1. (A)

Variance of X $= \delta^2 x = E[(X - mx)^2]$

here mx = Mean value of x or expected value

$$\delta x^2 = E[(X - mx)^2] = \int_{-\infty}^{\infty} (X - mx)^2 fx(x)\, dx$$

$$\delta x^2 = E[(X - mx)^2]$$

$$\delta x^2 = E[X^2 - 2Xmx + mx^2]$$

$$\delta x^2 = E[X^2] - 2mx\, E[X] + mx^2$$

$$\delta x^2 = E[X^2] - 2mxmx + mx^2 \quad \{\because E[X] = mx\}$$

$$\delta x^2 = E[X^2] - mx^2$$

or
$$\boxed{\delta x^2 = E[X^2] - E^2[X]}$$

2. (B) 3. (C)

4. (A) $\lim_{\theta \to 0} \dfrac{\sin(\theta/2)}{\theta}$

$$= \lim_{\theta \to 0} \frac{1}{2}\left[\frac{\sin(\theta/2)}{\theta/2}\right] \qquad \left(\because \lim_{\theta \to 0} \frac{\sin\theta}{\theta} = 1\right)$$

$$\therefore \frac{1}{2}\left[\lim_{\theta \to 0} \frac{\sin(\theta/2)}{\theta/2}\right] = \frac{1}{2}[1] = 0\cdot 5$$

Alternative method :

$$\lim_{\theta \to 0} \frac{\sin(\theta/2)}{\theta} = \lim_{\theta \to 0} \frac{\cos\frac{\theta}{2}\cdot\frac{1}{2}}{1}$$

(After differentiating numerator and denominator by θ)

$$= \frac{1}{2} \text{ (apply the limit)}$$

$$= 0\cdot 5$$

5. (D) 6. (A)

7. (D) According to maximum power transfer theorem for A.C. circuits, maximum average power will deliver to load impedance Z_L when

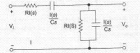
$$Z_L = Z_S^* = R_S - jX_S$$

where Z_S^* = denotes complex conjugate

8. (C) KVL—In Mesh I

$$RI(s) + \frac{I(s)}{Cs} + \left[\frac{R/Cs}{R + \frac{1}{Cs}}\right] I(S) = V_i(s)$$

$$V_i(s) = \left[\frac{(RCs+1)}{Cs} + \frac{R}{(RCs+1)}\right] I(s) \qquad \ldots\text{(i)}$$



$$V_O(s) = \frac{R}{(RCs+1)} I(s) \qquad \ldots\text{(ii)}$$

$$I(s) = \frac{V_O(s)(RCs+1)}{R}$$

Putting the value of $I(s)$ in equation (i)

$$V_i(s) = \left[\frac{RCs+1}{Cs} + \frac{R}{(RCs+1)}\right]\frac{(RCs+1)}{R} V_O(s)$$

$$V_i(s) = \left[\frac{(RCs+1)^2 + RCs}{CsR}\right] V_O(s)$$

$$H(s) = \frac{V_O(s)}{V_i(s)} = \frac{RCs}{RCs^2 + 3RCs + 1} \qquad \ldots\text{(iii)}$$

Compare equation (iii) to band-pass filter equation

$$H(s) = \frac{A_0\, \alpha\omega_0 s}{s^2 + \alpha\omega_0 s + \omega_0^2}$$

This is the band-pass filter.

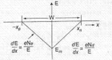
9. (D) $\because n_i^2 = N_A N_D$

$$\therefore N_D = \frac{n_i^2}{N_A}$$

[N_D = Concentration of donor impurities
N_A = Concentration of acceptor]

10. (C) From the figure at distance $x = 0$.

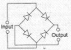
Electric field $|E| = |E_m|$



Electric field E with respect to distance

So the magnitude of the electric field is maximum at $p^+ n$ junction.

11. (C) For the half cycle diode D_2 and diode D_3 is 'ON' and D_1, D_4 is 'OFF' and for – ve half cycle. Diode D_1 and D_4 is ON and D_2, D_3 is OFF position so, this is the full wave rectifier.



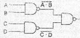
12. (A) Transconductance amplifier is a current series feed-back amplifier due to series connection at the input and output, and for transconductance amplifier both input resistance and output resistance should be large.

13. (A) Given X = 01110
Y = 11001

Sum of X and Y in two's complement format using 6 bits

```
  001110
+ 011001
  100111
```

14. (A) $Y = AB + CD$



15. (D) The given transfer function

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

$\therefore$ One-pole in the R.H.S. of s plane, therefore, given transfer function is a non-minimum phase system.

16. (A) $Y(s) = \frac{1}{s(s-1)}$

by final value theorem

$$\lim_{s \to \infty} Y(s) = \lim_{s \to 0^+} SY(s)$$

$$= \lim_{s \to 0^+} \frac{s}{s(s-1)}$$

17. (C) For real function $f(t)$ autocorrelation is given by

$$R(\tau) = \frac{1}{T} \int_{-T/2}^{T/2} f(t+\tau) f(t)\, dt$$

and $$R(-\tau) = \frac{1}{T} \int_{-T/2}^{T/2} f(t-\tau) f(t)\, dt$$

Let $t - \tau = P$

$dt = dp$

which gives

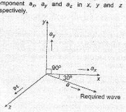
$$R(-\tau) = R(\tau) \text{ i.e. even function.}$$

From this result, we conclude that option (C) is wrong.

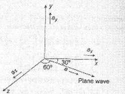
18. (B) Power spectral density, $S(\omega) = \lim_{\tau \to \infty} \frac{|X_\tau(j\omega)|^2}{\tau}$

Therefore, for wide-sense stationary random process, power spectral density is greater than or equal to zero, *i.e.*, $S(f) \geq 0$.

19. (A) According to question, A plane wave of wavelength λ is travelling in a direction making an angle 30° with positive x-axis and 90° with positive y-axis. Assume that component a_x, a_y and a_z in x, y and z direction respectively.



Let the magnitude of plane wave is as shown below



From above figure

$$a_x = a \cos 30° = \frac{\sqrt{3}}{2} a$$

$$a_y = a \cos 90° = 0$$

$$a_z = a \cos 60° = \frac{a}{2}$$

Now, plane wave equation can be written as

$$\vec{E} = \hat{y} E_0 e^{j\left(\omega t - \frac{\sqrt{3}}{2}\beta x - \frac{1}{2}\beta z\right)}$$

or $$\vec{E} = \hat{y} E_0 e^{j\left(\omega t - \frac{\sqrt{3}}{2}\frac{2\pi}{\lambda} x - \frac{1}{2}\frac{2\pi}{\lambda} z\right)}$$

or $$\vec{E} = \hat{y} E_0 e^{j\left(\omega t - \frac{\sqrt{3}\pi}{\lambda} x - \frac{\pi}{\lambda} z\right)}$$

20. (D) From Ampere's law

$$\vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t} \quad \text{...(i)}$$

and from Stoke's theorem

$$\iint_s \vec{\nabla} \times \vec{H} \cdot \vec{ds} = \oint_C \vec{H} \cdot \vec{dl} \quad \text{...(ii)}$$

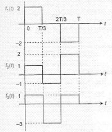
From equation (i) and (ii)

$$\oint_C \vec{H} \cdot \vec{dl} = \iint_s \vec{J} + \frac{\partial \vec{D}}{\partial t} \cdot \vec{ds}$$

21. (C) Since in the given problem there are M non-zero orthogonal vectors, so there is required M dimension to represent them.

22. (A) 23. (C) 24. (D) 25. (B)

26. (B) Given figure



Two signal/functions will be orthogonal if they satisfy the condition

$$\int_{-\infty}^{\infty} f_1(t) \cdot f_2(t)\, dt = 0$$

where, $f_1(t)$ and $f_2(t)$ are two functions

Here for

(A)
$$\int_0^T f_1(t) \cdot f_2(t)\, dt = \int_0^{T/3} f_1(t) \cdot f_2(t) + \int_{T/3}^{2T/3} f_1(t) \cdot f_2(t)\, dt + \int_{2T/3}^{T} f_1(t) \cdot f_2(t)\, dt$$
$$= \int_0^{T/3} 2 \cdot 1\, dt + \int_{T/3}^{2T/3} 0 \cdot (-1)\, dt + \int_{2T/3}^{T} (-2) \times 2\, dt$$
$$= \frac{2T}{3} + 0 + \left(-4T + 4 \cdot \frac{2T}{3}\right)$$
$$= 0 - \frac{2T}{3}$$
$$\neq 0 \text{ i.e. not orthogonal.}$$

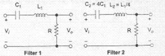
(B) For $f_1(t) \cdot f_3(t)$
$$\int_0^T f_1(t) f_3(t)\, dt = \int_0^{T/3} f_1(t) f_3(t)\, dt + \int_{T/3}^{2T/3} f_1(t) \cdot f_3(t)\, dt + \int_{2T/3}^{T} f_1(t) \cdot f_3(t)\, dt$$
$$= \int_0^{T/3} 2 \cdot 1\, dt + \int_{T/3}^{2T/3} 0 \cdot (-3)\, dt + \int_{2T/3}^{T} (-2) \cdot dt$$
$$= \frac{2T}{3} + 0 + 2\left(-2T + \frac{4T}{3}\right)$$
$$= \frac{2T}{3} - \frac{2T}{3}$$
$$= 0 \text{ i.e. orthogonal}$$

Therefore no need to solve further.

Hence alternative (B) is the correct choice.

27. (A)

28. (D) From given figures



We know that

$$\text{Quality factor} = \frac{\text{Resonance frequency}}{\text{Bandwidth}}$$

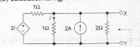
or
$$Q = \frac{\omega_0}{BW}$$

for figure 1
$$\text{BW say } B_1 = \frac{\omega_0}{Q} = \frac{\omega_0}{\frac{\omega L_1}{R}}$$

for figure 2
$$\text{BW say } B_2 = \frac{\omega_0}{Q} = \frac{\omega_0}{\frac{\omega L_2}{R}}$$

Now, $\frac{B_1}{B_2} = \frac{\omega L_2}{\omega L_1} = \frac{L_2}{L_1} = \frac{L_1/4}{L_1} = \frac{1}{4}$

29. (D) **Calculation for R_{th}**



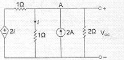
Since in the given circuit dependent source is present, therefore,

$$R_{th} = \frac{V_{OC}}{I_{SC}}$$

where V_{OC} = open circuit voltage (*i.e.* V_{th})

I_{SC} = short circuit current

Now, V_{OC} can be calculated for the circuit shown below :



Apply KCL at node A, we get

$$\frac{V_{OC}}{2} + \frac{V_{OC}}{1} + \frac{V_{OC} - 2i}{1} = 2 \quad \text{...(i)}$$

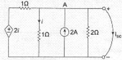
also
$$V_{OC} = i \quad \text{...(ii)}$$

from (i) and (ii)

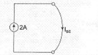
or
$$\frac{V_{OC}}{2} + \frac{V_{OC}}{1} + \frac{V_{OC} - 2\,V_{OC}}{1} = 2$$

or
$$V_{OC} = 4\text{ V}$$

Calculation for I_{SC} : Equivalent circuit of the given circuit when open terminal is short can be redrawn as shown below :



or



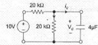
Thus, from figure shown just above

$$I_{SC} = 2A$$

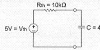
So, $$R_{th} = \frac{V_{OC}}{I_{SC}} = \frac{4}{2} = 2\ \Omega$$

$$V_{th} = V_{OC} = 4\ V$$

30. (A)



From given figure, Thevenin equivalent circuit across capacitor is shown below :



$$V_{th} = 10 \times \left(\frac{20}{20+20}\right) = 5V$$

$$R_{th} = (20 \parallel 20)\ k\Omega = 10\ k\Omega$$

Now, from above general equation of voltage across capacitor

$$V_C = iR + \frac{1}{C}\int i\, dt$$

$$5 = iR + \frac{1}{C}\int i\, dt$$

or $$0 = R\frac{di}{dt} + \frac{1}{C}i$$

or $$\frac{di}{i} = \frac{-1}{RC}dt$$

or $$\int_{i_0}^{i} \frac{di}{i} = -\frac{1}{RC}\int 1\, dt$$

or $$\log i - \log i_0 = \frac{-1}{RC}t$$

or $$\frac{i}{i_0} = e^{-t/RC}$$

or $$i = i_0\, e^{-t/RC}$$

when $t = 0$, and $V_C = 0$

$$i_0 = \frac{V_{th}}{R_{th}} = \frac{5V}{10\ k\Omega}$$

$$= 0.5\ mA$$

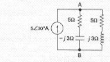
Now, $$i(t) = 0.5\, e^{-\frac{t}{10\ k\Omega \times 4\ \mu F}}$$

or $$i(t) = 0.5\, e^{-25t}$$

31. (D) From figure,

$$V_{AB} = I_{AB} \cdot Z_{AB}$$

and $$I_{AB} = 5\angle 30^\circ \times \frac{5+j3}{5-j3+5+j3}$$



or $$I_{AB} = 5\angle 30^\circ \times \frac{5+j3}{10}$$

or $$I_{AB} = \frac{1}{2}\angle 30^\circ\,(5+j3)$$

$$Z_{AB} = 5-j3$$

Now, $$V_{AB} = \frac{1}{2}\angle 30^\circ\,(5+j3)\cdot(5-j3)$$

or $$V_{AB} = \frac{1}{2}\angle 30^\circ\,(5^2-j^2 3^2)$$

or $$V_{AB} = \frac{1}{2}\angle 30^\circ\,(25+9)$$

or $$V_{AB} = 17\angle 30^\circ$$

32. (A) Depletion capacitance,

$$C_d \propto \frac{1}{\left(1+\frac{V_r}{V_{bi}}\right)^{1/2}}$$

where, V_r = Reverse bias voltage

V_{bi} = Built-in potential

C_d = Depletion layer capacitance

and $$C_d = \frac{\in_0 A}{d}$$

where d is width of depletion layer.

$$\therefore \quad \frac{d_1}{d_2} = \left(\frac{V_{bi}+V_{r_1}}{V_{bi}+V_{r_2}}\right)^{1/2}$$

or $$d_2 = d_1\left(\frac{V_{bi}+V_{r_2}}{V_{bi}+V_{r_1}}\right)^{1/2}$$

or $$d_2 = 2\ \mu m\left(\frac{0.8+7.2}{0.8+1.8}\right)^{1/2}$$

or $$d_2 = 2\ \mu m \times 2$$

or $$d_2 = 4\ \mu m$$

33. (B)

- Zener diode → Operates in reverse bias
- Solar cell → Operates in forward bias
- Laser diode → Operates in very high voltage forward bias to give population inversion.
- Photo diode → Operates in reverse bias in avalanche region.

34. (B) Given $\beta = 50$

emitter injection efficiency = 0·995

Base transport factor = ?

We know that

$$\text{Base transport factor} = \frac{\alpha}{\text{emitter injection efficiency}}$$

where, $\alpha = \frac{\beta}{1+\beta} = \frac{50}{51}$

Now, base transport factor

$$= \frac{50}{51 \times 0{\cdot}995}$$

$$= 0{\cdot}9853$$

35. (C)

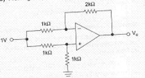
BJT → Early effect

MOS capacitor → Flat band voltage

LASER diode → Population inversion

JFET → Pinch-off voltage

36. (C) From figure (1)



$$V_O = V_{O_1} + V_{O_2}$$

$$V_O = V_1\left(-\frac{R_f}{R_1}\right) + V_2\left(1+\frac{R_f}{R_1}\right)$$

where,

$$R_f = 2\ k\Omega$$

$$R_1 = 1\ k\Omega$$

$$V_2 = \frac{1}{1+1} \times 1 = 0{\cdot}5\ V$$

$$V_1 = 1\ V$$

Now,

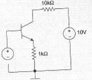
$$V_O = 1\left(\frac{-2}{1}\right) + 0{\cdot}5\left(1+\frac{2}{1}\right)$$

or $V_O = -2 + 1{\cdot}5$

or $V_O = -0{\cdot}5\ V$

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

$V_B = 2V$



In order to solve such type of problems, first check the condition for saturation. A transistor will operate in saturation if

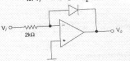
$$I_B \geq (I_B)_{min}$$

where, $(I_B)_{min} = \frac{I_C}{h_{FE}}$

since given that h_{FE} or β is very large, it means $(I_B)_{min}$ will be very small, therefore, the above condition is satisfied. Hence, the transistor operated in saturation region.

38. (D) Given, for $V_i = 2V, V_O = V_{O_1}$

and for $V_i = 4V, V_O = V_{O_2}$



The given circuit represents log amplifier

$$V_O = -V_T \ln V_i + C \quad \text{...(i)}$$

where C is any constant

V_{O_1} when $V_i = 2V$

$$V_{O_1} = -V_T \ln 2 + C \quad \text{...(ii)}$$

V_{O_2} when $V_i = 4V$

$$V_{O_2} = -V_T \ln 4 + C \quad \text{...(iii)}$$

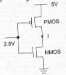
from equation (ii) and (iii)

$$V_{O_1} - V_{O_2} = -V_T \ln 2 + V_T \ln 4$$

or $V_{O_1} - V_{O_2} = V_T \ln 2$

39. (D) Given $k_n = k_p = \mu_n C_{OX}\frac{W_n}{L_n} = \mu_p C_{OX}\frac{W_p}{L_p} = 40\ \mu A/V^2$

and $V_{Th_n} = |V_{Th_p}| = 1$



we know that

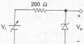
$$I = k_n (V_{gs} - V_{Th_n})^2$$

$$= 40\ (2{\cdot}5 - 1)^2$$

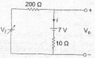
$$= 40 \times 2 \cdot 25$$
$$= 90\ \mu A$$

40. (C) Given $r_z = 10\ \Omega$ (zener dynamic resistance)

$$V_z = 7V$$



From the given information, the given circuit can be redrawn as shown below :



when $V_i = 10\ V,\ i = \frac{10-7}{210} = \frac{3}{210}$ amp

$$V_{O_1} = 7 + 10\,i = 7 + \frac{10 \times 2}{210} = 7 \cdot 14\ V$$

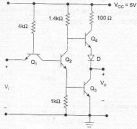
when $V_i = 16\ V,\ i = \frac{16-7}{210} = \frac{9}{210}$ amp

$$V_{O_2} = 7 + 10\,i = 7 + \frac{10 \cdot 9}{210} = 7 \cdot 43\ V$$

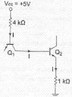
41. (C) Given expression

$$Y = \bar{A}\bar{B}\bar{C}D + \bar{A}BC\bar{D} + A\bar{B}\bar{C}D + AB\bar{C}\bar{D}$$
$$= \left(\bar{A}\bar{B}\bar{C}D + A\bar{B}\bar{C}D\right) + \bar{A}BC\bar{D} + AB\bar{C}\bar{D}$$
$$= \bar{B}\bar{C}D\left(\bar{A} + A\right) + \bar{A}BC\bar{D} + A\bar{B}\bar{C}\bar{D}$$
$$= \bar{B}\bar{C}D + \bar{A}BC\bar{D} + AB\bar{C}\bar{D}$$

42. (B) Given $V_i = 2 \cdot 5$ V, when V_{in} is at high voltage (say 2 – 5 V), base-emitter junction of transistor Q_1 becomes reverse biased and flows through 4 kΩ resistance. So, Q_1 operate in reverse active mode.



Because of base current of Q_2 it drives into saturation mode because



$$I = \frac{5 - V_{BE_1} - V_{BE_2}}{(4+1)\ k\Omega}$$
$$= \frac{5 - 0 \cdot 7 - 0 \cdot 7}{5\ k\Omega}$$
$$= 0 \cdot 72\ mA$$

or $$V_{B_2} = 5 - 0 \cdot 7 - 7 \times 4\ k\Omega$$
$$= 5 - 0 \cdot 7 - 0 \cdot 72 \times 4$$
$$= 1 \cdot 42\ V$$

$\therefore V_{B_2} > 0 \cdot 7$ volts so Q_2 operates in saturation mode.

Because of saturation of Q_2, a voltage drop across 1 kΩ resistance.

$$I_1 = \frac{V_{CC}}{(1 \cdot 4 + 1)\ k\Omega} = \frac{5}{1 \cdot 4 + 1} = 2 \cdot 03\ mA$$
$$V_{B_3} = (I + I_1)\ 1\ k\Omega$$
$$= (0 \cdot 72 + 2 \cdot 03)\ mA \times 1\ k\Omega$$
$$= 2 \cdot 75\ V$$

Since $V_{B_3} > 0 \cdot 7$ volts, so Q_3 operates in saturation region

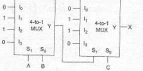
$\therefore$ Q_3 and Q_4 together form a totem pole output, one transistor operate at a time, so Q_4 will be in cut-off.

43. (A) From given circuit

$$Y = \bar{A}\,\bar{B}\,I_0 + \bar{A}BI_1 + A\bar{B}I_2 + ABI_3$$

or $$Y = \bar{A} \cdot \bar{B} 0 + \bar{A} \cdot B \cdot I + A \cdot \bar{B} \cdot I + A \cdot B \cdot 0$$

or $$Y = \bar{A}B + A\bar{B}$$



Again from given circuit

$$X = \bar{S}_1\bar{S}_0 I_0 + \bar{S}_1 \cdot S_0 I_1 + S_1\bar{S}_0 I_2 + S_1 S_0 I_3$$

or $$X = \bar{Y} \cdot \bar{C} \cdot 0 + \bar{Y} \cdot C \cdot 1 + Y \cdot \bar{C} \cdot 1 + Y \cdot C \cdot 0$$

or $$X = \bar{Y}C + Y\bar{C}$$

or $$X = \left(\overline{\bar{A}B + A\bar{B}}\right) \cdot C + \left(\bar{A}B + \bar{B}A\right)\bar{C}$$

or $X = \overline{\overline{AB} \cdot \overline{AB}} \cdot C + \overline{A}BC + A\overline{BC}$

or $X = \left(A + \overline{B}\right)\left(\overline{A} + B\right) \cdot C + \overline{A}BC + A\overline{BC}$

or $X = \left(A \cdot \overline{A} + \overline{A}\overline{B} + AB + B\overline{B}\right) C + \overline{A}BC + A\overline{BC}$

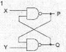
or $X = \overline{A}\overline{B}C + ABC + \overline{A}BC + A\overline{BC}$

44. (C) For the following sequence :

(i) X = 0, Y = 1

(ii) X = 0, Y = 0 and

(iii) X = 1, Y = 1



The corresponding stable outputs P, Q will be

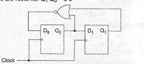
(i) P = 1, Q = 0

(ii) P = 1, Q = 1. Since if any input of the NAND gate is zero, output will be 1.

(iii) If we assume initial value at P and Q is 0 and 1 respectively then for X = 1, Y = 1 output P and Q will be 0 and 1 respectively and if we assume initial value at P and Q is 1 and 0 respectively then for X = 1, Y = 1 output P and Q will be 1 and 0 respectively. Thus

P = 1, Q = 0 or Q = 1, P = 0

45. (B) From given circuit, assume that initially both the flip-flops are reset *i.e.* $Q_1\,Q_0$ = 0 0



From the circuit

$D_0 = \overline{Q_0 + Q_1} = \overline{Q_0} \cdot \overline{Q_1}$

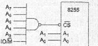
and $D_1 = Q_0$

Clock	Next output (Q_1Q_0)
1	01
2	10
3	00
4	01

Therefore, the counter state (Q_1Q_0) will follows the sequence

00, 01, 10, 00, 01 ....

46. (C) 8255 chip will select in I/O mapped when



A_7	A_6	A_5	A_4	A_3
1	1	1	1	1

However, there is A_2 in don't care condition

A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		Address
1	1	1	1	1	0	0	0	→	F 8 H
1	1	1	1	1	1	1	1	→	F F H

Therefore, the range of addresses for which the 8255 chip would get selected is F 8 H – F F H.

47. (A) The 3 dB bandwidth of a low-pass (RC) filter is given by relation

$$f_{3-dB} = \frac{1}{2\pi RC}\ \text{Hz}$$

gain of RC, low-pass filter is given as

$$A(s) = \frac{1}{1 + sRC} \qquad \text{...(i)}$$

$$f(t) = e^{-t}\,u(t)$$

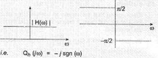
$$f(s) = \frac{1}{s+1} \qquad \text{...(ii)}$$

On comparing equation (ii) with the standard equation (i), we get

$$RC = 1$$

and $$f_{3-dB} = \frac{1}{2\pi}\ \text{Hz}$$

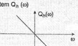
48. (A) A transfer function of a Hilbert transform is given as



i.e. $Q_h(j\omega) = -j\,\text{sgn}(\omega)$

$$= \begin{cases} -j = 1 \cdot e^{-\pi/2j} & \text{for } \omega > 0 \\ j = 1 \cdot e^{\pi/2j} & \text{for } \omega < 0 \end{cases}$$

for linear system $Q_h(\omega)$



So, finally we conclude that Hilbert transform is a non-linear system.

49. (D) Given $H(f) = \dfrac{5}{1 + j10\pi f}$

or $H(s) = \dfrac{5}{1 + 5s}$

$X(s) = \dfrac{1}{S}$ (∵ Given input is unit step)

Let the step response is $Y(s)$, related with the given information as

$$Y(s) = H(s).\,X(s)$$

or $$Y(s) = \frac{5}{(1+5s)}\frac{1}{s}$$

or $\quad Y(s) = 5\left[\frac{A}{1+5s}+\frac{B}{s}\right]$

or $\quad Y(s) = 5\left[\frac{-5}{1+5s}+\frac{1}{s}\right]$

Now by taking inverse Laplace transform

$$Y(t) = 5\left[1 - e^{-t/5t}\right] u(t)$$

This is the required step response.

50. (B) Given that $X(e^{j\omega})$ denote discrete-time Fourier transform of $x[n]$.

We know that $x[n]$ and $X(e^{j\omega})$ are related by relation

$$x[n] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(e^{j\omega})\, e^{j\omega n}\, d\omega \qquad \ldots(i)$$

Now, since we have to calculate the value of

$\int_{-\pi}^{\pi} X(e^{j\omega})\, d\omega$, which can be obtained by putting $n = 0$ in equation (i), we get

$$x[0] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(e^{j\omega})\, e^{j\omega 0}\, d\omega$$

or $\quad x[0] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(e^{j\omega})\, d\omega$

or $\quad \int_{-\pi}^{\pi} X(e^{j\omega})\, d\omega = 2\pi\, x[0]$

or $\quad \int_{-\pi}^{\pi} X(e^{j\omega})\, d\omega = 2\pi \cdot 5 \qquad$ given $x[0] = 5$

or $\quad \int_{-\pi}^{\pi} X(e^{j\omega})\, d\omega = 10\,\pi$

51. (D) Given $\quad X(z) = \frac{0\cdot 5}{1 - 2z^{-1}}$

Since, given that the region of convergence of $X(z)$ includes the unit circle. It means the given sequence $x(n)$ will be causal.

So, from the given $X(z) = \frac{0\cdot 5}{1-2z^{-1}}$ the causal sequence $x(n)$ is given as

$$x(n) = 0\cdot 5.\, 2^n$$

or $\quad x(0) = 0\cdot 5.\, 2^0$

$\quad = 0\cdot 5$

52. (B) Given $\quad K_V = 1000$

$\quad \xi = 0\cdot 5$

$\quad K_P, K_D = ?$

From given figure

$$G(s) = (K_P + K_D s)\,\frac{100}{s(s+10)}$$

Since we know that

$$K_V = \lim_{s\to 0} s\,G(s)$$

$$1000 = \lim_{s\to 0} \frac{s\,(K_P + K_D s)\cdot 100}{s\,(s+10)}$$

or $\quad 1000 = K_P \frac{100}{10}$

or $\quad K_P = 100$

T. F. of the given system is given by

$$T(s) = \frac{G(s)}{1 + H(s)\,G(s)}$$

$$T(s) = \frac{(K_P + K_D s)\cdot \frac{100}{s(s+10)}}{1 + 1\cdot\frac{(K_P + K_D s)\cdot 100}{s(s+10)}} \quad [\because H(s) = 1]$$

or $\quad T(s) = \frac{100\,(K_P + K_D\, s)}{s^2 + s\,(10 + 100\,K_D) + 100\,K_P}$

C.E. of the T.F. is

$$s^2 + s\,(10 + 100\,K_D) + 100\,K_P = 0 \qquad \ldots(i)$$

On comparing equation (i) with standard equation

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

$$\omega_n^2 = 100\,K_P$$

and $\quad 2\xi\omega_n = 10 + 100\,K_D$

$$\omega_n = \sqrt{100 \cdot K_P} = \sqrt{100 \cdot 100} = 100$$

Now, $\quad 2 \times 0\cdot 5 \times 100 = 10 + 100\,K_D$

or $\quad 90 = 100\,K_D$

or $\quad K_D = 0\cdot 9$

53. (D) Given transfer function,

$$T(s) = \frac{5}{(s+5)(s^2+s+1)}$$

or $\quad T(s) = \frac{5}{5\left(\frac{s}{5}+1\right)(s^2+s+1)}$

or $\quad T(s) = \frac{1}{\left(\frac{s}{5}+1\right)(s^2+s+1)}$

The second-order approximation of $T(s)$ using dominant pole concept

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

54. (A) Given open-loop transfer function,

$$G(s) = \frac{1}{s^2-1}$$

or $\quad G(s) = \frac{1}{(s-1)(s+1)}$

This open-loop system is unstable since there is pole (at $s = 1$) on the right half s-plane.

To stabilize this the unity gain feedback must compensated by lead compensator that eliminate this pole.

From the given options, options (A) *i.e.* $\frac{10\,(s-1)}{(s+1)}$ makes the system transfer function stable.

$$G_T(s) = \frac{1}{(s-1)(s+1)}\cdot\frac{10\,(s-1)}{(s+2)}$$

or $\quad G_T(s) = \frac{10}{(s+1)(s+2)}$

which is a stable system.

55. (D) Given, $\quad G(s) = \frac{K}{s\,(s^2+7s+12)}$

for unity feedback

$$\left|\frac{K}{s\,(s^2+7s+12)}\right| = 1$$

On putting $\quad s = -1 + j\,1$

$$K = |s\,(s^2+7s+12)|$$

$$= |[-1 + j\,1]\,[(-1+j\,1)^2 + 7\,(-1+j\,1) + 12]|$$

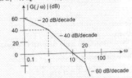
$= |[-1+j1][1+j^2-2j-7+7j+12]|$

$= |[-1+j1][5+5j]|$

$= \sqrt{2} \times 5\sqrt{2}$

$= 10$

56. (D) From given figure, corner frequencies at $\omega_1 = 0$, $\omega_2 = 1$ and $\omega_3 = 20$



The transfer function of the system

$$G(s) = \frac{K}{s(1+sT_1)(1+sT_2)}$$

where, $T_1 = \frac{1}{\omega_2} = \frac{1}{1} = 1$

$T_2 = \frac{1}{\omega_3} = \frac{1}{20} = 0{\cdot}05$

or $G(s) = \frac{K}{s(1+s)(1+0{\cdot}05s)}$

From given figure

$$|G(j\omega)|_{at\ \omega = 0\cdot1} = 60$$

or $20\log_{10}\left|\frac{K}{j\omega(1+j\omega)(1+0{\cdot}05j\omega)}\right|_{\omega=0\cdot1} = 60$

or $\frac{K}{\omega\sqrt{1+\omega^2}\sqrt{1+(0{\cdot}05\,\omega)^2}}\Big|_{at\ \omega=0\cdot1} = 10^3$

or $K = 100$

Finally, $G(s) = \frac{100}{s(s+1)(1+0{\cdot}05\,s)}$

57. (A) Given that

$$\begin{bmatrix}\frac{d\omega}{dt}\\ \frac{di_a}{dt}\end{bmatrix} = \begin{bmatrix}-1 & 1\\ -1 & -10\end{bmatrix}\begin{bmatrix}\omega\\ i_a\end{bmatrix} + \begin{bmatrix}0\\ 10\end{bmatrix}u$$

we can write

$$\frac{d\omega}{dt} = -\omega + i_a \quad \text{...(i)}$$

$$\frac{di_a}{dt} = -\omega - 10i_a + 10u \quad \text{...(ii)}$$

Taking Laplace transform of equation (i), we get

$s\omega(s) = -\omega(s) + i_a(s)$

or $\omega(s)[s+1] = i_a(s)$ ...(iii)

Again taking Laplace transform of equation (ii), we get

$s\,i_a(s) = -\omega(s) - 10\,i_a(s) + 10\,u(s)$

or $i_a(s)[s+10] = -\omega(s) + 10\,u(s)$ ...(iv)

Since, here we have to calculate the ratio of $\frac{\omega(s)}{u(s)}$,

So, eliminate $i_a(s)$ from equations (iii) and (iv)

On putting the value of $i_a(s)$ from equation (iii) into equation (iv), we get

$(s+10)(s+1)\,\omega(s) = -\omega(s) + 10\,u(s)$

or $[s^2 + 10s + s + 10 + 1]\,\omega(s) = 10\,u(s)$

or $\frac{\omega(s)}{u(s)} = \frac{10}{s^2+11s+11}$

58. (D) In delta modulation, the slope overload distortion would not occur if the following condition is satisfied.

$\frac{\Delta}{T_s} \geq$ slope of the modulating signal

or $\frac{\Delta}{T_s} \geq \frac{d}{dt}m(t)$

where, Δ = step size

T_s = sampling period

$m(t)$ = modulating signal

so, from the above relation we conclude that, in delta modulation, the slope over distortion can be reduced by increasing the step size.

59. (A) Given, $P(t) = \frac{\sin 4\pi\omega t}{4\pi\omega t(1-16\omega^2 t^2)}$

$P(t) = ?$ at $t = \frac{1}{4\omega}$

Now, $P(t)|_{at\ t=1/4\omega} = \lim_{t\to 1/4\omega}\frac{\sin 4\pi\omega t}{4\pi\omega t(1-16\omega^2t^2)}$

since at $t = \frac{1}{4\omega}$ expression becomes indeterminant form $\left(i.e.\ \frac{0}{0}\right)$

$\therefore P(t)|_{at\ t=1/4\omega}$

$$= \lim_{t\to 1/4\omega}\frac{\frac{d}{dt}\sin 4\pi\omega t}{\frac{d}{dt}[4\pi\omega t(1-16\omega^2t^2)]}$$

$$= \lim_{t\to 1/4\omega}\frac{4\pi\omega\cos 4\pi\omega t}{4\pi\omega(1-16\omega^2t^2) - 32\omega^2t(4\pi\omega t)}$$

$$= \lim_{t\to 1/4\omega}\frac{4\pi\omega\cos 4\pi\omega t}{4\pi\omega - 3\times 64\,\omega^3 t^2}$$

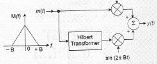
$$= \frac{4\pi\omega}{-8\pi\omega}$$

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

$$= -0{\cdot}5.$$

60. (A) From given figure

$$y(t) = m(t)\cos(2\pi Bt) + m_h(t)\sin(2\pi Bt)$$



$$\text{Let } m(t) = A \cos \omega_m t$$

$$m_h(t) = A \cos \omega_m t$$

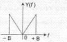
(since $\pi/2$ shift by Hilbert transform)

or $\quad y(t) = A \cos \omega_m t \cos (2\pi B t) + A \sin \omega_m t \sin (2\pi B t)$

or $\quad y(t) = A \cos (\omega_m - 2\pi B)\, t$

This is the equation of LSB

$$\omega_m = 2\pi B$$



61. (C) The probability of almost one bit in error in a block of n bits

$$= p \text{ (1 bit error)} + p \text{ (no bit error)}$$

$$= {}^nC_1 \times p^1 \times (1-p)^{n-1} + {}^nC_0 \times p^0 \times (1-p)^n$$

$$= n\,p\,(1-p)^{n-1} + (1-p)^n$$

62. (B) Given,

Total available bandwidth = 5 MHz

Since frequency reuse factor is $\frac{1}{5}$, so five cell repeat pattern.

So, available bandwidth for each cell

$$(BW)_{Cell} = \frac{(BW)_{Total}}{5} = \frac{5}{5} = 1 \text{ MHz}$$

Also given, $(BW)_{Channel} = 200$ kHz

$$\text{No. of cell} = \frac{(BW)_{Cell}}{(BW)_{Channel}} = \frac{1 \text{ MHz}}{200 \text{ kHz}} = 5$$

There are 8 channel co-exist in same channel bandwidth using TDMA.

So, total number of simultaneous channel that can exist

$$= 5 \times 8 = 40$$

63. (A) In direct sequence CDMA system

$$\text{Process gain, } G_P = \frac{f_{chip\ rate}}{f_{data\ rate}}$$

Given, $\quad G_{P(min)} = 100$

$$\therefore \quad G_P = \frac{f_{chip\ rate}}{f_{data\ rate}} \geq 100$$

or $\quad f_{chip\ rate} \geq f_{data\ rate} \times 100$

or $\quad f_{data\ rate} \leq \frac{f_{chip\ rate}}{100}$

or $f_{data\ rate} \leq \frac{1 \cdot 2288 \times 10^6}{100} \leq 12 \cdot 288 \times 10^3$ bits per sec

so, the data rate must be less than or equal to $12 \cdot 288 \times 10^3$ bits per sec.

64. (C) Given $\quad a = 3$ cm; $b = 2$ cm

$$\eta_0 = 377\ \Omega$$

Mode TE_{20} *i.e.* $m = 2$ and $n = 0$

$$f_0 = 30 \text{ GHz}$$

We know that $\lambda_0 = \frac{C}{f_0} = \frac{3 \times 10^8}{30 \times 10^9} = 1$ cm

and $\quad \frac{1}{\lambda_C^2} = \left(\frac{m}{2a}\right)^2 + \left(\frac{n}{2b}\right)^2$

$$\frac{1}{\lambda_C^2} = \left(\frac{2}{2 \times 3}\right)^2 + \left(\frac{0}{2 \times 2}\right)^2$$

or $\quad \lambda_C^2 = 3^2 \text{ cm}^2$

or $\quad \lambda_C = 3$ cm

Now, $\quad \eta = \frac{\eta_0}{\sqrt{1 - \left(\frac{\lambda_0}{\lambda_C}\right)^2}}$

$$= \frac{377}{\sqrt{1 - \left(\frac{1}{3}\right)^2}} = 400\ \Omega$$

65. (D) Given, $\quad \vec{H} = H_x \hat{x} + H_y \hat{y}$

So, the corresponding plane wave will propagate in z direction.

We know that Poynting vector,

$$\vec{P} = \vec{E} \times \vec{H} = \eta_0 \vec{H}^2 \hat{z}$$

Therefore, instantaneous power in z-direction

$$P = |\vec{P}| = \eta_0 H^2$$

Average power over an interval $(0, 2\pi)$ will be—

$$P_{av} = \frac{1}{2\pi}\int_0^{2\pi} p\, d\theta$$

$$= \frac{1}{2\pi}\int_0^{2\pi} \eta_0 H^2\, d\theta$$

$$= \frac{\eta_0}{T}\int_0^T H^2\, dt$$

$$= \frac{\eta_0}{T}\int_0^T (H_X^2 + H_Y^2)\, dt$$

$$= \frac{\eta_0}{T}\int_0^T \left[\left(\frac{5\sqrt{3}}{\eta_0}\right)^2 \cos^2(\omega t - \beta z) + \left(\frac{5}{\eta_0}\right)^2 \sin^2\left(\omega t - \beta z + \frac{\pi}{2}\right)\right] dt$$

$$= \frac{\eta_0}{T}\int_0^T \left[\frac{75}{\eta_0^2}\cos^2(\omega t - \beta z) + \frac{25}{\eta_0^2}\sin^2\left(\omega t - \beta z + \frac{\pi}{2}\right)\right] dt$$

$$= \frac{\eta_0}{T}\int_0^T \left[\frac{75}{\eta_0^2}\,\frac{\cos 2(\omega t - \beta z) + 1}{2} + \frac{25}{\eta_0^2}\left(\frac{1 - \cos 2(\omega t - \beta z + \frac{\pi}{2})}{2}\right)\right] dt$$

$$= \frac{\eta_0}{T}\int_0^T \left[\frac{75}{2\eta_0^2} + \frac{75}{2\eta_0^2}\cos 2(\omega t - \beta z) + \frac{25}{2\eta_0^2} + \frac{25}{2\eta_0^2}\cos 2(\omega t - \beta z)\right] dt$$

$$= \frac{\eta_0}{T}\,\frac{100}{2\eta_0^2} \cdot T$$

$$= \frac{50}{\eta_0}$$

66. (A) Since, $E \propto \sin\left(\frac{m\pi x}{a}\right)$

and given equation

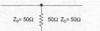
$$\vec{E} = \frac{\omega\mu}{h^2}\left(\frac{\pi}{a}\right) H_0 \sin\left(\frac{2\pi x}{a}\right) \sin(\omega t - \beta z)\, \hat{y}$$

On comparing these two equations, we get

$$m = 2$$

so TE_{20} is the required mode.

67. (B)



Scattering matrix fo 2-port network is given by

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

$$B = S\,A$$

where, B = scattered case matrix

A = incident case matrix

S = scattering matrix

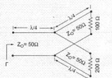
given that shunt resistance = 50 Ω is equal to the Z_0 (characteristic impedance); so perfect power condition occurs at both parts.

$\therefore \quad S_{11} = S_{22} = 0$ (no reflection)

and $\quad S_{12} = S_{21} = 1$ (complete power transfer)

$$\therefore \quad S = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

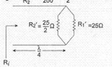
68. (D)



λ/4 section can be replaced by

$$R_1' = \frac{Z_0^2}{R_1} = \frac{50 \times 50}{100} = 25\ \Omega$$

$$R_2' = \frac{Z_0^2}{R_2} = \frac{50 \times 50}{200} = \frac{25}{2}$$



$$Z_i = \frac{Z_0^2}{R_1' \parallel R_2'}$$

$$= \frac{50 \times 50}{\dfrac{25 \times 25/2}{25 + \dfrac{25}{2}}} = 300\ \Omega$$

Now, reflection coefficient

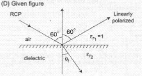
$$= \frac{Z_i - Z_0}{Z_i + Z_0}$$

$$= \frac{300 - 50}{300 + 50} = \frac{250}{350}$$

$$= \frac{5}{7}$$

69. (C) Refer synopsis of Electromagnetism.

70. (D) Given figure



from Snail's law,

$$n_1 \sin 60° = n_2 \sin \theta_t$$

given $n_1 = 1$, since $h \simeq \sqrt{\varepsilon}$

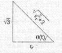
Now, $\quad \sqrt{\varepsilon_r}\sin\theta_t = 1 \cdot \sin 60°$

or $$\sin\theta_t = \frac{\sqrt{3}}{2\sqrt{\varepsilon_r}} \quad \text{...(i)}$$

By using boundary condition analysis

$$\frac{\tan 60°}{\tan \theta_t} = \varepsilon_r$$

or $$\tan\theta_t = \frac{\sqrt{3}}{\varepsilon_r}$$



From above figure

$$\sin\theta_t = \frac{\sqrt{3}}{\sqrt{\varepsilon_r^2 + 3}} \quad \text{...(ii)}$$

From equations (i) and (ii)

$$\frac{\sqrt{3}}{2\sqrt{\varepsilon_r}} = \frac{\sqrt{3}}{\sqrt{\varepsilon_r^2 + 3}}$$

or $\quad 4\,\varepsilon_r = \varepsilon_r^2 + 3$

or $\quad \varepsilon_r^2 - 4\,\varepsilon_r + 3 = 0$

or $\quad \varepsilon_r^2 - 3\,\varepsilon_r - \varepsilon_r + 3 = 0$

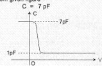
or $\quad \varepsilon_r(\varepsilon_r - 3) - 1(\varepsilon_r - 3) = 0$

or $\quad (\varepsilon_r - 1)(\varepsilon_r - 3) = 0$

$$\varepsilon_r = 1 \text{ or } 3$$

71. (A) From given figure

$$C = 7\ \text{pF} \quad \text{...(i)}$$



and depletion layer capacitance, C is also given as

$$C = \frac{\varepsilon_1 A}{d_1} \quad \ldots(ii)$$

where, d_1 = gate oxide thickness
A = Capacitor area
ε_1 = Permittivities of SiO_2

From equations (i) and (ii)

$$7 \text{ pF} = \frac{\varepsilon_1 A}{d_1}$$

or $$d_1 = \frac{3 \cdot 5 \times 10^{-13} \times 1 \times 10^{-4}}{7 \times 10^{-12}}$$

or $$d_1 = 50 \text{ nm}$$

72. (B) In maximum depletion layer width condition, there will be minimum capacitance (*i.e.* 1 pF from given figure)

since $$C = \frac{\varepsilon_0 A}{d}$$

Because here both capacitance (SiO_2 and Si) comes in series.
So total capacitance, C_T is given by

$$C_T = \frac{C_1 C_2}{C_1 + C_2} = 1 \text{ pF}$$

or $$\frac{7 C_2}{7 + C_2} = 1 \text{ pF}$$

or $$C_2 = \frac{7}{6} \text{pF}$$

Now, $$\frac{\varepsilon_2 A}{d_2} = C_2$$

or $$d_2 = \frac{\varepsilon_2 A}{C}$$

or $$d_2 = \frac{1 \times 10^{-12} \times 1 \times 10^{-4}}{\frac{7}{6} \times 10^{-12}}$$

or $$d_2 = 0.857 \times 10^{-4} \text{ cm}$$

or $$d_2 = 0.857 \text{ μm}$$

Hence alternative (B) is the correct choice.

73. (C) • The MOS capacitor has an *p*-type substrate.
• If positive charges are introduced in the oxide, they increase the depletion layer and decreases the capacitance, so C-V curve will shift to left direction. This concept is based on the fact that less voltage is needed to decrease the capacitance, because

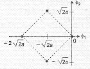
$$Q = CV$$

or $$V = \frac{Q}{C}$$

where C = Capacitance
Q = Charge
V = Applied voltage

High capacitance mean less input voltage.

74. (B) Two 4-ary signal constellation are given :
For Constellation 1, figure shown below :



Constellation 1

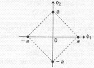
Table given below describes the symbol representation and power for Constellation 1.

Symbol	Representation	Power
1.	$-2\sqrt{2}\, a\, \hat{\phi}_1$	$(-2\sqrt{2}\, a)^2 = 8a^2$
2.	$-\sqrt{2}\, a\, \hat{\phi}_1 + \sqrt{2}\, a\, \hat{\phi}_2$	$(-\sqrt{2}\, a)^2 + (\sqrt{2}\, a)^2 = 4a^2$
3.	$-\sqrt{2}\, a\, \hat{\phi}_1 + \sqrt{2}\, a\, \hat{\phi}_2$	$(-\sqrt{2}\, a)^2 + (-\sqrt{2}\, a)^2 = 4a^2$
4.	$0\, \hat{\phi}_1 + 0\, \hat{\phi}_2$	0

Since they all have equal probability, so total power will be

$$P_1 = \frac{1}{4}(8a^2) + \frac{1}{4}(4a^2) + \frac{1}{4}(4a^2) + \frac{1}{4} \cdot (0) = 4a^2$$

for Constellation 2, figure shown below :



Constellation 2

Symbol	Representation	Power
1.	$-a\, \hat{\phi}_1$	a^2
2.	$a\, \hat{\phi}_2$	a^2
3.	$-a\, \phi_2$	a^2
4.	$a\, \phi_1$	a^2

Again, $$P_2 = \frac{1}{4} \cdot a^2 + \frac{1}{4} \cdot a^2 + \frac{1}{4} \cdot a^2 + \frac{1}{4} \cdot a^2$$

or $$P_2 = a^2$$

so, the ratio of average energy of Constellation 1 to the average energy of Constellation 2

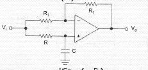
$$\frac{P_1}{P_2} = \frac{4a^2}{a^2} = 4.$$

75. (A) Higher the probability of energy per bit lower the error. Hence probability of symbol error for Constellation 1 is lower.

76. (A) From figure

$$V_O(s) = V_{O_1}(s) + V_{O_2}(s)$$

where $$V_{O_1}(s) = -\left(\frac{R_1}{R_1}\right) V_i(s) = -V_i(s)$$



and $$V_{O_2}(s) = \frac{1/Cs}{1/Cs + R}\left(1 + \frac{R_1}{R_1}\right) V_i(s)$$

or $$V_{O_2}(s) = \frac{1}{1 + RCs} \times 2\, V_i(s)$$

Now, $$V_O(s) = V_{O_1}(s) + V_{O_2}(s)$$

or $$V_O(s) = -V_i(s) + \frac{2\, V_i(s)}{1 + RCs}$$

or $\quad V_O(s) = \dfrac{1 - RCs}{1 + RCs} \cdot V_i(s)$

or $\quad \dfrac{V_O(s)}{V_i(s)} = \dfrac{1 - RCs}{1 + RCs}$

77. (C) Given $V_i = V_1 \sin \omega t$

and $\quad V_O = V_2 \sin(\omega t + \phi)$

Let $\quad T(s) = \dfrac{V_O(s)}{V_i(s)} = \dfrac{1 - RCs}{1 + RCs}$

$$\angle \phi = -\tan^{-1} sRC - \tan^{-1} sRC$$

or $\quad \angle \phi = -2 \tan^{-1}(\omega RC)$

when $\quad \omega = \infty, \angle \phi = -2 \times 90° = -\pi$

when $\quad \omega = 0, \angle \phi = -2 \times 0 = 0$

Thus $\quad \phi_{max} = 0°$

and $\quad \phi_{min} = -\pi$

Hence $\quad \phi = -\pi$ to 0.

78. (B) The given 8085 assembly language program

Line
1. MVI A,B5H
2. MVI B,0EH
3. XRI 69H
4. ADD B
5. ANI 9BH
6. CPI 9FH
7. STA 3010H
8. HLT

Result after the execution of line

1 : Contents of the A = B 5 H

2 : Contents of the B = 0 E H

3 : Content of the accumulator

XOR of B5 and 69 contents *i.e.*

```
 1011 0101
 0110 1001
 ---------
 1101 1100   ← XOR result
 └──┘ └──┘
  D    C
```

Thus the content of accumulator = DCH

4 : Content of accumulator

```
    D C  =  1101 1100
 +  O E  =  0000 1110
    ----    ---------
    E A     1110 1010
```

Therefore, after the execution of the ADD instruction the content of the accumulator will be EAH.

79. (C) Result after the execution of line

5 : This command will add immediate data 9BH with the contents of accumulator *i.e.*

```
 E A  =  1110 1010
 9 B  =  1001 1011
         ---------
         1000 1010
```

Accumulator store 8 A H

6 : Compare immediate with 9 F H

Since here 9 F H is greater than 8 A H so carry flag will be generated while zero flag remain unaffected.

80. (A) Given $\quad \dot{x}(t) = Ax(t)$

If $\quad x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$

then $\quad x(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix}$

Also given that initial state vector of the system changes to $\quad x(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$

then system response $x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$

Let $\phi(t)$ be the state transition matrix.

We know that $\quad \vec{x}(t) = \vec{\phi}(t) \cdot \vec{x}(0)$

$$\begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} 1 \\ -2 \end{bmatrix} \quad \text{...(i)}$$

and
$$\begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix} = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} 1 \\ -1 \end{bmatrix} \quad \text{...(ii)}$$

From equations (i) and (ii), we get

$$\phi_{11} - 2\phi_{12} = e^{-2t} \quad \text{...(iii)}$$

and
$$\phi_{11} - \phi_{12} = e^{-t} \quad \text{...(iv)}$$

From equations (iii) and (iv)

$$\phi_{12} = e^{-t} - e^{-2t} \quad \text{...(v)}$$

$$\phi_{11} = 2e^{-t} - e^{-2t} \quad \text{...(vi)}$$

Again from equations (i) and (ii)

$$\phi_{21} - 2\phi_{22} = -2e^{-2t} \quad \text{...(vii)}$$

$$\phi_{21} - \phi_{22} = -e^{-t} \quad \text{...(viii)}$$

From equations (vii) and (viii)

$$\phi_{22} = 2e^{-2t} - e^{-t} \quad \text{...(ix)}$$

$$\phi_{21} = 2e^{-2t} - 2e^{-t} \quad \text{...(x)}$$

From equations (v), (vi), (ix) and (x)

$$\vec{\phi}(t) = \begin{bmatrix} 2e^{-t} - e^{-2t} & e^{-t} - e^{-2t} \\ 2e^{-2t} - 2e^{-t} & 2e^{-2t} - e^{-t} \end{bmatrix}$$

We know that

$$\phi(\vec{t}) = L^{-1}[SI - A]^{-1}$$

or $\quad [SI - A]^{-1} = L[\phi(t)]$

or $\quad [SI - A]^{-1} = \begin{bmatrix} \dfrac{2}{s+1} - \dfrac{1}{s+2} & \dfrac{1}{s+1} - \dfrac{1}{s+2} \\ \dfrac{2}{s+2} - \dfrac{2}{s+1} & \dfrac{2}{s+1} - \dfrac{1}{s+1} \end{bmatrix}$

or $\quad [SI - A]^{-1} = \begin{bmatrix} \dfrac{(s+3)}{(s+2)(s+1)} & \dfrac{1}{(s+2)(s+1)} \\ \dfrac{-2}{(s+2)(s+1)} & \dfrac{s}{(s+1)(s+2)} \end{bmatrix}$

Let us assume that

$$[SI - A]^{-1} = \vec{P}$$

or $\quad [SI - A] = |\vec{P}|^{-1}$

$$= \frac{\text{adj } |\vec{P}|}{|\vec{P}|}$$

$$= \frac{\begin{bmatrix} \dfrac{(s+3)}{(s+2)(s+1)} & \dfrac{1}{(s+2)(s+1)} \\ \dfrac{-2}{(s+2)(s+1)} & \dfrac{s}{(s+1)(s+2)} \end{bmatrix}}{\dfrac{1}{(s+1)(s+2)}[s^2 + 3s + 2]}$$

$$[\vec{S}\vec{I} - \vec{A}] = \frac{(s+1)(s+2)}{s^2+3s+2}\begin{bmatrix} \frac{s}{(s+2)(s+1)} & \frac{-1}{(s+2)(s+1)} \\ \frac{2}{(s+2)(s+1)} & \frac{(s+3)}{(s+2)(s+1)} \end{bmatrix}$$

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

Characteristic equation is

$$|SI - A| = (s+1)(s+2) = 0$$

$$s = -1, -2$$

so given values are $-1, -2$

$\lambda_1 = -1$ and $\lambda_2 = -2$

For $\lambda_1 = -1$

$$[\lambda_1 - \vec{I} - \vec{A}]\,[\vec{P_1}] = 0$$

$$\begin{bmatrix} -1 & -1 \\ 2 & 2 \end{bmatrix}\begin{bmatrix} P_{11} \\ P_{12} \end{bmatrix} = 0$$

or $\quad P_{11} = -P_{12}$

$$\therefore \quad \left(-1, \begin{bmatrix} 1 \\ -1 \end{bmatrix}\right)$$

For $\lambda_2 = -2$

$$\begin{bmatrix} -2 & -1 \\ 2 & 1 \end{bmatrix}\begin{bmatrix} P_{21} \\ P_{22} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$P_{22} = -2P_{21}$$

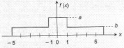
$$\left(-2, \begin{bmatrix} 1 \\ -2 \end{bmatrix}\right)$$

81. (D) $\quad \vec{S}\vec{I} - \vec{A} = \begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix}$

$$\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} = \begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix}$$

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

82. (A) From figure



for unity area

$$2a + 8b = 1 \qquad \text{...(i)}$$

and from given information

$$\int_{-1}^{1} a \cdot dx = \frac{1}{3} \qquad \text{...(ii)}$$

from equation (ii)

$$a \cdot 2 = \frac{1}{3}$$

or $\quad a = \frac{1}{6}$

and $\quad 2\frac{1}{6} + 8b = 1$

or $\quad 8b = 1 - \frac{1}{3}$

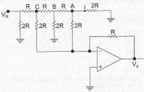
or $\quad 8b = \frac{2}{3}$

or $\quad b = \frac{1}{12}$

83. (?)

84. (B) Given, $\quad V_R = 10\text{ V}$

$$R = 10\text{ K}\Omega$$



Applying Nodal analysis

For node C

$$\frac{V_C - V_R}{R} + \frac{V_C - V_B}{R} + \frac{V_C - 0}{2R} = 0 \qquad \text{...(i)}$$

For node B

$$\frac{V_B - V_C}{R} + \frac{V_B - V_A}{R} + \frac{V_B - 0}{2R} = 0 \qquad \text{...(ii)}$$

For node A

$$\frac{V_A - V_B}{R} + \frac{V_A - 0}{2R} + \frac{V_A - 0}{2R} = 0 \qquad \text{...(iii)}$$

From equations (i), (ii) and (iii)

$$V_A = 1{\cdot}25\text{ V}$$

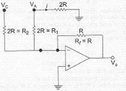
$$V_B = 2{\cdot}5\text{ V}$$

$$V_C = 5\text{ V}$$

Current $i = \frac{V_A}{2R} = \frac{1{\cdot}25}{2 \times 10 \times 10^3} = 62{\cdot}5\ \mu\text{A}$

85. (C) From given figure using superposition principle, we get

$$V_O = V_A\left(-\frac{R_f}{R_1}\right) + V_O\left(-\frac{R_f}{R_2}\right)$$



or $\quad V_O = 1{\cdot}25\left(-\frac{R}{2R}\right) + 5\left(-\frac{R}{2R}\right)$

or $\quad V_O = -0{\cdot}625 - 2{\cdot}5$

or $\quad V_O = -3{\cdot}125\text{ V.}$