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

Order = 2

$\because$ Highest derivative is $\frac{d^2y}{dt^2}$.

2. (a) Alternative (a) is correct choice.
3. (b) Given function, $f(t) = \sin^2 t + \cos 2t$

or $f(t) = \sin^2 t + 2\cos^2 t - 1$

or $f(t) = \sin^2 t + \cos^2 t + \cos^2 t - 1$

or $f(t) = 1 + \cos^2 t - 1$

or $f(t) = \cos^2 t$

or $f(t) = \frac{\cos 2t + 1}{2}$

or $f(t) = \frac{1}{2}\cos 2t + \frac{1}{2}$

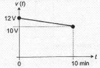
$$\downarrow \qquad \downarrow$$

$$f = \frac{1}{\pi} \quad f = 0$$

Therefore, f has frequency components at 0 and $\frac{1}{\pi}$ Hz.

Hence alternative (b) is the correct choice.

4. (c) Given current = 2A



$$\text{Energy} = \int V(t)\, I(t)\, dt$$
$$= \int_0^{10 \times 60} 2 \cdot V(t) dt$$

$$V(t) = \frac{12 - 10}{-10 \times 60}(t - 600) + 10$$

$$= 2\int_0^{600} -\frac{2}{600}[t - 600] + 10\, dt \quad \text{...(i)}$$

After solving this equation we get

Energy = 13200 J

= 13·2 kJ

5. (c) The concentration of dopant atoms in an n-type silicon crystal is 4×10^{19} cm^{-3}.
6. (c) Full form of TTL and CMOS in reference to logic families are :

TTL → Transistor Transistor Logic

CMOS → Complementary Metal Oxide Semiconductor

7. (a) The given discrete time sequence

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

For the term $\left(\frac{1}{3}\right)^n u(n) \leftrightarrow \frac{1}{1 - \frac{1}{3}z^{-1}}$

ROC $\left|\frac{z^{-1}}{3}\right| < 1$ or $|z| > \frac{1}{3}$

for the term $\left(\frac{1}{2}\right)^n u(-n-1) \leftrightarrow \frac{1}{1 - \frac{1}{2}z^{-1}}$

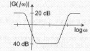
ROC $\left|\frac{z^{-1}}{2}\right| > 1$ or $|z| < 2$

Hence the ROC of the given discrete sequence is

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

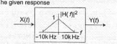
Hence alternative (a) is the correct choice.

8. (d) The given magnitude plot



The above figure represents lead-lag compensator.

9. (b) The given response



Given, $X(t) = 1 \times 10^{-10}$ W/Hz

$|H(f)|^2 = 1$

$Y(t) = ?$

We know that,

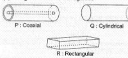
$$Y(f) = 2\pi \int |H(f)|^2 \times (f)\, df$$

$$= 2\pi \int |H(f)|^2 \cdot 1 \times 10^{-10}\, df$$

$$= 1 \times 10^{-10} \times 2\pi \int_0^{10^4/2\pi} 1\, df$$

$$= 2\pi \times 10^{-10} \times \frac{10^4}{2\pi} = 10^{-6} \text{ W}$$

10. (a) The given metallic waveguides



coaxial waveguide has no cut-off frequency.

11. (d) Probability of getting head $= \frac{1}{2}$

Probability of getting tail $= \frac{1}{2}$

$n = 10$

Number of success $= 2$

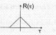
Probability of getting head in only first 2 tosses

$$= {}^{10}C_2 \left(\frac{1}{2}\right)^2 \left(\frac{1}{2}\right)^8$$

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

Option (d) is correct.

12. (b) If the power spectral density of stationary random process is a sinc squared function of frequency then the shape of its auto correlation will be triangular as shown in option (b).



13. (d) $f(z) = c_0 + c_1 z^{-1} \Rightarrow f'(z) = \frac{-c_1}{z^2}$

$$\oint \frac{1 + f(z)}{z} dz \qquad c : |z| = 1$$

Poles at $z = 0$

By Cauchy's Integral formula

$$\oint \frac{F(z)}{z - a} dz = 2\pi i\, F'(z)$$

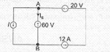
Here $F(z) = 1 + f(z),\ F'(z) = f'(z)$

$$\oint \frac{1 + f(z)}{z} = 2\pi j\, f'(z)$$

$$= 2\pi j\,(1 + c_0)$$

Hence alternative (d) is the correct choice.

14. (a) The given figure



Given that 60V source is absorbing power. It means current enters in the 60V source. Let the current enter in 60V source is I_S.

KCL at point B, we get

$$I + I_s = 12 \qquad \text{...(i)}$$

Now, this problem is further solved by applying Hit and trail method. From the given options, we conclude that only alternative (a) satisfy the equation (i).

15. (a) From the Einstein relation

$$\frac{D_p}{\mu_p} = \frac{D_n}{\mu_n}$$

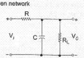
$$= \frac{KT}{q}$$

$$= V_T = 26\text{mV}$$

The ratio of mobility to the diffusion constant is $\frac{1}{V}$ or V^{-1}.

16. (d) INTR is internally generated interrupt. This interrupt is maskable and vectored. This interrupt can be delayed or rejected.

17. (c) The given network



The given transfer function

$$\frac{V_0(s)}{V_i(s)} = \frac{1}{2 + SCR} \qquad \text{...(i)}$$

From given network

$$V_0(s) = V_i(s) \cdot \frac{R_L \,||\, \frac{1}{Cs}}{R + R_L \,||\, \frac{1}{C}}$$

or
$$\frac{V_0(s)}{V_i(s)} = \frac{R_L}{R + R_L + RR_L CS}$$

$$= \frac{1}{\frac{R + R_L}{R_L} + RCS} \quad ...(ii)$$

On comparing equation (i) and (ii) we get

$$\frac{V_0(s)}{V_i(s)} = \frac{1}{\frac{R + R_L}{R_L} + CSR}$$

$$\frac{R + R_L}{R_L} = 2$$

$$R + R_L = 2R_L$$

$$\boxed{R_L = R}$$

Hence alternative (c) is the correct choice.

18. (c) Given $A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

and $B = \begin{bmatrix} p \\ q \end{bmatrix}$

For controllability, $C = [B : AB]$

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

$$= \begin{bmatrix} p \\ q \end{bmatrix}$$

Then $C = \begin{bmatrix} p & p \\ q & q \end{bmatrix}$

Rank of C ≠ Rank of A hence system is uncontrollable.

Hence alternative (c) is the correct choice.

19. (c) The given message signal

$$m(t) = \cos(2\pi f_m t)$$

frequency of carrier signal

$$= fc$$

Let $c(t) = \cos(2\pi f_c t)$

Now, DSB–SC modulated signal

$$s(t) = m(t)\, c(t)$$

or $s(t) = \cos(2\pi f_m t)\cos(2\pi f_c t)$

or $s(t) = \frac{1}{2}[\cos 2\pi (f_m + f_c)t + \cos 2\pi (f_m - f_c)t]$

The single side-band (SSB) signal is given by

$$s(t) = \frac{1}{2}\cos[2\pi(f_m + f_c)t]$$

or $s(t) = \cos[2\pi(f_c + f_m)t]$

20. (d) 21. (c)

22. (d) $f(x) = \frac{\sin x}{x - \pi}$ at $x = \pi$

$$\sin x = \sin(\pi - x) = -\sin(x - \pi)$$

$$\Rightarrow \quad f(x) = \frac{-\sin(x - \pi)}{x - \pi}$$

$$= -\frac{1}{x - \pi}\left[(x - \pi) - \frac{(x - \pi)^3}{3!} + \frac{(x - \pi)^5}{5!} + \ldots\ldots\right]$$

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

Option (d) is correct.

23. (b) $\vec{V} = \nabla \times \vec{A}$

From Stokes theorem

$$\int_C \vec{F} \cdot d\vec{r} = \int_A (\nabla \times \vec{F})\, dS$$

So, we have $\oint_C \vec{A} \cdot d\vec{l} = \iint_{S_C} \vec{V} \cdot d\vec{S}$

Option (b) is correct.

24. (b) $F(s) = L\{f(t)\}$

$$L\left\{\int_0^t f(\tau)\, d\tau\right\} = \frac{F(s)}{s}$$

Option (b) is correct choice.

25. (a) P. $\frac{dy}{dx} = \frac{y}{x}$

$$\Rightarrow \quad \int \frac{1}{y}\, dy = \int \frac{1}{x} dx$$

$$\log y = \log xc$$

$$y = xc \qquad \textit{i.e. Straight lines}$$

Q. $\frac{dy}{dx} = -\frac{y}{x}$

$$\log y = -\log x + \log e$$

$$\log y = \log c/x$$

$$y = \frac{c}{x}$$

$$\Rightarrow \quad xy = c \qquad \textit{i.e. Hyperbolas}$$

R. $\frac{dy}{dx} = \frac{x}{y}$

or $ydy = xdx$

$$\Rightarrow \quad y^2 = x^2 + c \qquad \textit{i.e. Hyperbolas}$$

S. $\frac{dy}{dx} = -\frac{x}{y}$

$$\Rightarrow \quad y^2 + x^2 = c \qquad \textit{i.e. Circles}$$

P – 2, Q – 3, R – 3, S – 1

Hence alternative (a) is the correct choice.

26. (d) $A = \begin{bmatrix} -1 & 3 & 5 \\ -3 & -1 & 6 \\ 0 & 0 & 3 \end{bmatrix}$

$$\text{trace } A = -1 + (-1) + 3 = 1$$

$$|A| = 3(1 + 9) = 30$$

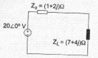
∵ Sum of eigen values = trace A

For option (d), sum of eigen values

$$= 3 - 1 + 3j - 1 - 3j = 1$$

So option (d) is correct choice.

27. (b) The given circuit



Given,

$$V = 20\ V_{rms}$$
$$Z_s = (1+2j)\ \Omega$$
$$Z_L = (7+4j)\ \Omega$$
$$P_{Reactive}\ (\text{Load}) = ?$$
$$I_{rms} = \frac{V_{rms}}{Z_{eq}} = \frac{V_{rms}}{Z_s + Z_L}$$

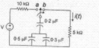
or

$$I_{rms} = \frac{20V}{1+2j+7+4j} = \frac{20}{8+6j} = \frac{20}{\sqrt{8^2+6^2}} = \frac{20}{10} = 2\ \text{Amp.}$$

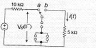
Now, $P_{Reactive}$ (Load) $= I_{rms}^2 \times X_L$

$$= 2^2 \times 4$$
$$= 16\ \text{VAR}$$

28. (b) The given circuit



For $t < 0$: *i.e.* when switch was on position a for a log time it mean all the capacitors are replaced by open circuited as shown below :



From above figure $V_C(0^-) = V_C(0^+) = 100V$ (since current is zero) for $t > 0$: *i.e.* when switch is moved to position (b).

Equivalent capacitance is given by

$$C_{eq} = [(0.3 + 0.5) \parallel 0.2]\ \mu F$$

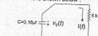
or

$$C_{eq} = \frac{0.8 \times 0.2}{0.8 + 0.2}\ \mu F$$

or

$$C_{eq} = 0.16\ \mu F$$

The circuit for this is shown below :



Now, applying KVL in the above circuit, we get

$$V_C(t) + I(t)\,5000 = 0 \qquad \left[\begin{array}{l} \because I(t) = C\dfrac{dV_C(t)}{dt} \\ \text{or } I(t) = 0.16 \times 10^{-6}\dfrac{dv_C(t)}{dt} \end{array}\right.$$

$$V_C(t) + 5000 \cdot 0.16 \times 10^{-6}\frac{d}{dt}V_C(t) = 0$$

$$\frac{dV_C(t)}{dt} + \frac{1}{5000 \times 0.16 \times 10^{-6}}V_C(t) = 0$$

$$\text{I.F.} = e^{1250t}$$

$$V_C(t) = Ae^{-1250t} \qquad \text{...(i)}$$

Since at $t = 0$,

$$V_C(0+) = 100$$

gives $100 = A$

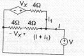
$$V_C(t) = 100e^{-1250t}$$
$$I(t) = C\frac{dV_C(t)}{dt}$$

or $I(t) = -0.16 \times 10^{-6} \times 100 \times (1250)e^{-1250t}$

or $I(t) = 20e^{-1250t}$ mA

Hence alternative (b) is the correct choice.

29. (b) For maximize power to R_L. R_L should be equal to R_{th} Calculation for R_{th}. Equivalent circuit is shown below :



$$V = 8I + 8I_1 \qquad \text{...(i)}$$
$$-V_X + 4I_1 + 8I + 8I_1 = 0 \qquad \text{...(ii)}$$
$$V_X = 4I + 4I_1 = \frac{V}{2}$$
$$-4I - 4I_1 + 4I_1 + 8I + 8I_1 = 0$$
$$4I + 8I_1 = 0$$

or

$$I_1 = -\frac{I}{2}$$

Now,

$$V = 8I - \frac{8}{2}I = 4I$$

Therefore,

$$R_{th} = \frac{V}{I} = 4\Omega$$

30. (a) Given $\dfrac{di}{dt} + \dfrac{R}{L}i = \dfrac{V_0}{L}\left(1 + Be^{\frac{-R}{L}t}\sin t\right)u(t)$

$$\text{I.F.} = e^{\frac{R}{L}t}$$

$$I(t)e^{\frac{R}{L}t} = \frac{V_0}{L}\int e^{\frac{R}{L}t}\left(1 + Be^{\frac{-R}{L}t}\sin t\right)dt + C$$

$$= \frac{V_0}{L}\int e^{\frac{R}{L}t} + B\sin t\,dt + C$$

$$I(t)e^{\frac{R}{L}t} = \frac{V_0}{L}\left[\frac{L}{R}e^{\frac{R}{L}t} - B\cos t\right] + C$$

$$I(t) = \frac{V_0}{R} - \frac{V_0}{L}Be^{-\frac{R}{L}t}\cos t + Ce^{\frac{-R}{L}t}$$

at $t = 0, I(0) = \frac{V_0}{R}$

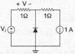
Now, $\frac{V_0}{R} = \frac{V_0}{R} - \frac{V_0}{L}B + C$

which gives, $C = \frac{B}{L}V_0$

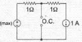
Hence, $I(t) = \frac{V_0}{R} - \frac{V_0}{L}Be^{\frac{-R}{L}t}\cos t + \frac{B}{L}V_0\, e^{\frac{-R}{L}t}$

For steady state value $I(t) \to \frac{V_0}{R}$

31. (d) The given circuit

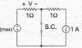


The given diode is ideal. When V_i is positive the diode gets reverse biased



Here, $V = 1V$

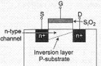
When V_i is negative the diode becomes short circuited



Here, $V = -V_{i(max.)}$

Hence alternative (d) is the correct choice.

32. (d) In an *n*–channel MOSFET operating in the active region. The inversion charge decreases from source to drain as shown below :

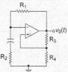


Where,
S = Source
G = Gate
D = Drain

When a voltage V_{ds} (*i.e.* voltage between drain and source) is applied between source and drain, with $V_{gs} = V_t$ (V_{gs} = voltage between gate and source and V_t is the threshold voltage) the horizontal and vertical components of the electrical field due to the source-drain voltage and gate-to substrate voltage interact, causing conduction to occur along the channel. The horizontal component of electric field is associated with drain-to-source voltage (*i.e.* $V_{ds} > 0$) is responsible for sweeping the electron in the channel from the source towards drain. As the voltage from source to drain increases it means inversion charge decreases from source to drain. However the channel potential increases from source to drain.

Hence alternative (d) is the correct choice.

33. (a) The given circuit

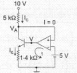


In as table multivibrator, the value of peak voltage say, V_m is fixed *i.e.* not changed by changing the value of R_2 and C but time going $+V_{max}$ and $-V_{max}$ is changed. It means frequency changes. Hence alternative (a) is the correct choice.

34. (d) The given circuit

$$V_A = 5V$$

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



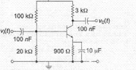
Applying KVL in loop 1, we get

$$V_0 = 0{\cdot}6 + 1{\cdot}4 \times 1$$

$$V_0 = 2V$$

and negative feedback.

35. (b) The given circuit



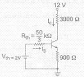
From given circuit, first off all we will draw thevenin equivalent circuit.

$$V_{th} = V_{CC} \times \frac{R_2}{R_1 + R_2}$$

$$= 12 \times \frac{20}{20 + 100} = 2\text{V}$$

$$R_{th} = \frac{20 \times 100}{20 + 100} = \frac{100}{6} = \frac{50}{3}\ \text{k}\Omega$$

The thevenin equivalent of the given circuit is shown below.



Here, $V_0 = -150\, I \times 3\text{k}\Omega$ ...(1)

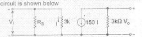
and $I = \frac{V_i}{3\text{k}\Omega}$

$$V_0 = -150 \times \frac{3\text{k}\Omega}{3\text{k}\Omega} \times V_i$$

$$= -150\, V_i$$

$$= -150\, [A \cos 20(t + B \sin 10^6 t]$$

Now the h-parameter model of the thevenin equivalent circuit is shown below



Hence alternative (b) is the correct choice.

36. (d) The given logic equation

$$\left[X + Z\left\{\bar{Y} + \left(\bar{Z} + X\bar{Y}\right)\right\}\right]\left\{\bar{X} + \bar{Z}(X + Y)\right\} = 1$$

given If X = 1, then

$$\left[1 + Z\left\{\bar{Y} + \left(\bar{Z} + \bar{Y}\right)\right\}\right]\left\{\bar{1} + \bar{Z}(1 + Y)\right\} = 1$$

or $$\left[1 + Z\left\{\bar{Y} + \bar{Z}\right\}\right]\left\{0 + \bar{Z}\right\} = 1$$

or $$\left[\bar{Z} + Z\bar{Z}\left\{\bar{Y} + \bar{Z}\right\}\right] = 1$$

or $$\left[\bar{Z} + 0\left\{\bar{Y} + \bar{Z}\right\}\right] = 1$$

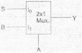
or $$\bar{Z} = 1$$

or $$Z = 0$$

Hence alternative (d) is the correct choice.

37. (c) Let the inputs are A and B, and Y is the output.

- For 2-input AND gate, Y = AB



From above figure

$$Y = \bar{A}S + AB$$

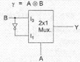
or $$Y = AB \leftarrow \text{AND gate} \quad \text{(When S = 0}$$

Thus, we need one 2 × 1 Maximum to realize 2-input AND gate

- For 2-input EX–OR gate,

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

or $$\gamma = A \oplus B$$



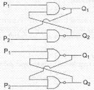
From above figure

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

or $$Y = A \oplus B$$

Hence alternative (c) is the correct choice.

38. (c) The given figure :



- For NAND gate latch

Initially P_1, P_2 inputs are 0, 1

$$Q_1 = \overline{P_1 Q_2}$$

and $$Q_2 = \overline{P_2 Q_1}$$

gives $$Q_1 = 1$$

and $$Q_2 = 0$$

After few seconds P_1, P_2 inputs becomes 1, 1

$$Q_1 = \overline{P_1 Q_2}$$

and $$Q_2 = \overline{P_2 Q_1}$$

gives $$Q_1 = 1$$

and $$Q_2 = 0$$

- For NOR gate latch

Initially P_1, P_2 inputs are 0, 1

$$Q_1 = \sqrt{P_1 + Q_2}$$

and $$Q_2 = \sqrt{P_2 + Q_1}$$

gives $$Q_1 = 1$$

and $$Q_2 = 0$$

After few seconds P_1, P_2 inputs becomes 1, 1

$$Q_1 = \sqrt{P_1 + Q_2}$$

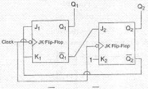
and $Q_2 = \sqrt{P_2 + Q_1}$

gives $Q_1 = 0$

and $Q_2 = 0$ (*i.e.* Indeterminate condition)

Hence alternative (c) is the correct choice.

39. (a)



$J_1 = \overline{Q_2}$ $K_1 = \overline{Q_2}$ FF – 1

$J_2 = \overline{Q_1}$ $K_2 = 1$ FF – 2

Seq. 11, 10, 00, 11, 10

Step 1 $Q_1Q_2 = 11$

$J_1 = T = 0$ $K_1 = 0$ No change

$K_2 = 1$ $J_2 = T = 0$ Reset

$Q_1Q_2 = 10$

Step II $J_1 = \overline{0} = 1$ $K_1 = 1$ Comp

$J_2 = 0$ $K_1 = 1$

Then $Q_1Q_2 = 00$

Step III $J_1 = 1$ $K_1 = 1$

$J_2 = 1$ $K_2 = 1$

$Q_1Q_2 = 11$

Hence option (a) correct

For option (b)

$Q_1Q_2 = 01$

$J_1 = 0$ $K_1 = 0$

$J_2 = 1$ $K_2 = 1$

Hence $Q_1Q_2 = 00$

Then option (b) is not correct

For option (c)

$Q_1Q_2 = 00$

Next $Q_1Q_2 = 11$

Next $Q_1Q_2 = 10$

But given 01 (c) is not correct

For option (d)

$Q_1Q_2 = 01$

Next $Q_1Q_2 = 10$

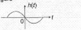
Next $Q_1Q_2 = 00$

Next $Q_1Q_2 = 11$

But given 10 (d) is not correct

40. (a)

41. (b) From given figure



$h(t) \neq 0$ $t < 0$

Hence system is non causal

For Bounded Input

$$y(t) \le \left| \int_{-\infty}^{\infty} x(t-\tau)\, h(2\tau)\, d\tau \right|$$

or $$y(t) \le |x(t-\tau)| \int_{-\infty}^{\infty} |h(2\tau)|\, d\tau < \infty$$

Hence system is bounded output

42. (d)

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

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

or $$M(s) = \frac{K(s^2 - 2s + 2)}{2s^2 + 4}$$

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

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

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

for breakway points

$$\frac{dK}{ds} = 0$$

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

$= 0$

$2(s^2 - 2s + 2)(s + 1) - 2(s^2 + 2s + 2)(s - 1) = 0$

$s^3 - 2s^2 + 2s + s^2 - 2s + 2 - s^3 - 2s^2 - 2s + s^2 + 2s + 2 = 0$

$$-2s^2 + 4 = 0$$

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

Roots of pole : $s^2 + 2s + 2 = 0$

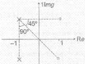
$$s = \frac{-2 \pm \sqrt{4 - 8}}{2} = \frac{-2 \pm 2j}{2}$$

$$= -1 \pm j$$

Roots of zero : $s^2 - 2s + 2 = 0$

$$s = \frac{2 \pm \sqrt{4 - 8}}{2}$$

$$= 1 \pm j$$



Angle of dep $= \angle\phi_1 + \angle\phi_2 + \angle\phi_3$

$= 90 - 45 + 0$

$= 45°$

44. (a) $$H(s) = \frac{s^2 + 1}{s^2 + 2s + 1}$$

$$x(t) = \sin(t + 1)$$

$$\omega = 1$$

$$H(s)|_{s=j\omega} = \frac{-\omega^2+1}{-\omega^2+2j\omega+1}$$

at $\omega = 1$

$$H(\omega=1) = \frac{-1+1}{-1+2j+1} = 0$$

Hence $y(k)$ is zero for all value of ω_s.

45. (b) Steady State Value = −2

Input = Unit Step Response

for unit stape $SSV = \lim_{s \to 0} F(s)$

and for under damped $\varepsilon < 1$

only $\frac{-3{\cdot}82}{s^2+1{\cdot}915+1{\cdot}91}$

$$\omega_n = \sqrt{1{\cdot}91}$$

$$2\varepsilon\omega_n = 1{\cdot}91$$

$$\varepsilon = \frac{1{\cdot}91}{2\sqrt{1{\cdot}91}} = \frac{\sqrt{1{\cdot}91}}{2} < 1$$

and $$SSV = \lim_{s \to 0} \frac{-3{\cdot}82}{s^2+1{\cdot}915+1{\cdot}91} = \frac{-3{\cdot}82}{1{\cdot}91} = -2$$

46. (b) (Also product of eigen values = det A.)

k^2	1	4	9	16	25
k	1	2	3	4	5
P (X = k)	0·1	0·2	0·4	0·2	0·1
Pk	0·1	0·4	1·2	0·8	0·5

μ_s = Mean calculated by student = 3·5

σ_T^2 = Variance calculated by teacher = 1·5

Now, Mean $\mu = \sum_{k=1}^{5} P_k\, k = (0{\cdot}1 + 0{\cdot}4 + 1{\cdot}2 + 0{\cdot}8 + 0{\cdot}5) = 3$

Variance $= \sum_{k=1}^{5} P_k\, k^2 - \mu^2$

$$\sigma^2 = (0{\cdot}1 + 1{\cdot}6 + 10{\cdot}8 + 14{\cdot}4 + 12{\cdot}5) - (3)^2 = 39{\cdot}4 - 9 = 30{\cdot}4$$

Both student and teacher are wrong.

So, option (b) is correct choice.

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

$\Rightarrow$ $m_1 = \frac{1}{2}, m_2 = \frac{1}{2}$

$$s(t) = [1+m(t)]\cos\omega_c t$$

We have $$P_t = P_c\left[1+\frac{m^2}{2}\right]$$

$$\eta = \left[\frac{P_t - P_c}{P_t}\right] \times 100$$

$$m = \sqrt{m_1^2+m_2^2} = \sqrt{\frac{1}{4}+\frac{1}{4}} = \frac{1}{\sqrt{2}}$$

$$P_t = P_c\left[1+\frac{1}{4}\right] = P_c\left[\frac{5}{4}\right]$$

$$4P_t = 5P_c$$

$$\Rightarrow 4[P_t - P_c] = P_c \qquad \text{...(i)}$$

$$\eta = \frac{P_{c/4} \times 100}{\frac{5P_c}{4}}$$

or $$\eta = \frac{1}{5} \times 100 = 20\%$$

48. (b) Given SNR >> 1, bandwidth = B, capacity C_1

We have, $$C = B\ln\left[1+\frac{S}{N}\right]$$

$$C_1 = B\ln\left[1+\frac{S}{N}\right] \qquad \frac{S}{N} >> 1$$

$$C_1 \approx B\ln\frac{S}{N}$$

and if $\frac{S}{N}$ doubled

$$C_2 = B\ln\left[1+2\frac{S}{N}\right]$$

$$C_2 \approx B\ln 2\frac{S}{N}$$

$$C_2 \approx B\ln 2 + B\ln\frac{S}{N}$$

$$C_2 \approx B + C_1$$

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

We have, $H = \frac{B}{\mu}$

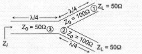
$$\nabla \times H = J$$

$$\nabla \times H = \begin{bmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ -\frac{B_0}{\mu_0}\cdot\frac{y}{x^2+y^2} & \frac{B_0}{\mu_0}\frac{x}{x^2+y^2} & 0 \end{bmatrix}$$

$$\nabla \times H = i\left[\frac{\partial}{\partial y}\times 0 - \frac{B_0}{\mu_0}\frac{\partial}{\partial z}\frac{x}{x^2+y^2}\right] + j\left[0 + \frac{B_0}{\mu_0}\frac{\partial}{\partial z}\frac{y}{x^2+y^2}\right] - k\frac{B_0}{\mu}\left[\frac{\partial}{\partial x}\cdot\frac{x}{x^2+y^2} + \frac{\partial}{\partial y}\frac{y}{x^2+y^2}\right]$$

$$\nabla \times H = -\frac{B_0}{\mu_0}\cdot\hat{z}\cdot\left(\frac{2}{x^2+y^2}\right) \quad r \neq 0$$

50. (d)



We have $Z_i = Z_0 \left[\frac{Z_L + Z_0 j \tan \beta_L}{Z_0 + Z_L j \tan \beta_L}\right]$

Branch (1)

$$\beta_L = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} = \frac{\pi}{2}$$

$$Z_i = Z_0 \left[\frac{Z_L + Z_0\, j \tan\frac{\pi}{2}}{Z_0 + Z_L\, j \tan\frac{\pi}{2}}\right]$$

$$Z_i = \frac{Z_0 \cdot Z_0}{Z_L} = \frac{100 \times 100}{50} = 200$$

Branch (2) $Z_i = 200$

Then for Branch (3)

$$Z_i = \frac{50 \times 50}{100} = 25\Omega \cdot \frac{200 \times 200}{400} = 100\Omega$$

Overall, $Z_i = \frac{Z_0 Z_0}{Z_L} = \frac{50 \times 50}{100} = 25\ \Omega$

51. (b)

$$n = 1 \times 10^{17}$$
$$x_n = 0.1\ \mu m$$
$$x_p = 1.0\ \mu m$$
$$n_i = 1.4 \times 10^{10}\ cm^{-3}$$
$$V_T = 26\ mv$$
$$\varepsilon_r = 12$$
$$\varepsilon_0 = 8.85 \times 10^{-14}\ F-(m)^{-1}$$
$$V_0 = \frac{KT}{q} \ln \left[\frac{N_a N_d}{n_i^2}\right]$$
$$\frac{kT}{q} = V_T$$

We know that

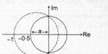
$$x_n N_d = x_p N_a$$
$$N_a = \frac{x_n}{x_p} N_d = \frac{0.1}{1.0} \times 10^{17} = 10^{16}$$
$$V_0 = 26 \times 10^{-3} \ln \left[\frac{10^{16} \times 10^{17}}{(1.4 \times 10^{10})^2}\right] = 0.76\ \text{Volt}$$

52. (b)

$$E = -\frac{q}{\varepsilon} = -\frac{q}{\varepsilon_r \varepsilon_0} = -\frac{1.6 \times 10^{-19}}{8.85 \times 10^{-14} \times 12} \times 1 \times 10^{17} \times 0.1 \times 10^{-6} \times 100 = 0.15\ MV\ cm^{-1}$$

53. (c)

54. (c)



Given $a = 0.5$

$$GM = 20 \log \frac{1}{a} = 20 \log_{10} \frac{10}{0.5} \approx 6\ dB$$

For $PM = 180 - \angle\phi$

$\angle\phi = 90$ from figure

Hence $PM = 180° - 90° = 90°$

55. (c) $\left(\frac{S}{N}\right)_{dB} = 43.5\ dB$

$$\left(\frac{S}{N}\right)_{dB} \approx 1.8 + 6n = 43.5 \qquad m_p = 5$$
$$n = 7$$
$$\Delta = \frac{2m_p}{L} = \frac{2 \times 5}{2^7} = 0.07$$

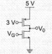
Option (c) is correct

56. (b) $\Delta_1 = 0.05$ V for positive value

$\Delta_2 = 0.1$V for negative value

$$L_1 = \frac{2m_p}{\Delta_1} = \frac{5}{0.05} = 100$$
$$L_2 = \frac{2m_p}{\Delta_2} = \frac{5}{0.1} = 50$$
$$L = L_1 + L_2 = 150 = 2^n$$
$$(SNR)_{dB} = 1.72 + 6.02\,n = 1.72 + 6.02 \times 7 = 43.86\ dB$$

57. (c) The given circuit



In c-MOS circuit p-MOS is connected to supply voltage while n-MOS is connected to ground voltage.

given $V_T = 1V$ for both type MOSFET

For n-MOS

Given $V_{Tn} = 1\ V$

and V_G is small increase in 1 volt

Hence $V_{GS} - V_T \approx 0$

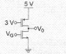
or slightly greates than zero. Then n-MOS is in triode region.

For p-MOS $V_{Gs} = 3 - 5 = -2$ volt

which is more negative to V_{TP}. Hence it is in saturation region.

Hence alternative (c) is the correct choice.

58. (d) Given V_{in} = 1·5 volt



From transistor (1)

$$V_{Tn} = 1\text{V}$$

$$V_{GS} - V_{Tn} = 1{\cdot}5 - 1 = 0{\cdot}5\text{V}$$

Hence the transistor (1) is in saturation.

Then, $$I_D = \mu\, C_{ox}\frac{W}{2L}[V_{GS} - V_{Tn}]^2$$

$$\mu\, C_{ox}\frac{W}{L} = 1\text{ mA}$$

$$I_D = \frac{1}{2}[1{\cdot}5 - 1]^2 = \frac{1}{8}\text{mA}$$

and from transistor (2)

$$I_D = \mu\, C_{ox}\frac{W}{L}\left[(V_{GS} - V_{Tp})\,V_{DS} - \frac{V^2_{DS}}{2}\right]$$

$$\frac{1}{8} = \frac{1}{2}\left[(2-1)\,V_{DS} - \frac{V^2_{DS}}{2}\right]$$

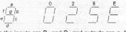
or $$\frac{1}{8} = V^2_{DS} - 4V_{DS} + 1$$

Hence $$V_{DS} = 1 - \frac{\sqrt{3}}{2}$$

$$V_D = 5 - V_{DS}$$

or $$V_D = 5 - 1 + \frac{\sqrt{3}}{2} = 4 + \frac{\sqrt{3}}{2}$$

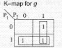
59. (b) The given 7 segment display

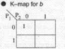


Here the inputs are P_1 and P_2 and outputs are *a, b, c, d, e, f, g*. In order to solve this problem we have to calculate *g* in terms of P_1 and P_2.

Inputs		outputs						
P_1	P_2	*a*	*b*	*c*	*d*	*e*	*f*	*g*
0	0	1	1	1	1	1	1	0
0	1	1	1	0	1	0	1	1
1	0	1	0	1	1	0	1	1
1	1	1	0	0	1	1	1	1

● K–map for *g* ● K–map for *b*

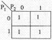




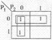
$$g = P_1 + P_2$$

$$b = \overline{P_1}\,\overline{P_2}$$

● K–map for *d* ● K–map for *c*

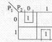


$d = 1$



$c = \overline{P_1}\,\overline{P_2}$

● K–map for *e*



$$e = \overline{P_1}\,\overline{P_2} + \overline{P_1}\,\overline{P_2}$$

Since, $g = P_1 + P_2$,

so either alternative (b) or (d) will be correct

Now, $$c + e = \overline{P_1} + \overline{P_2} + \overline{P_1}\,\overline{P_2} + P_1P_2$$

$$= \overline{P_1} + \overline{P_2}\left(1 + \overline{P_1}\right) + P_1P_2$$

$$= \overline{P_1} + \overline{P_2} + P_1P_2 \qquad (\text{since } 1 + \overline{P_2} = 1)$$

$$= \overline{P_1} + \overline{P_2} + P_1$$

$$(\text{since } A + \overline{A}B = A + B \text{ so, } \overline{P_2} + P_1P_2 = \overline{P_2} + \overline{P_1})$$

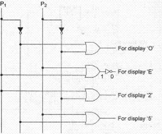
$$= P_1 + \overline{P_1} + \overline{P_2}$$

$$= 1 + \overline{P_2} \qquad (\text{since } P_1 + \overline{P_1} = 1)$$

$$= 1 = d \qquad (\text{since } 1 + \overline{P_2} = 1)$$

Therefore, alternative (b) is the correct choice.

60. (a)



Thus minimum number of 3-NOT gates and 4-OR gates are required to design the logic of the driver.

Hence alternative (a) is the correct choice.