1. (C) The Rank of the matrix

$$= \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

If $R_3 \to R_3 - R_1$

$$= \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

If $C_2 \to C_1 + C_2$

$$= \begin{bmatrix} 1 & 2 & 1 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$C_1 \leftrightarrow C_2$ & $C_2 \leftrightarrow C_3$

$$= \begin{bmatrix} 2 & 1 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}$$

No. of non-zero rows = 2

Hence rank is 2.

2. (D) Given $\nabla \times \nabla \times \mathbf{P}$, $\mathbf{P}$ is a vector

$$\mathbf{P} = \mathbf{P}_x\hat{i} + \mathbf{P}_y\hat{j} + \mathbf{P}_z\hat{k}$$

$$\because \quad \nabla = \left(\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}\right)$$

$$\therefore \quad \nabla \times \nabla \times \mathbf{P} = \left[\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}\right] \times \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \mathbf{P}_x & \mathbf{P}_y & \mathbf{P}_z \end{bmatrix}$$

$$= \nabla(\nabla \cdot \mathbf{P}) - \nabla^2 \mathbf{P}.$$

3. (A) According to Stoke's theorem "The surface integral of the component of curl P along the normal to the surface S. Taken over the surface bounded by curve C is equal to the live integral of the vector point function P taken along the closed curve C.

Mathematically

$$\oint \mathbf{P} \cdot dl = \iint_S (\nabla \times \mathbf{P}) \cdot ds$$

4. (C) Probability density function

$$P(x) = Ke^{-\alpha x} \cdot x\,(-\infty, \infty)$$

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

$$\int_{-\infty}^{\infty} Ke^{-\alpha|x|}\,dx = \frac{+K}{\alpha}[e^0 - e^{\infty}] + \frac{(-K)}{\alpha}[e^{-\infty} - e^0]$$

$$= 2K/\alpha$$

$$\frac{2K}{\alpha} = 1$$

$$K = \frac{\alpha}{2}$$

or $\quad K = 0{\cdot}5\,\alpha$

5. (A) $\quad x(t) + 2x(t) - \delta(t) = 0$

$$\frac{\partial}{\partial t}x(t) + 2x = \delta(t)$$

taking Laplace transform on both side

$$[S\,X(S) - x(0^-)] + 2\,X(S) = 1$$

Given $\quad X(0^-) = 0$

$$\therefore \quad [SX(S) - 0] + 2\,X(S) = 1$$

$$X(S)(S+2) = 1$$

$$X(S) = \frac{1}{(S+2)}$$

Taking inverse Laplace transform

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

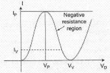
6. (B) We know that for distortionless transmission, the amplitude response $|H(\omega)|$ must be a constant and the phase $\phi(\omega)$ must be a linear function of ω.

Here for given transfer function

$$H(j\omega) = A(\omega)\,e^{j\phi(\omega)}$$

does not produce and phase distortion if $\phi(\omega) = k\omega$.

7. (C) I-V characteristics of the tunnel diode is



Hence $\quad V_P \leq V_D < V_V$.

8. (B) From mass action law relation, as given below :

$$n_p = n_i^2$$

here, if we increase number of e^- in n-type semi-conductor holes coill definitely decreases

$$P_n \propto \frac{1}{n_n} \qquad (\because n_i = \text{constant})$$

or $$P_n \propto \frac{1}{N_D}$$

So inversely proportional to doping concentration.

9. (A) For extrinsic semiconductor the current density is given by relation

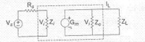
$$J_n(x) = \underbrace{q\,\mu n(x)\,E(x)}_{\text{Drift term}} + \underbrace{q\,D_n \frac{dn(x)}{dx}}_{\text{Diffusion term}}$$

and for minority carrier current, low level injection, $n(x)$ is very less, *i.e.* negligible but term $\frac{dn(x)}{dx}$ is significant.

Hence, the current is essentially due to diffusion term.

10. (B) The phenomenon known as 'Early Effect' in a bipolar transistor refers to a reduction of the effective base-width due to reverse biasing of the base-collector junction. This is based on the fact that depletion region or space charge region increases on increasing reverse biased voltage, results decrease in the effective base width.

11. (D) The transconductance amplifier is a voltage to current amplifier as shown below :



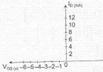
The ideal transconductance amplifier supplies an output current which is proportional to the signal voltage, independent of the magnitudes of source resistance and load resistance. To achieve this

$$Z_i = \infty \text{ and } Z_o = \infty$$

12. (D) The given two points are

(i) $V_{GS} = 0V$ at $I_D = 12$ mA and

(ii) $V_{GS} = -6V$ at $I_D = 0$



From the given information, I_D-V_{GS} curve is shown below :

From figure $V_{GS} = V_P = -6V$, because

Here $I_D = 0$ and $I_{DSS} = 12$ mA

Now, transconductance is given by relation

$$g_m = g_{m_0}\left(1 - \frac{V_{GS}}{V_P}\right)$$

where, $g_{m_0} = \frac{-2I_{DSS}}{V_P}$

or $$g_m = \frac{-2I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right) \qquad \text{...(A)}$$

from equation (A) it is clear that out of given options, g_m will be maximum when $V_{GS} = 3V$.

13. (A) The given K-map :

1	0	0	1
0	d	0	0
0	0	d	1
1	0	0	1

Here only 2 groups are possible in the minimized some-of-product expression.

14. (A) $\because x(t) \xleftrightarrow{\text{F.T.}} x(j\omega)$

$$x(5t^{-3})$$

Here we consider

$$x[5(t - 3/5)]$$

So, here we consider two property

(i) Scaling property

$$x(at) = \left(\frac{1}{a}\right) \times \left(\frac{j\omega}{|a|}\right)$$

(ii) Time shifting property

$$x(t - t_0) = e^{-j\omega t_0} \times (j\omega)$$

$$\therefore \quad F[x(5t-3)] = \frac{1}{5} e^{-j3\omega/5} \times \left(\frac{j\omega}{5}\right)$$

15. (C) The Dirac delta function $\delta(t)$

$$\delta(t) = \begin{cases} 1, & t = 0 \\ 0, & \text{otherwise} \end{cases}$$

and $$\int_{-\infty}^{\infty} \delta(t)\,dt = 1.$$

16. (D) If the region of convergence of

$x_1(n) + x_2(n)$ is $\frac{1}{3} < |z| < \frac{2}{3}$

Then the region of convergence of $x_1(n) - x_2(n)$ indicates $\frac{1}{3} < |z| < \frac{2}{3}$.

17. (D) $$G(s) = \frac{K}{(s+1)(s+2)}$$

given $H(s) = 1$

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

put $s = j\omega$

$$G(j\omega)H(j\omega) = \frac{K(2-\omega^2)}{(\omega^2+1)(\omega^2+4)} - \frac{jK3\omega}{(\omega^2+1)(\omega^2+4)}$$

$$\frac{K3\omega}{(\omega^2+1)(\omega^2+4)} = 0$$

$$\omega_1 = 0$$

Gain margin $= 20\log_{10}\frac{1}{|G(j\omega_1)H(j\omega_1)|}$ dB

Gain Margin $= \infty$

18. (A) $x(t) = \sin t\, u(t)$

taking Laplace transform

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

$$\xrightarrow[x(t)]{} \boxed{\frac{1}{s+1}} \longrightarrow y(t)$$

$$\xrightarrow{X(s)} \boxed{\frac{1}{s+1}} \longrightarrow Y(s)$$

for steady-state response Y (s)

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

Using partial fraction

$$y(s) = \frac{1}{2(s+1)} - \frac{1}{2}\left[\frac{(s-1)}{(s^2+1)}\right]$$

$$y(s) = \frac{1}{2(s+1)} - \frac{1}{2}\left[\frac{s}{s^2+1} - \frac{1}{s^2+1}\right]$$

$$= \frac{1}{2}\left[\frac{1}{s+1} - \frac{s}{s^2+1} + \frac{1}{s^2+1}\right]$$

Taking inverse Laplace transform

$$Y(t) = [e^{-t} - \cos t + \sin t]$$

for steady state response

i.e. $t \to \infty$

$$y(t) = \frac{1}{2}(\sin t - \cos t)$$

$$= \frac{1}{\sqrt{2}}\sin(t - \pi/4)$$

19. (C) Here $E = E_1 + E_2$

$E_1 = \hat{a}_x \sin(\omega t - \beta z) \to$ linearly polarized

$E_2 = \hat{a}y \sin(\omega t - \beta z + \pi/2) \to -90°$ phase shift

Here E is left handed circularly polarized.

20. (A) Given gain = 10 dB

P_{in} = 1 watt

$$\text{Gain} = 10\log_{10}\frac{P_{out}}{P_{in}}$$

$$10 = 10\log_{10}\frac{P_{out}}{1\text{ watt}}$$

$$1 = \log_{10} P_{out}$$

$$P_{out} = \text{antilog}_{10}(1)$$

$$P_{out} = 10 \text{ watt.}$$

21. (A)

$$\lambda_1 = 8 \quad V_1 = \begin{bmatrix}1\\1\end{bmatrix}$$

$$[\lambda_1 I - A]V_1 = 0$$

$$\left\{8\begin{bmatrix}1&0\\0&1\end{bmatrix} - A\right\}\begin{bmatrix}1\\1\end{bmatrix} = 0$$

$$\left\{\begin{bmatrix}8&0\\0&8\end{bmatrix} - \begin{bmatrix}A_{11}&A_{12}\\A_{21}&A_{22}\end{bmatrix}\right\}\begin{bmatrix}1\\1\end{bmatrix} = 0$$

$$8 - A_{11} - A_{12} = 0 \quad \ldots(i)$$

$$-A_{21} + 8 - A_{22} = 0$$

$$[\lambda_2 I - A]x_2 = 0$$

$$\left\{4\begin{bmatrix}1&0\\0&1\end{bmatrix} - \begin{bmatrix}A_{11}&A_{12}\\A_{21}&A_{22}\end{bmatrix}\right\}\begin{bmatrix}1\\-1\end{bmatrix} = 0$$

$$\left\{\begin{bmatrix}4&0\\0&4\end{bmatrix} - \begin{bmatrix}A_{12}&A_{12}\\A_{21}&A_{22}\end{bmatrix}\right\}\begin{bmatrix}1\\-1\end{bmatrix} = 0$$

$$\begin{bmatrix}4-A_{11} & -A_{12}\\ -A_{21} & 4-A_{22}\end{bmatrix}\begin{bmatrix}1\\-1\end{bmatrix} = 0$$

$$\begin{bmatrix}4 - A_{11} + A_{12} = 0 \Rightarrow A_{12} = A_{11} - 4\\ -A_{21} - 4 + A_{22} = 0 \Rightarrow A_{12} = 4 + 4A_{21}\end{bmatrix} \quad \ldots(ii)$$

Put this values in equation (i)

$$8 - A_{11} - A_{11} + 4 = 0$$

$$2A_{11} = 12$$

$$A_{11} = 6$$

$$A_{12} = 6 - 4 = 2$$

$$-A_{21} + 8 - 4 - A_{21} = 0$$

$$-2A_{21} + 4 = 0$$

$$A_{21} = 2$$

$$A_{22} = 6$$

$$\begin{bmatrix}A_{11}&A_{12}\\A_{21}&A_{22}\end{bmatrix} = \begin{bmatrix}6&2\\2&6\end{bmatrix}$$

22. (B) 23. (D)

24. (C) $\int_0^{\pi} \sin^3\theta\, d\theta$

$$= \int_0^{\pi}\frac{3\sin\theta - \sin 3\theta\, d\theta}{4}$$

$$= \int_0^{\pi}\frac{1}{4}[3\sin\theta - \sin 3\theta]\, d\theta$$

$$= \frac{1}{4}\left[\int_0^{\pi} 3\sin\theta\, d\theta - \int_0^{\pi}\sin 3\theta\, d\theta\right]$$

$$= \frac{1}{4}\left[[-3\cos\theta]_0^{\pi} - \left[\frac{-\cos 3\theta}{3}\right]_0^{\pi}\right]$$

$$= \frac{1}{4}\left[-3\cos\pi + 3\cos 0 - \frac{1}{3}\left(-\cos 3\pi + \cos 0\right)\right]$$

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

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

$$= \frac{1}{4}\left[\frac{6}{1} - \frac{2}{3}\right]$$

$$= \frac{1}{4}\left[\frac{18-2}{3}\right]$$

$$= \frac{1}{4}\times\frac{16}{3}$$

$$= \frac{4}{3}$$

25. (D) The probability of defective part supplied by Y is

$$= \frac{0{\cdot}3 \times 0{\cdot}02}{0{\cdot}6 \times 0{\cdot}01 + 0{\cdot}3 \times 0{\cdot}02 + 0{\cdot}1 \times 0{\cdot}03}$$

$$= \frac{6}{6+6+3}$$

$$= 0{\cdot}4$$

26. (C) $|\lambda I - A|\, x = 0$ ...(1)

Given $A = \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$ $x = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

From eqation (1)

$$\left[\lambda \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}\right]\begin{bmatrix} 1 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix} = 0$$

$$\left[\begin{bmatrix} \lambda & 0 \\ 0 & \lambda \end{bmatrix} - \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}\right]\begin{bmatrix} 1 \\ 1 \end{bmatrix} = 0$$

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

$$(\lambda - 4)^2 - 4 = 0$$
$$(\lambda - 4)^2 = 4$$
$$\lambda - 4 = 2$$
$$\lambda = 6$$

27. (A)

28. (C) $F(s) = \dfrac{\omega_0}{s^2 + \omega_0^2}$ Re [s] > 0

taking inverse Laplace

$$f(t) = \sin t\, \omega_0$$

To find final value of $f(t)$

$$f(t) = \sin t$$
$$t \to \infty$$

Hence final value of sin t will vary between – 1 and 1 which are the extreme value of sin t.

29. (A) $f(x) = \dfrac{e^x}{1 + e^x}$

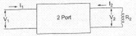
Here x is varies from $-\infty$ to ∞

$$f(-\infty) = 0$$
$$f(0) = 1/2$$
$$f(\infty) = 1$$

Hence, it is clear from the above result that as x increases the O/P of function is monotonically increases.

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

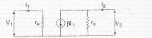
$$V_1 = AV_2 - BI_2$$
$$I_1 = CV_2 - DI_2$$



$$V_2 = -I_2 R_L \quad ...(1)$$
$$I_1 = -(CR_L + D)\, I_2$$
$$I_2 = -\left(\frac{I_1}{CR_L + D}\right) \quad ...(2)$$
$$V_1 = AV_2 - BI_2$$
$$V_1 = -A\,(I_2 R_L) - BI_2$$
$$V_1 = (-AR_L - B)\, I_2$$
$$V_1 = (-AR_L - B)\left(\frac{-I_1}{CR_L + D}\right)$$
$$V_{in} = \frac{V_1}{I_1} = \frac{(AR_L + B)}{(CR_L + D)}$$

31. (B) Apply KVL at I/P and O/P side

$$V_1 = I_1 r_e \quad ...(1)$$
$$V_2 = -\beta I_1 r_0 + r_0 I_2 \quad ...(2)$$



The z-parameter two port equation

$$V_1 = z_{11} I_1 + z_{12} I_2 \quad ...(3)$$
$$V_2 = z_{21} I_1 + z_{22} I_2 \quad ...(4)$$

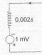
on comparing (1) and (2) to equation (3) and (4)

$$z_{12} = 0 \text{ and } z_{21} = -\beta r_0$$

32. (B) The pole and zero of a passive network is obtained by RC network only.

i.e. $R + \dfrac{1}{Cs}$ or $\dfrac{RCs + 1}{Cs}$ having both pole and zero.

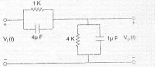
33. (A)



Applying KVL on the above circuit with initial current $I(0^-)$

$$-L\,I(0^-) + 1\text{ mV} = 0$$
$$LI(0^-) = 1\text{ mV}$$
$$I(0^-) = \frac{1\text{ mV}}{L} = \frac{1 \times 10^{-3}}{2 \times 10^{-3}}$$
$$= \frac{1}{2} = 0{\cdot}5$$
$$I(0^-) = 0{\cdot}5$$

34. (C)



Let $1\text{ K} = R_1$ and $4\text{K} = R_2$

$4\ \mu\text{F} = C_1$ and $1\ \mu\text{F} = C_2$

Now, from given figure

$$\frac{V_O(s)}{V_i(s)} = \frac{\left(R_2 \,\|\, \frac{1}{sC_2}\right)}{\left(R_2 \,\|\, \frac{1}{sC_2}\right) + \left(R_1 \,\|\, \frac{1}{sC_2}\right)}$$

$$\frac{\frac{R_2}{sC_2}}{R_2+\frac{1}{sC_2}}$$

or $$\frac{V_O(s)}{V_i(s)} = \frac{\dfrac{\frac{R_2}{sC_2}}{R_2+\frac{1}{sC_2}}}{\dfrac{\frac{R_2}{sC_2}}{R_2+\frac{1}{sC_2}}+\dfrac{\frac{R_1}{sC_1}}{R_1+\frac{1}{sC_1}}}$$

or $$\frac{V_O(s)}{V_i(s)} = \frac{\frac{R_2}{R_2C_2s+1}}{\frac{R_2}{R_2C_2s+1}+\frac{R_1}{R_1C_1s+1}}$$

or $$\frac{V_O(s)}{V_i(s)} = \frac{R_2(R_1C_1s+1)}{R_2R_1C_1s+R_2+R_1R_2C_2s+R_1}$$

or $$\frac{V_O(t)}{V_i(t)} = \frac{R_2}{R_1}$$ (on putting $s = 0$)

or $$V_O(t) = V_i(t)\cdot\frac{R_2}{R_1+R_2}$$

or $$V_O(t) = 10\,u(t)\left(\frac{u}{1+u}\right)$$

(given $V_i(t) = 10u(t)$)

or $$V_O(t) = 8u(t)$$

35. (C) The given transfer functions

$$G_1(s) = \frac{1}{s^2+as+b}$$

and $$G_2(s) = \frac{s}{s^2+as+b}$$

The 3-dB bandwidths depends on the C.E. *i.e.* denominator and it is specified by discriminant

$$D = \sqrt{B^2-4AC}$$

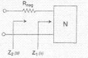
here, $\left.\begin{matrix}B=a\\A=1\\C=b\end{matrix}\right\}$ for both transfer functions.

Therefore, $D = \sqrt{a^2-4b}$

and 3-dB bandwidth for both transfer functions is $\sqrt{a^2-4b}$.

36. (A) From given figure

$$Z_2(s) = R_{neg} + Re[Z_1(j\omega)] + j\,I_m[Z_1(j\omega)] \quad ...(1)$$



and for $Z_2(s)$ to be positive real

$$Re[Z(j\omega)] \geq 0$$

or $$Re[Z(s)] \geq 0$$

so, from equation (1)

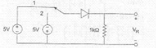
$$R_{neg} + Re[Z_1(j\omega)] \geq 0$$

or $$Re[Z_1(j\omega)] \geq -R_{neg}$$

or $$|Re\,Z_1(j\omega)| \geq |R_{neg}|$$

or $$Re\,Z_1(j\omega) \geq |R_{neg}|$$

37. (A) The injected charge carriers across the junction cannot be removed simultaneously, but takes certain time



equal to storage time (t_s). Thus for time t_s, diode will remain forward biased and will conduct.

Since, voltage drop across diode is zero, hence

$$V_R = -5\text{V for } 0 \leq t < t_s$$

38. (B) Refer synopsis.

39. (C) Varactor diode → Tuned circuits

PIN diode → Current controlled attenuator

Zener diode → Voltage reference

Schottky diode → High frequency switch

40. (D) (Doping concentration) $n_n = 4{\cdot}2 \times 10^8$ atom/m³

(Intrinsic concentration) $n_i = 1{\cdot}5 \times 10^4$ atom/m³

$$\frac{\delta_{N\text{-type}}}{\delta_{\text{intrinsic}}} = \frac{n_n\mu_e}{n_i\mu_e + n_i\mu_p}$$

$$= \frac{4{\cdot}2\times10^8\,\mu_e}{1{\cdot}5\times10^4\,\mu_e + 1{\cdot}5\times10^4\,\mu_p} \quad ...(1)$$

$\because$ $$\frac{\mu_p}{\mu_e} = 0{\cdot}4 \text{ (given)}$$

$$\mu_p = 0{\cdot}4\,\mu_e$$

then from equation (1)

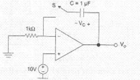
$$\frac{\delta_{N\text{-type}}}{\delta_{\text{intrinsic}}} = \frac{4{\cdot}2\times10^8\,\mu_e}{1{\cdot}5\times10^4\,[\mu_e + 0{\cdot}4\,\mu_e]}$$

$$= \frac{4{\cdot}2\times10^8}{1{\cdot}4\times1{\cdot}5\times10^4}$$

$$= 2\times10^4$$

$$= 20{,}000.$$

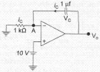
41. (D)



Given $C = 1\ \mu\text{F}$

$t = 1$ ms

$V_C(0^-) = V_C(0^+) = ?$



We know that

$$V_C = \frac{1}{C}\int_0^t i_C\,dt$$

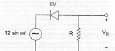
By using virtual ground concept

$$V_A = 10\text{ V}$$

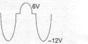
$$i_C = \frac{10\text{ V}}{1\text{ k}\Omega} = 10^{-2}$$

Now, $$V_C(0^+) = \frac{1}{1\times10^{-6}}\int_0^{1\times10^{-3}} 1\times10^{-2}\,dt = \frac{1\times10^{-2}\times1\times10^{-3}}{1\times10^{-6}} = 10\text{ V}$$

42. (B) Here the peak magnitude of applied input is = 12 V during positive half cycle the applied voltage will be reverse bias, then the breakdown voltage of zener diode is 6V.



The O/P will be max ·6V during positive half cycle. During – ve half cycle the zener diode will be forward bias and work like ordinary diode so.



43. (D) The BCP code of a base 5-number.
24 will be 010100

$$(24)_5 = \begin{pmatrix}010 & 100\\ 2 & 4\end{pmatrix}_{\text{BCP code}}$$

So, $$\begin{pmatrix}100 & 010 & 011 & 001\\ 4 & 2 & 3 & 1\end{pmatrix}_{\text{BCP}} = (4231)_5$$

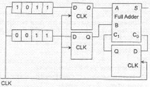
44. (B) Given the address range is D4 H to D7H

A_7	A_6	A_5	:	A_4	A_3	A_2	:	A_1	A_0	
1	1	0	:	1	0	1	:	0	0	→ D 4 H
1	1	0	:	1	1	1	:	1	1	→ D 7

Since its chip-select is connected to the output of the decoder and chip will select only when both A_1 = 0 and A_0 = 0, corresponding to this we get A_4, A_3, A_2 equals to 1, 0, 1 respectively. 101 → 5.

i.e. output 5 is the correct choice.

45. (D) Given that initially all the flip-flops are in clear state output S and C_0 after 1st clock pulse



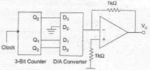
$$S = 0 \quad C_0 = 1$$

output S and C_0 after 2nd clock pulse

$$S = 1 \quad [\because S = (A + B) + C_i = (1 + 1) + 1 = 0 + 1 = 1]$$

$$C_0 = 1 \quad (\because C = A + B = 1 + 1 = 1)$$

46. (B)



D_3	D_2	D_1	D_0		
0	0	0	0	→	0
0	0	0	1	→	1
0	0	1	0	→	2
0	0	1	1	→	3

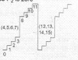
4 to 7 will not exist because D_2 = 0

1	0	0	0	→	8
1	0	0	1	→	9
1	0	1	0	→	10
1	0	1	1	→	11

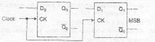
12 to 15 coil not exist because P_2 is zero

Similarly for next cycle

D_3	D_2	D_1	D_0
0	0	0	0
:	:	:	:
0	0	1	1
1	0	0	0
:	:	:	:
1	0	1	1



47. (A) Here two Flip-Flops are given and after 4 clock pulse output repeats or in other words we can say that after four stages output repeats.



Thus, we conclude that the given figure represent 2-bit Johnson counter.

In Johnson counter invert output (*i.e.* $\overline{Q}$) of the LSB flip-flop is feedback to the input of the MSB flip-flop and output of the MSB is used as a input for next flip-flop.

Therefore, $D_0 = \overline{Q_1}$

and $D_1 = Q_0$

Hence alternative (A) is the correct choice.

48. (B) **Given program ↔ Corresponding output of SP**

LXI SP, EFFFH   EFFFH

CALL 3000 H

:

:

3000 H : LXIH, 3CF4H ↔ EFFFH

PUSH PSW ↔ EFFDH

(Content decremented by 2)

SPHL ↔ 3 CF4

(Loading stock pointer)

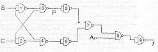
POP PSW ↔ 3CF6

(Content incremented by 2)

RET ↔ 3 CF8

(Content incremented by 2, because return RET instruction is equivalent to POP instruction.)

49. (D) Given that point P is stuck at-1



If P = 1

O/P of gate 5 will be 0.

Now, for any value of gate 6 output, the output of gate 7 will be 1.

output of gate 8 $= \overline{A \cdot 1}$

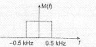
$= \overline{A}$

and output of gate 9 $= \overline{\overline{A}} = A$

50. (B) Given, $m(t)$ with bandwidth 500 Hz or 0·5 kHz multiplied by $g(t)$

where $g(t) = \sum_{k=-\infty}^{\infty} (-1)^k \delta(t - 0{\cdot}5 \times 10^{-4} K)$

Multiplication of two signal in time domain is equivalent to convolution in frequency domain.



for $k = 1$

$$g(t) = (-1)^1 \delta(t - 0{\cdot}5 \times 10^{-4})$$

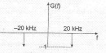
or $$g(t) = -1\,\delta(t - 0{\cdot}5 \times 10^{-4})$$

Sampling period

$$T = 0{\cdot}5 \times 10^{-4}$$

and sampling frequency

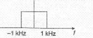
$$= \frac{1}{T} = 20 \text{ kHz}$$



Let the resulting signal be $y(t)$ *i.e.*

$$y(t) = m(t) * g(t)$$

when this resulting signal is passed through an ideal low pass filter with bandwidth 1 kHz



The output of the low pass filter would be $m(t)$.

51. (C) Given $x(t) = 5\left(\frac{\sin 2\pi\, 100\, t}{\pi t}\right)^3 + 7\left(\frac{\sin 2\pi\, 100\, t}{\pi t}\right)^2$

we know that

$$\sin 3A = 3 \sin A - 4 \sin^3 A$$

or $$\sin^3 A = \frac{3 \sin A - \sin 3A}{4}$$

If $$A = 2\pi\, 1000\, t, \text{ then}$$

$$x(t) = \frac{5}{(\pi t)^3}\left[\frac{3 \sin 2\pi\, 1000\, t - \sin 2\pi\, 1000 \times 3t}{4}\right]$$

$$+ \frac{7}{(\pi t)^2}\left[\frac{1 - \cos(2 \times 2\pi\, 1000\, t)}{2}\right]$$

Here the maximum value of modulating frequency *i.e.*

$$f_m = 3 \times 1000 = 3 \times 10^3 \text{ Hz}$$

So, minimum sampling frequency required to reconstruct the signal $= 2 f_m$

or $$f_s = 2 \times 3 \times 10^3 = 6 \times 10^3 \text{ samples/sec}$$

52. (B)

53. (C) Given input, $x(n)$ and output $y(n)$ is given as

$$y(n) = \left(\sin \frac{5}{6}\pi n\right) x(n)$$

- The given system equation is linear, since there is no constant and square terms in the given equation.
- The given system is stable, since $\left(\sin\frac{5}{6}\pi n\right)$ always less than | 1 |.
- The given system equation is non-invertible, since for different input say $n = 6$ and $n = 12$, it gives the identical output.

54. (B) $C(t) = 1 - e^{-2t}$ for $t \geq 0$

$$C(t) = 1 - e^{-2t}$$

Taking Laplace transform

$$C(s) = \frac{1}{s} - \frac{1}{(s+2)}$$

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

$$C(s) = \frac{2}{s(s+2)}$$

Here $R(s) = 1/s$ unit step response

$$\frac{C(s)}{R(s)} = \frac{2s}{s(s+2)}$$

$$\frac{C(s)}{R(s)} = \frac{2}{(s+2)}.$$

55. (D) The Nyquist plot of $G(j\omega)\ H(j\omega)$ for a closed loop control system, passes through $(-1, j\,0)$ point in GH plane, so it is passes on unit circle. So the gain margin is zero.

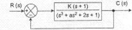
56. (B) $G(s) = \frac{K(s+1)}{s^3 + as^2 + 2s + 1}$

$$H(s) = 1$$

Characteristic equation

$$s^3 + as^2 + 2s + 1 + Ks + K = 0$$

$$s^3 + as^2 + (2+K)s + (K+1) = 0$$



From Routh's Harwitz array

s^3	1	(2 + K)
s^2	a	(K + 1)
s^1	$\frac{(2+K)a-(K-1)}{a}$	
s^0		

$$\frac{(2+K)a-(K+1)}{a} = 0$$

$$\frac{(2+K)-(K+1)}{a} = 0$$

$$(2+K) - \frac{(K+1)}{a} = 0$$

$$(2+K) = \frac{(K+1)}{a}$$

$$a = \frac{(K+1)}{(2+K)}$$

$$(2a + Ka) = (K+1)$$

$$K(a-1) = (1-2a)$$

$$K = \frac{(1-2a)}{(a-1)} \quad ...(i)$$

$$as^2 + (K+1) = 0$$

$$a(j\omega)^2 + (K+1) = 0$$

$$a = \frac{(K+1)}{\omega^2} \quad ...(ii)$$

Putting the value of K for equation (i) to (ii)

and $\omega = 2$ rad/sec

then $a = 0{\cdot}75$

57. (C) The unit impulse response of system

$$h(t) = e^{-t} \text{ and } t \leq 0$$

taking Laplace transform

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

for unit impulse

$$Y(s) = H(s)\,R(s)$$

$$= \frac{1}{(S+1)}\cdot\frac{1}{s}$$

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

Taking inverse Laplace transform

$$y(t) = 1 - e^{-t}$$

to steady state $t \to \infty$

$$y(t) = 1$$

58. (D) For phase lead compensator

$$G_C(s) = \left(\frac{1+3Ts}{1+Ts}\right)$$

where $T > 0$

For max. phase shift provided by this compensator

$$G_C(s) = \frac{1+3Ts}{1+Ts}$$

$$= \frac{3T\left(\frac{1}{3T}+s\right)}{T\left(\frac{1}{T}+s\right)}$$

$$= \frac{3\left(s+\frac{1}{3T}\right)}{\left(s+\frac{1}{T}\right)}$$

$$\alpha = \frac{1/3T}{1/T}$$

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

$$\sin\phi_m = \frac{1-\alpha}{1+\alpha}$$

$$\sin\phi_m = \frac{1-0{\cdot}33}{1+0{\cdot}33}$$

$$\phi_m = \sin^{-1}\left(\frac{0{\cdot}66}{1{\cdot}33}\right)$$

$$\phi_m = 30° = \pi/6.$$

59. (A) The given state equation

$$\dot{X}(t) = AX(t) + BU(t)$$

and $$A = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

State transition matrix

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

Here, $$SI - A = \begin{bmatrix} S & 0 \\ 0 & S \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

or $$SI - A = \begin{bmatrix} S & -1 \\ 1 & S \end{bmatrix}$$

and $$[SI - A]^{-1} = \frac{\text{Adjoint of } [SI - A]}{|[SI - A]|}$$

$$\phi(t) = L^{-1}\begin{bmatrix} \frac{S}{S^2+1} & \frac{1}{S^2+1} \\ \frac{-1}{S^2+1} & \frac{S}{S^2+1} \end{bmatrix}$$

or $$\phi(t) = \begin{bmatrix} \cos t & \sin t \\ -\sin t & \cos t \end{bmatrix}$$

Hence alternative (A) is the correct choice.

60. (B) Given f_s = 32 K samples/sec

or $f_s = 32 \times 1024$ samples/sec

$$x(t) = 125\, t\,[u(t) - u(t-1)] + (250 - 125\, t)\,[u(t-1) - u(t-2)]$$

or $$x(t) = 125\, t\,[u(t) - u(t-1)] + 250\,[u(t-1) - u(t-2)] - 125\, t\,[u(t-1) - u(t-2)]$$

from the given expression of $x(t)$, the slope is 125.

To avoid slope-overload noise in delta-modulator

$$\frac{\Delta}{T_s} \geq \frac{dx(t)}{dt}$$

where, Δ = step size

T_s = sampling period

$\frac{dx(t)}{dt}$ = slope of the modulating signal

Now, $$\Delta \geq T_s \frac{d}{dt} x(t)$$

or $$\Delta_{min} = \frac{1}{f_s} \times 125$$

or $$\Delta_{min} = \frac{1 \times 125}{32 \times 1024}$$

or $$\Delta_{min} = \frac{4}{2^{10}}$$

or $$\Delta_{min} = 2^{-8}$$

61. (B)

62. (B) Using Shannon-Fano coding

$$\begin{matrix} 0{\cdot}25 \\ 0{\cdot}25 \end{matrix} \left| \begin{matrix} 0 & 0 \\ 0 & 1 \end{matrix} \right\} 2 \text{ bits}$$

$$0{\cdot}50 \mid 1 \quad \} 1 \text{ bit}$$

∴ Number of bits/sec

$$= 0{\cdot}25 \times 3000 \times 2 + 0{\cdot}25 \times 3000 \times 2 + 0{\cdot}5 \times 3000 \times 1$$

$$= 1500 + 1500 + 1500$$

$$= 4500 \text{ bits/sec}$$

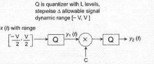
63. (D) Refer synopsis for more detail

The diagonal clipping in the AM using envelop detector can be avoided if

$\frac{1}{W} > RC$ where W = Message bandwidth

RC = time constant of envelop detector.

64. (C) From given figure, it is clear that



Constant 'C' is nothing but a quantizing error. And this quantizing error in DM is equally likely to lie anywhere in the interval $\left(\frac{-\Delta}{2}, \frac{\Delta}{2}\right)$ is $\frac{\Delta^2}{12}$.

65. (B) Given $f_m = 10$ kHz $= 10 \times 10^3$ Hz

We know that, bandwidth of the given by relation

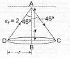
$$BW = 2(\beta + 1) f_m$$

since for NBFM, $\beta << 1$

So, $BW = 2 f_m = 2f_{c1} = 2 \times 10^6$ Hz

66. (D) Given depth = 1 m

r = radius



From figure

$$\sin\theta = \frac{DB}{AD}$$

or $$\sin 45° = \frac{r}{\sqrt{r^2 + d^2}}$$

or $$\frac{1}{\sqrt{2}} = \frac{r}{\sqrt{r^2 + 1^2}}$$

or $$2r^2 = r^2 + 1$$

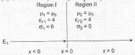
or $$r^2 = 1$$

or $$r = 1$$

Now, $$\text{Area} = \pi \times r^2$$

$$= \pi\, m^2$$

67. (C) Given $E_1 = 4\hat{a}_x + 3\hat{a}_y + 5\hat{a}_z$



Since, $\sigma = 0$

Therefore $\overline{E}_{t_1} = \overline{E}_{t_2}$

and $\overline{D}_{x_1} = \overline{D}_{x_2}$

which gives $\overline{E}_{y_1} = \overline{E}_{y_2}$

and $\overline{E}_{z_1} = \overline{E}_{z_2}$

and $\varepsilon_{r_1}\overline{E}_{x_1} = \varepsilon_{r_2}\overline{E}_{x_2}$

or $\overline{E}_{x_2} = \varepsilon_{r_2} \cdot \overline{E}_{x_1}$

or $\overline{E}_{x_2} = \varepsilon_{r_2}$

or $\overline{E}_{x_2} = \frac{3}{4} \cdot 4\,\hat{a}_x$

or $\overline{E}_{x_2} = 3\,\hat{a}_x$

Therefore, $E_2 = 3\,\hat{a}_x + 3\,\hat{a}_y + 5\,\hat{a}_z$

68. (A) We know that transmitted power is given as

$$P_t = P_i\,(1 - \Gamma^2)$$

where, π = reflection coefficient

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

$$= \frac{\sqrt{\frac{\mu_0}{\epsilon_0 \epsilon_{r2}}} - \sqrt{\frac{\mu_0}{\epsilon_0}}}{\sqrt{\frac{\mu_0}{\epsilon_0 \epsilon_{r2}}} + \sqrt{\frac{\mu_0}{\epsilon_0}}}$$

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

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

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

Now, $P_t = P_i\left(1 - \frac{1}{9}\right)$

or $\frac{P_t}{P_i} = \frac{8}{9}$ (*i.e.* ratio of transmitted power to the incident power)

69. We know that cut-off frequency is given by relation

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

where, c = velocity of light in free space.

for, TE_{10} mode

$$f_c = \frac{c}{2a}$$

and for TE_{30} mode

$$fc = \frac{3c}{2a}$$

given $fc = 18$ GHz

or $18 \times 10^{10} = \frac{3 \times 3 \times 10^8}{2 \cdot a}$

or $a = \frac{1}{4 \times 10^2}$

or $a = 0{\cdot}25$ cm

Note : Here all the options are incorrect.

70. (C) Given l = 50 m

f = 600 kHz

Radiation resistance, R_{rad}

$$R_{rad} = 80\,\pi^2\left(\frac{dl}{\lambda}\right)^2$$

where λ = wavelength

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^5}$$

$$= 0{\cdot}5 \times 10^3 \text{ m}$$

Now, $R_{rad} = 80 \times (3{\cdot}14)^2\left(\frac{50}{0{\cdot}5 \times 10^3}\right)^2$

or $R_{rad} = 7{\cdot}887\ \Omega$

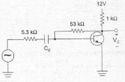
or $R_{rad} = \frac{4}{5}\pi^2$

71. (C) Given, $\beta_{DC} = 60$, $V_{BE} = 0{\cdot}7$ V

$h_{ie} \to \infty$

$h_{fe} \to \infty$

$C_c = \infty$



From figure

$$12 - 1\,K{\cdot}I_E - 53\,K{\cdot}I_B - V_{BE} = 0$$

or $12 - 1{\cdot}K\,(I_B + I_C) - 53\,K{\cdot}I_B - V_{BE} = 0$

or $12 - 1{\cdot}K\left(\frac{I_C}{B_{DC}} + I_C\right) - 53\,\frac{K{\cdot}I_C}{B_{DC}} - V_{BE} = 0$

or $J_C = \frac{12 - 0{\cdot}7}{\left(\frac{1}{60} + 1 + \frac{53}{60}\right)K} = \frac{11{\cdot}3}{\frac{114\,K}{60}K} = 5{\cdot}95$ mA

Now, $V_{CE} = V_{CC} - I_C R_C$

or $V_{CE} = 12 - 5.95 \times 10^{-3} \times 10^{3}$

$= 6.05$ V

72. (B) $V_{CE} = V_{CC} - I_C R_C$

or $V_{CE} = V_{CC} - \frac{(\beta+1)(V_{CC}-V_{BE}) R_C}{R_B + R_C(1+\beta)}$

or $\frac{dV_{CE}}{d\beta} = 0 - \frac{[R_B + R_C(1+\beta)] \cdot (V_{CC}-V_{BE}) R_C - (\beta+1)(V_{CC}-V_{BE}) R_C \cdot R_C}{[R_B + R_C(1+\beta)]^2}$

or $\frac{dV_{CE}}{d\beta} = \frac{-(V_{CC}-V_{BE}) R_C [R_B + R_C(1+\beta) - (\beta+1) R_C]}{[R_B + R_C(1+\beta)]^2}$

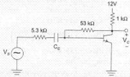
or $\frac{dV_{CE}}{d\beta} = \frac{-(V_{CC}-V_{BE}) R_C R_B}{[R_B + R_C(1+\beta)]^2}$

or $dV_{CE} = \frac{-(V_{CC}-V_{BE}) R_C \cdot R_B}{[R_B + R_C(1+\beta)]^2} \cdot d\beta$

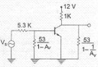
From above expression we conclude that for $d\beta = 10\%$, dV_{CE}, decreases by less than or equal to 10%.

73. (A) We have already calculated (In solution no. 71)

$V_{CE} = V_C - V_E = V_C = 6.05$ volts



Here Miller's theorem is applied to 53 K resistance and given amplifier circuit becomes



Assuming that gain is much larger than unity

(*i.e.* $-A_V >> 1$), then $\frac{53\text{ K}}{1-\frac{1}{A_V}} \approx 53$ K

Therefore, the effective load resistance is

$R_L' = 1\text{K}//53\text{ K} \approx 1$ K

Now, small signal gain

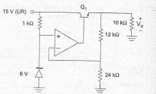
$A_{V_s} = \frac{V_c}{V_s} = -10.$

74. (D) 75. (A)

76. (C) Given, unregulated input voltage

$= 15$ V

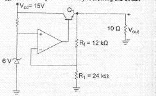
$V^+ = 6$ V



From the first sight, it seems very confusing.

Here the transistor base is connected with output of the op-amp and collector terminal is connected to + 15 V supply, it makes the transistor ON.

V_{out} can be easily calculated by redrawing the circuit



From above figure

$V_{out} = \left(1 + \frac{R_f}{R_1}\right) V_i$

$= \left(1 + \frac{12}{24}\right) 6$

$= \frac{3}{2} \cdot 6$

$= 9$ V

$V_{CE} = 15 - V_{out}$

or $V_{CE} = 15 - 9 = 6$ V

$I_C = \frac{V_{CC} - V_Z}{1\text{ K}} = \frac{15-6}{1\text{ K}}$

$= 9$ mA

Power dissipation across the transistor Q_1

$P_d = V_{CE} \times I_C = 6 \times 9\text{ mA} = 5.4$ mW

77. (B) Let new unregulated voltage is V_{CC}'

$= 120\%$ of 15

$= \frac{15 \times 120}{100} = 18$ V

Now, $V_{CE}' = V_{CC}' - V_{out} = 18 - 9 = 9$ V

and $I_C' = \frac{V_{CC}' - V_Z}{1\text{ k}\Omega} = \frac{18-6}{1\text{ k}\Omega} = 12$ mA

$P_d' = V_{CE}' \times I_C'$

or $P_d' = 9 \times 12$ mW

or $P_d' = 108$ mW

% change in power dissipation

$$= \frac{P'_d - P_d}{P'_d} \times 100$$

$$= \frac{108 - 54}{108} \times 100$$

$$= \frac{54}{108} \times 100$$

$$= 50\%$$

Hence power dissipation across the transistor Q_1 is increases by 50%.

78. (A) Given

$$S_{YY}(\omega) = \frac{16}{16 + \omega^2}$$

$$S_{XX}(\omega) = 1$$

(with noise power spectral density)

We know that

$$S_{YY}(\omega) = |H(\omega)|^2 \cdot S_{XX}(\omega)$$

or $$|H(\omega)|^2 = \frac{S_{YY}(\omega)}{S_{XX}(\omega)} = \frac{16}{16 + \omega^2}$$

or $$|H(\omega)| = \frac{4}{\sqrt{4 + \omega^2}}$$

or $$H(S) = \frac{4}{s + 4}$$ (which is first order R-L filter)

79. (A) We know the type of first order R-L filter is given by

$$H(s) = \frac{R}{R + s}$$

On comparing $\frac{R}{R + Ls}$ with $\frac{4}{4 + s}$

we get $R = 4\,\Omega$

$L = 1\text{ H}$

80. (C) Given amplitude modulated signal, where $f_m < \beta$

$$x_{AM}(t) = 10\,(1 + 0{\cdot}5 \sin 2\pi f_m t) \cos 2\pi f_c t$$

Here, $A_c = 10$

$\mu = 0{\cdot}5$

Average side-band power,

$$P_{av} = \frac{\mu^2 AC^2}{4}$$

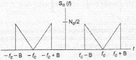
$$= \frac{0{\cdot}5^2 \times 10^2}{4}$$

$$= 6{\cdot}25$$

81. (B) From given figure

Noise power $= \frac{N_0}{2} \cdot 2B = N_0 B$

(*i.e.* area enclosed by the spectrum)



Now, $$\text{Ratio} = \frac{\text{Average side-band power}}{\text{Mean noise power}}$$

or $$\text{Ratio} = \frac{6{\cdot}25}{N_0 B}$$

or $$\text{Ratio} = \frac{25}{4\, N_0 B}$$

82. (C) Given, $$G(s) = \frac{as + 1}{s^2}$$

Phase margin $= 180° + \angle G(j\omega)|_{\text{at } \omega = \omega_c}$

or $$\frac{\pi}{4} = 180° + \tan^{-1}\omega_c a - 2\,(90°)$$

or $$\frac{\pi}{4} = \tan^{-1}\omega_c \cdot a$$

or $$\tan\frac{\pi}{4} = \omega_c \cdot a$$

or $$\omega_c \cdot a = 1 \qquad \text{...(i)}$$

and at cut-off frequency (ω_c), magnitude should be equal to 1.

i.e. $$|G(j\omega)|_{at\,\omega = \omega c} = 1$$

or $$\frac{\sqrt{(a\omega_c)^2 + 1}}{\omega_c^2} = 1$$

or $$\omega_c = a^2\omega_c^2 + 1 \qquad \text{...(ii)}$$

From equation (i) and (ii)

$$\frac{1}{a^4} = \frac{a^2}{a^2} + 1$$

or $$\frac{1}{a^4} = 1 + 1$$

or $$a^4 = \frac{1}{2}$$

or $$a = \left(\frac{1}{2}\right)^{1/4}$$

or $$a = 0{\cdot}84$$

83. (C) We know that

$$G(s) = \frac{C(s)}{X(s)}$$

If $x(t) = \delta(t)$ (given)

then $X(s) = 1$

Now, $$C(s) = G(s) = \frac{as + 1}{s^2}$$

$$C(t) = au(t) + t$$

or $C(t) = 0{\cdot}84\, u(t) + t$

at t $= 1$

$C(1) = 0{\cdot}84 + 1 = 1{\cdot}84$

84. (D) Given, $V = 30$ volts

$Z_0 = 50\,\Omega$

at $t = 400\,\mu s = 400 \times 10^{-6}$ sec

V at load end $= 40$ volts.

85. (B) The steady-state current through the load resistance is—

$$i = \frac{V}{R_L} = \frac{30}{100} = 0{\cdot}3 \text{ amp.}$$