambda + 4\lambda + \lambda^2 - 8 = 0$

or $\lambda^2 + \lambda - 20 = 0$

or $(\lambda - 4)(\lambda + 5) = 0$

or $\lambda = 4, -5$

on putting $\lambda = -5$

$[A - \lambda I]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = 0$

or $\begin{bmatrix} 1 & 2 \\ 4 & 8 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = 0$

or $x_1 + 2x_2 = 0$

or $x_1 = -2x_2$

If $x_2 = -1$

$x_1 = 2$

$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 2 \\ -1 \end{bmatrix}$

33. (A) Given, $A = \begin{bmatrix} 2 & -0{\cdot}1 \\ 0 & 3 \end{bmatrix}$

and $A^{-1} = \begin{bmatrix} \frac{1}{2} & a \\ 0 & b \end{bmatrix}$

We know that $A.A^{-1} = I$

where, I = identity matrix

$\begin{bmatrix} 2 & -0{\cdot}1 \\ 0 & 3 \end{bmatrix}\begin{bmatrix} \frac{1}{2} & a \\ 0 & b \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

$0 \cdot a + 3 \cdot b = 1$

or $b = \frac{1}{3}$

and $2 \cdot a - 0{\cdot}1.b = 0$

or $2a = 0{\cdot}1b$

or $a = \frac{0{\cdot}1}{2} \cdot \frac{1}{3} = \frac{1}{60}$

Now, $a + b = \frac{1}{60} + \frac{1}{3}$

or $a + b = \frac{1 + 20}{60}$

or $a + b = \frac{21}{60} = \frac{7}{20}$

34. (A) Given $I = \frac{1}{\sqrt{2\pi}} \int_0^\infty \exp\left(\frac{-x^2}{8}\right) dx$

$= k \int_0^\infty e^{-bx^2} dx$

where $k = \frac{1}{\sqrt{2\pi}}$, $b = \frac{1}{8}$

Let $bx^2 = t$

or $x = \sqrt{\frac{t}{b}}$

$dx = \frac{1}{2} \cdot \frac{t^{-1/2}}{\sqrt{b}} dt$

or $I = \frac{k}{2\sqrt{b}} \int_0^\infty e^{-t} t^{-1/2} dt$

$= \frac{\Gamma\left(\frac{1}{2}\right)}{2\sqrt{2\pi b}}$

$\Gamma\left(\frac{1}{2}\right) \rightarrow$ Gamma function and $\Gamma\left(\frac{1}{2}\right)$ is equal to $\sqrt{\pi}$

Now, $I = \frac{\sqrt{\pi}}{2\sqrt{2\pi b}} = \frac{1}{2\sqrt{2b}}$

$= \frac{1}{2\sqrt{2 \times \frac{1}{8}}} = \frac{\sqrt{4}}{2} = 1$

35. (C) The symmetric function equation is e^{-t^2} (Simple Gaussian function).

Let the derivative of the symmetric function is $y(t)$ *i.e.*

$y(t) = \frac{d}{dt} \cdot e^{-t^2} = -2t \cdot e^{-t^2}$

$y(t) = \begin{cases} \text{Negative, when } t \text{ is positive} \\ \text{Positive, when } t \text{ is negative} \end{cases}$

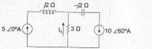
36. (C) Refer synopsis

37. (C) Since $[A.A^T]^{-1} = I$

where, A^T = transpose of matrix A

I = Identity matrix

38. (B) Here the instantaneous current $i_1(t)$ is easily calculated by using superposition theorem.



Case 1. When current source 5∠0°A is taken while 10 ∠60°A is open-circuited. The equivalent circuit becomes as shown in fig. (a)

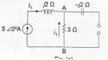


Fig. (a)

From figure (a)

$I_1 = 5\angle 0°A$ (from A to B)

Case 2. When current source 10∠60°A is taken while 5∠0°A is open-circuited. The equivalent circuit becomes as shown in fig. (b).

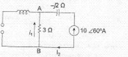


Fig. (b)

From figure (b)

$I_2 = 10\angle 60°A$

Now, $i_1 = I_2 - I$

$= 10\angle 60° - 5\angle 0°$

$= 10 \cos 60° + J\,10 \sin 60° - (5 \cos 0° + J\,5 \sin 0°)$

$= \frac{10}{2} + j\,10\frac{\sqrt{3}}{2} - 5 - j\,5 \cdot 0$

$= j\,10\frac{\sqrt{3}}{2}$

$= 10\frac{\sqrt{3}}{2} \angle -90°$ amp.

Alternative method :

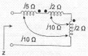
KCL at node A

$5\angle 0° + i_1 = 10\angle 60°$

or $i_1 = 10\angle 60° - 5\angle 0°$

or $i_1 = \frac{10\sqrt{3}}{2} \angle -90°$ amp.

39. (B) From given figure



$Z = L_1 + L_2 + L_3 - 2M_1 + 2M_2$

where $L_1 = j\,5\Omega$

$L_2 = j\,2\Omega$

$L_3 = j\,2\Omega$

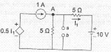
$M_1 = j\,10\Omega$

$M_2 = j\,10\Omega$

or $Z = [j5 + j2 + j2 - 2 \cdot j10 + 2 \cdot j10]\,\Omega$

$= j\,9\Omega$

40. (B) **Calculation for V_{th}** (Thevenin's voltage)



KCL at Node A

$$\frac{V_A - 0}{5} + \frac{V_A - 10}{5} = 1$$

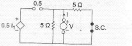
or $$\frac{2V_A}{5} = 3$$

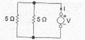
or $$V_A = \frac{15}{2} = 7{\cdot}5\text{V}$$

or $$V_{ab} = V_A = V_{th} = 7{\cdot}5\text{V}$$

Calculation for R_{th} : R_{th} in the dependent source network is the ratio of $\frac{V}{I}$ where, V is the voltage applied between the open-terminal and I is the current produced by this voltage source provided that all the independent source is replaced by their internal resistance.

Now, the equivalent circuit becomes





So, $$R_{th} = \frac{V}{I}$$

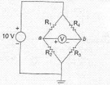
or $$V = I.\,R_{eq}$$

or $$V = I\,2{\cdot}5$$

or $$\frac{V}{I} = 2{\cdot}5\Omega$$

or $$R_{th} = 2{\cdot}5\Omega$$

41. (C) From fig. reading in the ideal voltameter



$$= V_a - V_b$$

$$= 10 \times \frac{R_2}{R_1 + R_2} - 10 \times \frac{R_3}{R_4 + R_3}$$

$$= 10\left(\frac{R}{R+R} - \frac{1{\cdot}1R}{1{\cdot}1R + R}\right)$$

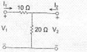
$$= 10\left(\frac{1}{2} - \frac{1{\cdot}1}{2{\cdot}1}\right)$$

$$= 10\left(\frac{2{\cdot}1 - 2{\cdot}2}{4{\cdot}2}\right)$$

$$= \frac{10 \times (-0{\cdot}1)}{4{\cdot}2}$$

$$= -0{\cdot}238\text{V}.$$

42. (D) From the synopsis the standard equation of the *h*-parameters are



$$V_1 = h_{11}\,I_1 + h_{12}V_2 \quad \text{...(A)}$$
$$I_2 = h_{21}\,I_1 + h_{22}V_2 \quad \text{...(B)}$$

from given figure

$$V_1 = 10I_1 + V_2 \quad \text{...(i)}$$
$$V_2 = 20\,(I_1 + I_2)$$

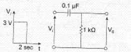
or $$I_2 = -I_1 + \frac{V_2}{20} \quad \text{...(ii)}$$

On comparing equation (i) with equation (A) and equation (ii) with equation (B), we get

$$h_{11} = 10; \quad h_{12} = 1$$
$$h_{21} = -1; \quad h_{22} = \frac{1}{20} = 0{\cdot}05$$

or $$\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} 10 & 1 \\ -1 & 0{\cdot}05 \end{bmatrix}$$

43. (B) The given C-R circuit is a HPF (high pass filter) acts as a differentiator



$$V_0 = -RC\frac{dV_i}{dt}$$

Thus, we get the same magnitude output but opposite polarity.

i.e. $$V_0 = -3V$$

44. (B) Give N_D for sample A $= 10^{18}$ atoms/cm^3 $= p$

N_A for sample B $= 10^{18}$ atoms/cm^3 $= n$

$$\frac{\mu_n}{\mu_p} = 3$$

Conductivity, $$\sigma_n = nq\,\mu_n$$

and $$\sigma_p = pq.\,\mu_p$$

$$\frac{\sigma_p}{\sigma_n} = \frac{p.\mu_p}{n\mu_n} = \frac{10^{18} \times 1}{10^{18} \times 3} = \frac{1}{3}$$

45. (B) Given $d = 10\mu m = 10 \times 10^{-6}$ m

$\epsilon_r = 11{\cdot}7$

$\epsilon_0 = 8{\cdot}85 \times 10^{-12}$ F/m

$\frac{C}{A} = ?$

We know that

$$C = \frac{\epsilon_0 \epsilon_r A}{d}$$

or $\frac{C}{A} = \frac{\epsilon_0 \epsilon_r}{d}$ (depletion capacitance of the diode per square metre)

$$= \frac{8{\cdot}85 \times 10^{-12} \times 11{\cdot}7}{10 \times 10^{-6}}$$

$= 10{\cdot}35\ \mu F$

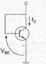
$\approx 10\mu F$

46. (C) Given, $V_{BE} = 0{\cdot}7V$

$I_0 = 10^{-13}$ A at T = 300 K

$I_C = ?$

take $n = 1$



Since here base and emitter are shorted to each other, therefore, the given circuit will work as a diode.

The diode current is given by relation

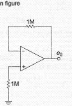
$$I = I_0 \left(e^{\frac{V}{\eta V T}} - 1\right)$$

$$= 10^{-13}\left(e^{\frac{0{\cdot}7}{26 \times 10^{-3}}} - 1\right) \quad [\because V = V_{BE} = 0{\cdot}7\ V]$$

$= 10^{-13} \times 4{\cdot}932 \times 10^{11}$

$= 49$ mA

47. (C) From given figure



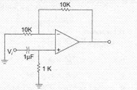
$R_{comp} = 1\ M\ \Omega$ is equal to

$R_f \| R_i$ *i.e.* $1\ M\ \Omega \| R_i = 1\ M\ \Omega$

Since $R_i = \infty$

Therefore, only input offset current can be measured.

48. (A) The given op-amp circuit is a high pass filter and its cut-off frequency in rad/sec is given by

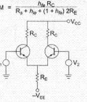


$$\omega_C = \frac{1}{RC} = \frac{1}{1K.\ 1\mu F} = 1000 \text{ rad/sec}$$

49. (D) We know that in differential amplifier differential mode gain, ADM is given by

$$ADM = \frac{1}{2}\frac{h_{fe}.R_C}{(R_s + h_{ie})} \text{ and common mode gain}$$

$$ACM = \frac{h_{fe} R_C}{R_s + h_{ie} + (1 + h_{fe})\,2R_E}$$



From above expression are conclude that large value of R_E decreases the common mode gain only.

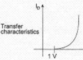
50. (C) Given : $V_T = 1V$

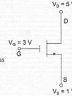
$V_{DS} = V_D - V_S = 5 - 1 = 4V$

$V_{GS} = V_G - V_S = 3 - 1 = 2V$

Now, $V_{GS} - V_T = 2 - 1 = 1V$

since $V_{GS} - V_T < V_{DS}$

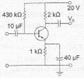




Therefore, the device is in saturation region.

51. (B) Given : $V_{BE} = 0{\cdot}7V$

$V_{CC} = 20V$



$\beta = 50$

$R_C = 2k\Omega$

$I_B = ?$

$V_C = ?$

On applying KVL in input side, we get

$$V_{CC} = I_B R_B + V_{BE} + I_E R_E$$

$$20 = I_B (430k\Omega) + 0{\cdot}7 + (I_B + \beta I_B)\, 1k\Omega$$

or $\quad 20 - 0{\cdot}7 = I_B (430 + 1 + 50)\, 10^3$

or $\quad I_B = \dfrac{19{\cdot}3}{481 \times 10^3}$ amp

or $\quad I_B = 0{\cdot}0401 \times 10^{-3}$

or $\quad I_B = 40\mu A$

From figure, voltage across terminal C of the transistor

$$V_C = V_{CC} - I_C R_C$$

$$= 20 - \beta I_B\, 2 \times 10^3$$

$$= 20 - 50 \times 40 \times 10^{-6} \times 2 \times 10^3$$

$$= (20 - 4) \text{ volt}$$

$$= 16 \text{ volt.}$$

52. (C) Given : $V_Z = 5{\cdot}8V$

$I_{Z(min)} = 0{\cdot}5$ mA

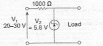
$I_{Z(min)}$ = Called Zener knee current

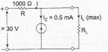
$V_i = 20 - 30$ V, R = 1000 Ω

$I_{L(max.)} = ?$

We know that

$$I_{Z\,(min)} = \frac{V_{i\,(min)} - V_Z}{R} - I_{L\,(max)}$$





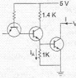
or $\quad I_{L\,(max)} = \dfrac{V_{i\,(min)} - V_Z}{R} - I_{Z\,(min)}$

or $\quad I_{L\,(max)} = \dfrac{20 - 5{\cdot}8}{1000} - 0{\cdot}5\text{mA} = 13{\cdot}7\text{mA}.$

53. (C) Given, $V_{BE} = 0{\cdot}7$ V (active region)

$V_{BE} = 0{\cdot}75$ V (saturation region)

$\beta = 100$



Since output is at logic 0.

So transistor is in saturation

$$V_{BE} = 0{\cdot}75V$$

$$\therefore \quad I_R = \frac{V_{BE}}{1\,k\Omega}$$

$$= \frac{0{\cdot}75}{1\,k\Omega}$$

$$= 0{\cdot}75 \text{ mA.}$$

54. (A)

A	B	C	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	0	1	0
1	1	0	1
1	1	1	0

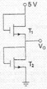
From the *k*-map of the given function, we get

$$f = B\,(A + C)\left(\overline{A} + \overline{C}\right)$$

55. (C) We know that for transistor T_1 and T_2 is given by relation

$$I_{DS}\,(T_1) = \frac{1}{2} K_1 (V_{GS_1} - V_t)^2$$

$$I_{DS}\,(T_2) = \frac{1}{2} K_2 (V_{GS_2} - V_t)^2$$



given $K_1 = 36\ \mu A/V^2$

$K_2 = 9\ \mu A/V^2$

$V_t = 1V$

from given figure

$V_{GS_1} = 5 - V_0$

and $V_{GS_2} = V_0$

Since $I_{DS}(T_1) = I_{DS}(T_2)$

so, $\frac{1}{2} K_1 (V_{GS_1} - V_t)^2 = \frac{1}{2} K_2 (V_{GS_2} - V_t)^2$

or $\frac{1}{2} 36 (5 - V_0 - 1) = \frac{1}{2} \cdot 9 (V_0 - 1)^2$

or $8 + 1 = 3 V_0$

or $V_0 = 3$ V.

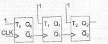
56. (C) Given that $Q_n = 0$. The characteristic table of JK F/F as shown below :

J	K	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$

from the characteristic table it is clear if J = 1 and $Q_n = 0$.

So for any value of K (*i.e.* either 0 or 1). Q_{n+1} will be logic 1.

57. (A) From the given figure it is clear that it is 3 bit binary ripple **down** counter.



Since $\overline{Q_0}$ of F/F T_0 is passed through T_1 and $\overline{Q_1}$ of T_1 is passed through T_2.

Hence the next state will be 0 1 0.

58. (D) Let CS = 1

A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	...	A_0
X	X	X	X	X	X	0	1	0	...	0
						0	1	1	...	1
						1	0	0	...	0
						1	0	1	...	1

'X' can be considered as '0' or '1'.

F 800 → F9FF

↓

1111 1000 0000 0000

↓

In this address A8 and A9 both are in '0' Logic, so both chip will not select, so this address will not select any chip.

59. (A) Given equation

$y(t) = 0{\cdot}5\, x(t - t_d + T) + x(t - t_d) + 0{\cdot}5\, x(t - t_d - T)$ ...(A)

We know that

$x(t - t_0) \Leftrightarrow e^{-j\omega t_0} X(\omega)$, By using time shifting property

or $Y(\omega) = 0{\cdot}5 e^{-j\omega(t_d - T)} X(\omega) + e^{-j\omega t_d} X(\omega)$
$+ 0{\cdot}5\, e^{-j\omega(t_d + T)} X(\omega)$

or $Y(\omega) = X(\omega)\, e^{-j\omega t_d}\, [0{\cdot}5\, e^{j\omega t} + 0{\cdot}5\, e^{-j\omega T} + 1]$

or $Y(\omega) = X(\omega)\, e^{-j\omega t_d}\, [1 + \cos \omega T]$

Now, the filter transfer function H (ω),

$$H(\omega) = \frac{Y(\omega)}{X(\omega)} = (1 + \cos \omega T)\, e^{-j\omega t_d}$$

60. (C) Refer synopsis.

61. (B) Given the output of the system

$y(n) = A\, x(n - n_0)$ ...(A)

Equation (A) can be written as

$Y(e^{j\omega}) = A\, e^{-j\omega n_0} X(e^{j\omega})$

$H(e^{j\omega}) = \frac{Y(e^{j\omega})}{X(e^{j\omega})} = A\, e^{-j\omega n_0}$

$= |H(e^{j\omega})| \angle H(e^{j\omega})$

$\angle H(e^{j\omega}) = -\omega n_0$

or $\angle H(e^{j\omega}) = -\omega_0 n_0 + 2\pi k$

(general solution)

where, *k* is a arbitrary integer.

62. (B) Given $x(t) \xrightarrow{FT} X(t)$

for X (3*f* + 2) what will be *x'* (*t*)

Inverse Fourier transform of X (*af* + *b*) is

$$\frac{1}{a} e^{-j2\pi \frac{b}{a} t}\, x\left(\frac{t}{a}\right)$$

Here *a* = 3, *b* = 2.

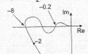
we get $x'(t) = \frac{1}{3} x\left(\frac{t}{3}\right) e^{\frac{-j4\pi t}{3}}$

63. (B) The closed loop system is stable for

$8k < 1$ which gives $k < \frac{1}{8}$

$0{\cdot}2\, k > 1$ which gives $k < 5$

$2k > 1$ which gives $k > \frac{1}{2}$



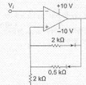
GH Plane

Thus final range of *k* is

$k < \frac{1}{8}$ and $\frac{1}{2} < k < 5$.

64. (C)

65. (B)



$V_0 = \pm 10$ V as supply voltage = ± 10 V

when, $V_0 = 10$ V

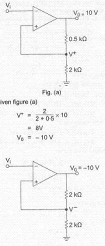


Fig. (a)

From given figure (a)

$$V^+ = \frac{2}{2+0{\cdot}5} \times 10$$

$$= 8V$$

when, $V_0 = -10$ V

Fig. (b)

From figure (b)

$$V^- = \frac{2}{2+2}(-10) = -5V$$

The required hysteresis loop is given in option (B).

66. (D) Given, $r(t) = t$ (*i.e.* ramp input)

or $R(s) = \frac{1}{s^2}$

$H(s) = 1$

We know that steady state error

$$e_{ss} = \lim_{s \to 0} sE(s)$$

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

or $$e_{ss} = \lim_{s \to 0} \cdot \frac{s \cdot 1}{s^2 [1 + G(s)]} \quad (\because H(s) = 1)$$

or $$e_{ss} = \lim_{s \to 0} \frac{1}{s[1 + G(s)]}$$

type of system = 1

$$e_{ss} = 5\% = \frac{1}{20} = K_a$$

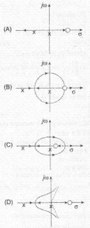
or $$K_a = \frac{1}{20}$$

where K_a = Zero frequency gain of the system.

67. (A)

68. (A) Given $G(s) = \frac{K(1-s)}{s(s+3)}$

$H(s) = 1$



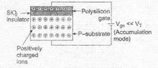
Alternative (A) is the correct choice because of the following reasons :

(i) Open loop poles are stats at K = 0 and terminate either at open loop zero or infinity.

(ii) A point on the real axis lie on locus if the number of open loop poles plus zeros on the real axis to the right of this points is odd. Here alternative (B), (C) and (D) are not satisfied by this condition.

69. (C) In a p-type substrate there is majority of fixed positive charged ions and minority of electron. Therefore, in the accumulation mode the dominant charge in the channel is due to the presence of positively charged ions.

This can be better understood by the figure shown below :



70. (A) Given, $\Delta f = 90$ kHz

$f_m = 5$ kHz (modulating signal)

BW = ? (Output signal)

and device input $x(t)$ and output $y(t)$ is characterized by $y(t) = x^2(t)$

FM equation is given as

$$x(t) = A\cos[\omega_c t + \beta \sin \omega_m t]$$

We know that

$$\beta = \frac{\Delta f}{f_m} = \frac{90 \text{ kHz}}{5 \text{ kHz}} = 18$$

or $y(t) = A\cos[\omega_c t + 18 \sin \omega_m t]$

$\therefore$ $y(t) = x^2(t)$ {given}

so, $y(t) = A^2 \cos^2[\omega_c t + 18 \sin \omega_m t]$

or $y(t) = A^2\left[\frac{1}{2} + \frac{1}{2}\cos(2\omega_c t + 36 \sin \omega_m t)\right]$

or $y(t) = \frac{A^2}{2} + \frac{A^2}{2}\cos(2\omega_c t + 36 \sin \omega_m t)$

The bandwidth of the output signal

$$\beta' = \frac{\Delta f}{f_m}$$

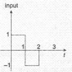
or $\Delta f = \beta' \cdot f_m$ (where $\beta' = 36$ for output signal)

or $\Delta f = 36 \times 5 = 180$

Therefore, the bandwidth of the output signal by Cardons rule

$$= 2(\Delta f + f_m)$$
$$= 2(180 + 5)$$
$$= 370 \text{ kHz}$$

71. (A)



From given figure input $x(t)$ can be represented as

$$x(t) = u(t) - 2u(t-1) + u(t-2)$$

The impulse response of a matched filter is delayed version of input.

Since delay is not given, so assumed to be zero.

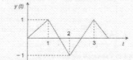
$\therefore$ $y(t) = x(t) * x(t)$

where, $*$ represents convolution

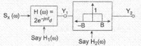
or $y(t) = r(t) - 2 \cdot 2r(t-1) + 2 \cdot 2r(t-2) - 2 \cdot 2r(t-3) + r(t-4)$

or $y(t) = r(t) - 4r(t-1) - 4r(t-2) - 4r(t-3) + r(t-4)$

graphically $y(t)$ is shown below :



72. (C) Given that noise with uniform power spectral density of N_0 W/Hz is passed through a filter $H(\omega) = 2e^{-j\omega t_d}$ followed by an ideal low pass filter of bandwidth B Hz *i.e.*



From above figure

Power spectral density of input

$$S_X(\omega) = N_0 \text{ W/Hz}$$
$$SY_1(\omega) = |H_1(\omega)|^2 \cdot S_X(\omega)$$

or $SY_1(\omega) = 4 \cdot N_0$ W/Hz $(\because |H_1(\omega)|^2 = 4)$

Again from above figure

$$SY_2(\omega) = |H_2(\omega)|^2 \cdot SY_1(\omega)$$

or $SY_2(\omega) = 4N_0$ W/Hz, $-B \le \omega \le B$

Now, output noise power

$$= \int_{-\beta}^{\beta} SY_2(\omega)\, d\omega$$
$$= \int_{-\beta}^{\beta} 4N_0\, d\omega$$
$$= 8 N_0 B \text{ watt}$$

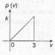
73. (C)

74. (C) From given figure

$$\int_{-\infty}^{\infty} p(v)\, dv = 1$$
$$\frac{1}{2} \times 4 \times k = 1$$

or $k = \frac{1}{2}$

and $p(v) = mv$ $\left(\because m = \text{slope} = \frac{k}{4}\right)$



or $p(v) = \frac{k}{4} \cdot v$

or $p(v) = \frac{1}{8} \times v$

Now, mean square value $= \int_{-\infty}^{\infty} v^2 p(v)\, dv$

$$= \int_0^4 v^2 \frac{v}{8}\, dv$$

$$= \frac{1}{8}\left[\frac{v^4}{4}\right]_0^4$$

$$= \frac{1}{8}\left[\frac{4^4}{4}\right]$$

$$= 8$$

75. (B)

76. (D) We know that

$$Z_O = \sqrt{Z_{OC} \times Z_{SC}}$$

where Z_O = characteristic impedance
Z_{OC} = open circuit impedance
Z_{SC} = short circuit impedance

given, $Z_O = 50$
$Z_{OC} = 100 + j\,150$
$Z_{SC} = Z_{in}$ (when transmission line is short-circuited)

Now, $50 \times 50 = (100 + j\,150)\, Z_{SC}$

or $Z_{SC} = \frac{2500}{100 + j\,150}$

or $Z_{SC} = \frac{2500\,(100 - j\,150)}{(100 + j\,150)\,(100 - j\,150)}$

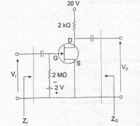
or $Z_{SC} = \frac{25}{325}(100 - j\,150)$

or $Z_{SC} = \frac{100}{13} - \frac{j\,150}{13}$

or $Z_{SC} = 7{\cdot}69 - j\,11{\cdot}54\ \Omega$

77. (A)

78. (B) Given, $r_d = 20\ k\Omega$
$I_{DSS} = 10\ mA$
$V_P = -8\ V$



from given figure

$Z_i = 2\ M\Omega$

and $Z_O = R_d \,||\, r_d$

or $Z_O = 2\ k\Omega \,||\, 20\ k\Omega$

or $Z_O = \frac{20}{11}\ k\Omega$

79. (A) We know that

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

Here $V_{GS} = -2\ V$

Now, $I_D = 10\ mA\left[1 - \left(\frac{-2}{-8}\right)\right]^2$

or $I_D = 10 \times \frac{9}{16}\ mA$

or $I_D = 5{\cdot}625\ mA$

and $V_{DS} = V_{DD} - I_D R_D$

or $V_{DS} = 20 - 5{\cdot}625 \times 10^{-3} \times 2 \times 10^3$

or $V_{DS} = 20 - 11{\cdot}250$

or $V_{DS} = 8{\cdot}75\ V$

80. (C) Transconductance, $g_m = 3{\cdot}3\ mS$

and Voltage gain, $A_V = -g_m R_D$

$= -3{\cdot}3\ mS \times 2\ k\Omega$

$= -6{\cdot}6$

or $A = -6$

81a. (A) The given program starts at location 0100 H

LXI SP, 00FF

LXI H, 0701

MVI A, 20 H ← Data 20 H is transferred into A

SUB M ← When SUB M is encountered, PC reaches 0109 H

81b. (C)

ORI 40H ← 20 H = 00100000

ADD M 40 H = 01000000

01100000 ← OR ing

6 0 = 60H

Therefore, the result in the accumulator after the last instruction is executed is 60 H.

82a. (D) Given open loop transfer function with unity feedback

$$G(s) = \frac{3e^{-2s}}{s(s+2)}$$

Gain crossover frequency

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

where, $|e^{-2s}| = \cos 2\omega - j \sin 2\omega$

$= 1$

or $\left|\frac{3 \times 1}{j\omega\,(j\omega + 2)}\right| = 1$

or $\left|\frac{3}{j2\omega - \omega^2}\right| = 1$

or $\left|\frac{3}{\sqrt{\omega^4 + (2\omega)^2}}\right| = 1$

or $\omega^4 + 4\omega^2 = 9$

Let $\omega^2 = P$

or $P^2 + 4P = 9$

or $P = \frac{-4 \pm \sqrt{52}}{2}$

or $P = -2 \pm \sqrt{13}$

or $P = 1 \cdot 605$

or $P = \omega^2 = 1 \cdot 605$

or $\omega = 1 \cdot 26$

Now, **phase crossover frequency**

$$\text{phase angle} = \tan^{-1}(-2\omega) - 90° - \tan^{-1}\left(\frac{\omega}{2}\right)$$

or $$-180° = \tan^{-1}(-2\omega) - 90° - \tan^{-1}\left(\frac{\omega}{2}\right)$$

or $$-270° = -\tan^{-1}\left(\frac{2\omega + \frac{\omega}{2}}{1 - 2\omega \times \frac{\omega}{2}}\right)$$

or $\omega = 0 \cdot 632.$

82b. (D) **Gain Margin**

$$\text{Gain margin} = \left|\frac{3e^{-2s}}{s(s+2)}\right|_{\text{at } \omega = 0 \cdot 632} = a$$

or $a = 2 \cdot 2631$

$$\text{G. M. in dB} = 20 \log\left(\frac{1}{a}\right)$$

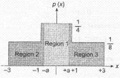
$$= 20 \log\left(\frac{1}{2 \cdot 2631}\right)$$

$$= -7 \cdot 094 \text{ dB}$$

and phase margin $= -86 \cdot 59°$.

83a. (B) We know that

$$\int_{-\infty}^{\infty} f(x)\, dx = 1$$



Since given that the three regions are divided into equi-probable region

Therefore, $\int_{-a}^{a} f(x)\, dx = \frac{1}{3}$

or $\int_{-a}^{a} \frac{1}{4}\, dx = \frac{1}{3}$

or $2a\,\frac{1}{4} = \frac{1}{3}$

or $a = \frac{2}{3}$

83b. (A) Quantization noise power is given as

$$= \int_{-a}^{a} f(x) \cdot x^2\, dx$$

$$= \int_{-a}^{a} \frac{1}{4} \cdot x^2\, dx$$

$$= \frac{1}{4}\left[\frac{x^3}{3}\right]_{-a}^{a}$$

$$= \frac{1}{4}\left[\frac{a^3}{3} - \left(\frac{-a^3}{3}\right)\right]$$

$$= \frac{1}{4} \times \frac{2a^3}{3}$$

$$= \frac{a^3}{6}$$

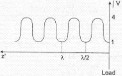
$$= \frac{1}{6}\left(\frac{2}{3}\right)^3$$

$$= \frac{4}{81}$$

84a. (B) Given, $Z_0 = 50\ \Omega$

Here, $V_{max} = 4$

and $V_{min} = 1$



Reflection coefficient,

$$\Gamma = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

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

$$= \frac{3}{5} = 0 \cdot 6$$

Given that load is resistive,

Now, $$\Gamma = \frac{Z_R - Z_O}{Z_R + Z_O}$$

or $$0 \cdot 6 = \frac{Z_R - 50}{Z_R + 50}$$

or $0 \cdot 6\, Z_R + 30 = Z_R - 50$

or $80 = 0 \cdot 4\, Z_R$

or $Z_R = \frac{80}{0 \cdot 4} = 200\ \Omega$

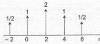
84b. (C) Just calculated in solution Q. 84. (a).

85a. (A)

From given figure, the plot of $y(n) = x(n-1)$ is shown below :

by applying time shifting property

and the plot of $y(n) \left\{x\left(\frac{n}{2}-1\right)\right\}$ is shown given figure :



by applying scaling property

from this plot we conclude that alternative (A) is the correct choice.

85b. (B) From given figure

$$y(1\,\omega) = \frac{1}{2}\cdot e^{-j2\omega} + 1.e^{-j\omega} + 2 + 1.e^{j\omega} + \frac{1}{2}\,e^{j2\omega}$$

$$= \frac{1}{2}\left(e^{j2\omega} + e^{-j2\omega}\right) + 2\cdot\left(\frac{e^{j\omega} + e^{-j\omega}}{2}\right) + 2$$

$$= \cos 2\,\omega + 2\cos\omega + 2.$$