Full Length Test
Electronics and Communication Engineering

Answer Keys and Explanations

1. **[Ans. A]**

$PQRS = I$

$P^{-1}\,PQRSS^{-1} = P^{-1}IS^{-1}$

$QR = P^{-1}S^{-1}$

$Q^{-1}QR = Q^{-1}P^{-1}S^{-1}$

$R = Q^{-1}P^{-1}S^{-1}$

$R^{-1} = (Q^{-1}P^{-1}S^{-1})^{-1}$

$= SPQ$

2. **[Ans. A]**

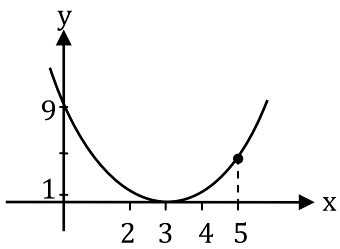
Green's theorem and stokes theorem convert line integral to surface integral and vice versa. Whereas Gauss's Divergence theorem converts from surface to volume and vice versa.

3. **[Ans. *] Range: 5 to 5**

$y = x^2 - 6x + 9 = (x-3)^2$

$y(2) = 1$

$y(5) = 4$



$\therefore$ Maximum value of y over the interval 2 to 5 will be at x = 5

4. **[Ans. A]**

$$\text{Let } S = \sum_{r=0}^{n-1} \frac{1}{\sqrt{4n^2 - r^2}} = \frac{1}{n}\sum_{r=0}^{n-1} \frac{1}{\sqrt{4 - \left(\frac{r}{n}\right)^2}}$$

$$= \int_0^1 \frac{dx}{\sqrt{4 - x^2}}$$

$$= \sin^{-1}\frac{x}{2}\Big|_0^1 = \frac{\pi}{6}$$

5. **[Ans. D]**

Given $(D^2+5D+6)=\sin 2x, y_p=\dfrac{1}{D^2+5D+6}\sin 2x, D^2=-2^2=-4$

$$=\frac{1}{-4+5D+6}\sin 2x=\frac{1}{5D+2}\sin 2x$$

$$=\frac{5D-2}{25D^2-4}\sin 2x=\frac{5\times D(\sin 2x)-2\sin 2x}{25\times -4-4}$$

$$=\frac{10\cos 2x-2\sin 2x}{-104}$$

6. **[Ans. C]**

By K.V.L

$2I_x=2I_x+2I_x+2$

$2I_x=-2A$

$I_x=-1$

$V=2i_x=-2V$

7. **[Ans. *] Range: 0.15 to 0.16**

Bandwidth of series RLC circuit

$B=\dfrac{R}{L}$ rad\sec

$=1$ rad\sec

$B=\dfrac{1}{2\pi}$ Hz

$=0.159$ Hz

8. **[Ans. B]**

$n_1^2=A_0T^3e^{-E_{g_0}/kT}$

$$\frac{n_y}{n_x}=\left(\frac{e^{-\frac{E_{gy}}{kT}}}{e^{-\frac{E_{gx}}{kT}}}\right)^{\frac{1}{2}}$$

$$\Rightarrow \frac{n_i(y)}{n_i(x)}=\frac{e^{-\frac{E_{gy}}{2kT}}}{e^{-\frac{E_{gx}}{2kT}}}=2.9\times 10^{-34}$$

9. **[Ans. C]**

Since, thermal run away is due to minority charge carriers and in FET, the conduction is due to majority carriers, so as temperature increases, mobility decreases and thus no trouble of thermal stability.

10. [Ans. *] Range 155.25 to 156.50

$L = 2.5$ cm

$A = 2 \times 10^{-4}$ cm^2

$N_D = 10^{17}\text{cm}^{-3}$ and $N_A = 9.0 \times 10^{16}\text{cm}^{-3}$

$$R = \rho \frac{L}{A}$$

$$\text{where } \rho = \frac{1}{qN'_D\mu_n}(N'_D = N_D - N_A = 10^{16})$$

$$= 1.25\Omega\text{-cm}$$

$\therefore R = 156.25\Omega$

11. [Ans. *] Range: 0.008 to 0.01

Open loop gain $= 1000 \pm 10$

A dA

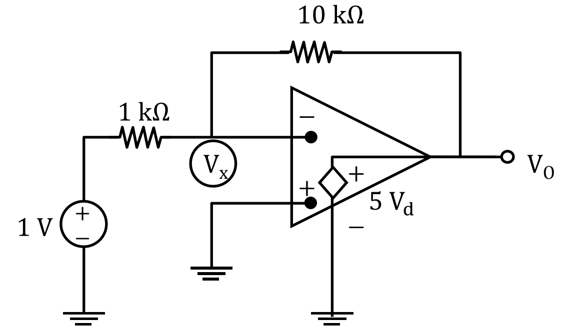
$$0.1\% = \frac{dA_f}{A_f} = \frac{0.1}{100}$$

$$\frac{dA_f}{A_f} = \frac{dA}{A}\left(\frac{1}{1 + A\beta}\right)$$

$$\Rightarrow \frac{0.1}{100} = \frac{10}{1000}\left(\frac{1}{1 + 1000\beta}\right)$$

$$\therefore \beta = \frac{0.9}{100} = 0.009$$

12. [Ans. *] Range: −3.2 to −3.1



Using KCL

$$\frac{V_x - 1}{1k} + \frac{V_x - V_O}{10k} = 0$$

$$\Rightarrow \frac{10V_x - 10 + V_x - V_O}{10k} = 0$$

$$\Rightarrow 11V_x = V_O + 10$$

$$\Rightarrow V_x = \frac{V_O + 10}{11}$$

$$0 - V_x = V_d$$

$$V_d = -V_x = -\left[\frac{V_O + 10}{11}\right]$$

$$V_O = 5\,V_d$$

$$V_O = -5\left[\frac{V_O + 10}{11}\right]$$

$$11V_O = -5V_O - 50 \Rightarrow V_O = -\frac{50}{16}V$$

$$V_O = -3.125V$$

13. [Ans. *] Range: 5.5 to 5.8

$$A_v = -\frac{\mu R_d}{R_D + r_d} \qquad \omega_H = \frac{1}{C_M R_S}$$

Where ,$C_M = C_{gs} + C_{gd}(1 + g_m R_L)$ and

$R = R_s$ and $R_L = r_d || R_d$

$$A_V = \frac{-2 \times 20 \times 20}{20 + 20} = -20$$

$$R_L = 10k$$

$$C_M = 8 + 4(1 + 2 \times 10) = 92pF$$

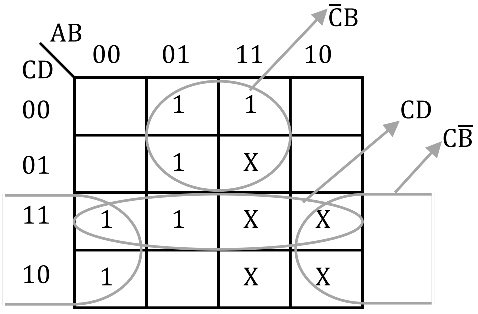
$$R_s = 0.3\ k\Omega$$

$$C_M R_s = 92 \times 0.3 = 27.6 \times 10^{-9}\ sec$$

$$\omega_H = \frac{10^9}{27.6}$$

$$\therefore f_M = \frac{\omega_H}{2\pi} = 5.77\ MHz$$

14. [Ans. D]



$\therefore$ Minimised form is $\bar{C}B + CD + C\bar{B}$

15. [Ans. D]

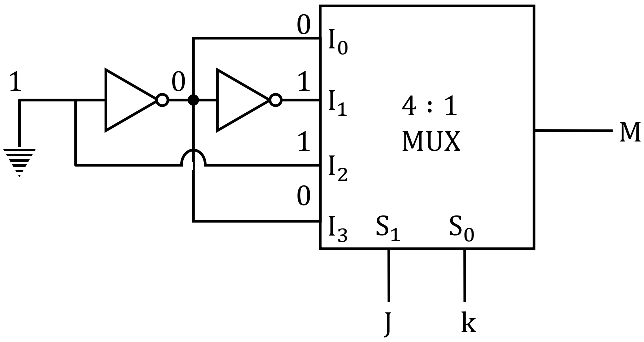
If $x = 1$

	X	y_{in}	y_{out}
$1^{st} \rightarrow$	1	0	0
$2^{nd} \rightarrow$	1	0	0
$3^{rd} \rightarrow$	1	0	0
⋮	⋮	⋮	⋮
15^{th}	1	0	0

$\therefore$ If $X = 1, y_{out} = 0$

And If $X = 0, y_{out} = 1$ after 15^{th} clock $= \bar{X}$

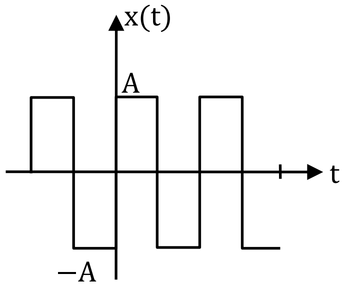
16. [Ans. D]



$M = J \oplus K$

$= XOR (J, K)$

17. [Ans. B]



Since the wave has odd symmetry, hence $a_n = 0$

18. [Ans. A]

$h(n) = \frac{1}{2}[\delta(n) + \delta(n-2)]$

$H(z) = \frac{1}{2}[1 + z^{-2}]$

Put $z = e^{j\Omega}$

$H(e^{j\Omega}) = \frac{1}{2}[1 + e^{-2j\Omega}]$

$= \frac{1}{2}e^{-j\Omega}[e^{j\Omega} + e^{-j\Omega}]$

$\Rightarrow H(e^{j\Omega}) = e^{-j\Omega}\cos\Omega$

$\therefore |H(e^{j\Omega})| = |e^{-j\Omega}||\cos\Omega|$

$= |\cos\Omega|$

19. [Ans. *] Range: 6 to 6

$y(t) = x(3t) + x(t) + x(0.5t)$

If x(t) is band limited to 'f'Hz. Then, x(3t) is band limited to '3f' Hz.

$\therefore$ Nyquist rate $= 2 \times 3f = 6f$

$\therefore a = 6$

20. [Ans. C]

Maximum occurs at $\frac{n\pi}{\omega_d}$ where, n is odd

Hence first maximum occurs at $\frac{\pi}{\omega_d}$

$= \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$

$s^2 + 6s + 25 = s^3 + 2\xi\omega_n s + \omega_n^2$

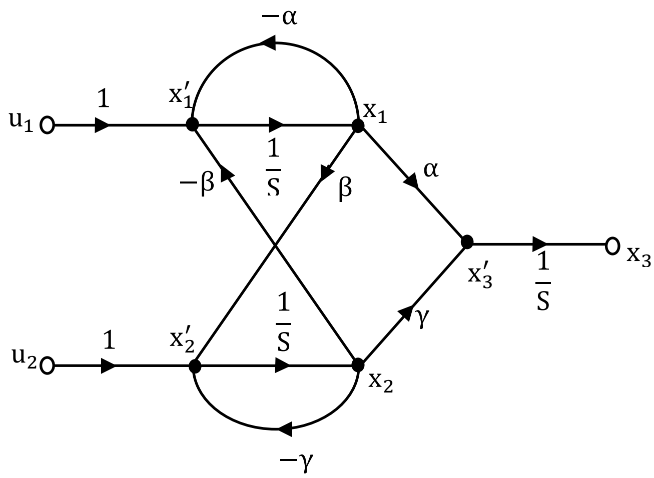
Comparing, $\omega_n = 5$ and $\xi = \frac{6}{2\omega_n} = 0.6$

$\omega_n = 5$

$= \frac{\pi}{5\sqrt{1-0.36}}$

$= \frac{\pi}{4}$

21. [Ans. D]



$\dot{x}_1 = -\alpha x_1 - \beta x_2 + u_1$

$\dot{x}_2 = \beta x_1 - \gamma x_2 + u_2$

$\dot{x}_3 = \alpha x_1 + \gamma x_2$

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

One can denote any state by any name; changing $x_1 \to x_3, x_2 \to x_1$ and $x_3 \to x_2$

So, that answer is

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

22. [Ans. *] Range: 43.91 to 44

$$\text{SQNR} = 10\log\frac{(V_{rms})^2}{s^2/12}\,\text{dB}$$

$$= 10\log 12 + 20\log\frac{V_{rms}}{s}$$

$$V_{rms} = \frac{1}{2\sqrt{2}}$$

$$\text{SQNR} = 10.8 + 20\log\frac{\frac{1}{2\sqrt{2}}}{\frac{1}{2^7}}$$

$$= 43.913\text{ dB}$$

23. [Ans. *] Range: 2 to 2

$A_C \cos\omega_c t + 2\cos\omega_m t \times \cos\omega_c t$

$A_C \cos\omega_c t\left[1 + \frac{2}{A_C}\cos\omega_m t\right]$

For envelope detection $\mu < 1 \Rightarrow \frac{2}{A_C} < 1 \Rightarrow A_C$ Should be atleast 2

24. **[Ans. A]**

$\nabla \cdot \overline{D} = e^{-x}\cos y + e^{-x}\sin y + 0$

$(\nabla \cdot \overline{D})$ at $(0,0,0)$is $= 1\ C/m^3$

$\therefore$ Charge enclosed $= (1 \times 10^{-6})\ C = 1\ \mu C$

25. **[Ans. *] Range: 9 to 9**

$\overline{E} = 20\cos(9\pi \times 10^8 t - \beta x)\hat{a}y$

Velocity of EM wave in a los-less medium

$\beta = \dfrac{\omega}{V_p} \qquad V_p = \dfrac{C}{\sqrt{\mu_r \varepsilon_r}}$

$= \dfrac{9\pi \times 10^8}{10^8} \qquad = \dfrac{3 \times 10^8}{\sqrt{1 \times 9}}$

$[\beta = 9\pi] \qquad V_p = 10^8 m/sec$

26. **[Ans. D]**

$x^2 - x + I = 0$, Multiplying both sides by x^{-1}

$x - I + x^{-1} = 0$

$$\therefore x^{-1} = I - x = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} b^2 & 1 \\ (b^2 + b - 1) & (1 - b) \end{bmatrix} = \begin{bmatrix} (1 - b^2) & -1 \\ (1 - b - b^2) & b \end{bmatrix}$$

27. **[Ans. D]**

Given that $a > 0$

So, $I_o\ a^{f(x)} > 0$

And also $g(x) > \dfrac{1}{2}$

So $a^{f(x)} + g(x) > \dfrac{1}{2}$ for all $x \epsilon R$,

$\therefore a^{f(x)} + g(x) = 0$ Has no solution

28. **[Ans. A]**

$z^2 e^{-z} \Rightarrow (x + iy)^2 e^{-(x+iy)}$

$(x^2 - y^2 + 2xy)(e^{-x})(\cos y - i\sin y)$

$(e^{-x})[(x^2 - y^2)\cos y + 2xy\sin y]$

29. **[Ans. C]**

For TE_{10} mode, $f_c = \frac{u^1}{2a}$. Since the wave guide is air filled; $u' = c = 3 \times 10^8$

Hence, $f_c = \frac{3 \times 10^8}{2 \times 5 \times 10^{-2}} = 3 \times 10^9 \text{ Hz} = 3 \text{ GHz}$

As $f = 4 \text{ GHz} > f_c$, the TE_{10} mode will propagated

$$V_p = \frac{u'\varepsilon}{\sqrt{1 - \left(\frac{f_c}{f}\right)^2}} = \frac{3 \times 10^8}{\sqrt{1 - \left(\frac{3}{4}\right)^2}} = 4.54 \times 10^8 \text{m/s}$$

$$V_g = \frac{u'^2}{V_p} = \frac{(3 \times 10^8)^2}{4.54 \times 10^8} = 1.98 \times 10^8 \text{ m/s}$$

V_p = phase velocity

V_g = group velocity

30. **[Ans.*] Range: 4 to 4**

$$\text{Current at node} = \frac{e^{-2t}(\sin t + \cos t)}{1/2} + 1 \cdot \frac{d}{dt} e^{-2t}(\sin t + \cos t)$$

$$= e^{-2t}(\cos t - \sin t)$$

$$V_L = L\frac{di}{dt} = 1\frac{d}{dt}\{e^{-2t}(\cos t - \sin t)\}$$

$$= e^{-2t} \sin t - 3e^{-2t} \cos t$$

$\therefore k_1 = 1;\ k_2 = -3 \therefore k_1 - k_2 = 4$

31. **[Ans. *] Range: 24 to 24**

By KCL at output node

$I_x + I_2 = 2I_x$

$I_2 = I_x$

$V_x = 4I_2 + V_2$ ……….. ①

$\frac{V_1 - V_x}{4} = \frac{V_x}{4} + I_2$ ……….. ②

$V_1 - V_x = V_x + 4I_2$

So,

$V_1 = 2V_x + 4I_2$

$V_1 = 2(4I_2 + V_2) + 4I_2$

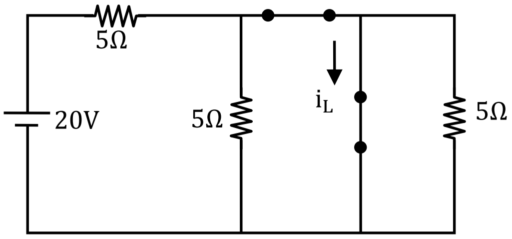
$= 8I_2 + 4I_2 + 2V_2$

$V_1 = 2V_2 + 12I_2$

$S = 2, \quad M = 12$

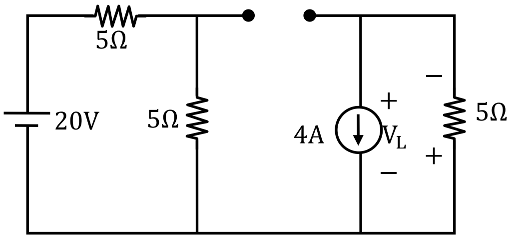
$M \times S = 24$

32. [Ans. *] Range: -20 to -20



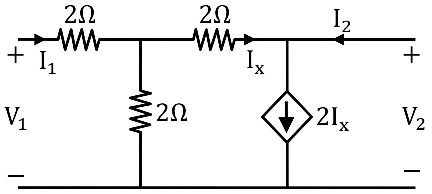
$$i_L(0^-) = i_L(0^+) = \frac{20}{5} = 4A$$

At $t = 0^+$



$$V_L(0^+) = -5 \times 4 = -20V$$

33. [Ans. B]



$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0}$$

Means $I_x = I_2 = 0$

$V_2 = 2I_1$

$V_1 = 4I_1$

$$\boxed{A = \frac{V_1}{V_2} = 2}$$

$$C = \left.\frac{I_1}{V_2}\right|_{I_2=0}$$

$V_2 = 2I_1$

$$\frac{I_1}{V_2} = \frac{1}{2} = 0.5℧$$

34. [Ans. B]

Effective density of states Function $(N_c) = 2.8 \times 10^{19}\ \text{cm}^{-3}$

Therefore, the electron conduction is given by

$$n_o = N_c \exp\left[-\frac{E_C - E_F}{kT}\right]$$
$$= 2.8 \times 10^{19} \times \exp\left(\frac{-0.25}{0.0259}\right)$$
$$= 1.8 \times 10^{15}\text{cm}^{-3}$$

35. [Ans. *] Range: 13 to 13

$$\frac{D_P}{\mu_P} = V_T \Rightarrow D_p = \mu_P V_T$$
$$= 500\frac{\text{cm}^2}{\text{V sec}} \times 26 \times 10^{-3}\text{V}$$
$$= 13\ \text{cm}^2/\text{sec}$$

So, diffusion length of holes,

$$L_P = \sqrt{D_P \tau}$$
$$= \sqrt{13 \times 10^{-4} \times 130 \times 10^{-9}}\ \text{cm}$$
$$= 13\ \mu\text{m}$$

36. [Ans. A]

Case I: CB configuration

$\alpha =$ Emitter injection efficiency $\times$ Base transport factor

$= 0.98 \times 0.99 = 0.97,$ input current $I_E = 20\mu A$

$I_{CBO} = 100\ \text{nA}$

$$I_C = \alpha\, I_E + I_{CBO} = 1.94 \times 10^{-5} + 100 \times 10^{-9}$$
$$= 1.95 \times 10^{-5}$$

Case II: CE configuration

$$\therefore \beta = \frac{\alpha}{1-\alpha} = \frac{0.97}{1-0.97} \approx 32.3\ 32$$

$T \uparrow = 400\text{K}$

$$\frac{T_1 - T_2}{10} = 100 \times 10^{-9} \times 2^{\left(\frac{100}{10}\right)}$$

$I_{CBO2} = I_{CBO1}$

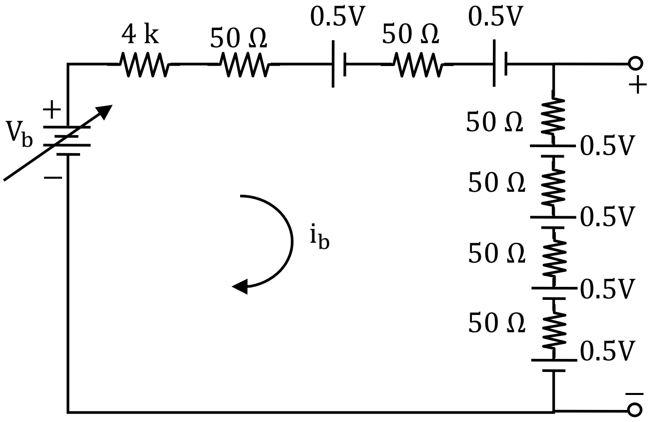
$I_{CBO2} = 1.024 \times 10^{-4}\text{A}$

$\therefore I_{CEO} = (1+B)I_{CBO2} = 3.41 \times 10^{-3}\ \text{mA}$

$$I_C = \beta I_B + I_{CEO}$$
$$= 32.33 \times 1 \times 10^{-6} + 3.41 \times 10^{-3}$$
$$= 3.41 \times 10^{-3}$$

$$\frac{(I_C)_{CE}}{(I_C)_{CB}} = \frac{3.41 \times 10^{-3}}{1.95 \times 10^{-5}} \approx 174.8$$

37. [Ans. *]Range 4.50 to 5.00



$i_b = \frac{V_b - 3}{4.3k}$

and $V_0 = i_b \times 200 + 2$

$V_0 = \left(\frac{V_b - 3}{4.3k}\right) \times 200 + 2$

for $V_{b1} = 4\text{ V}$

$V_{01} = \frac{1}{4.3} \times 0.2 + 2$

$V_{01} = 2.046\text{ V}$

and for $V_{b2} = 6\text{ V}$

$V_{02} = \frac{6 - 3}{4.3} \times 0.2 + 2$

$V_{02} = 2.139\text{ V}$

$\text{Regulation} = \frac{V_{02} - V_{01}}{V_{01}} \times 100\%$

$\text{Regulation} = 4.545\%$

38. [Ans. *] Range: 2.5 to 3.0

For $V_0 = 0V$ current through the 3kΩ resistance connected in the collector terminal of pnp transistor is

$$\frac{0V - (-6V)}{3k\Omega} = 2\ mA$$

Therefore, emitter potential of the pnp transistor

$$V_{Epnp} = 6V - \text{Voltage drop across } 1.5\ k\Omega \text{ Resistor}$$
$$= 6V - 2mA \times 1.5\ k\Omega$$
$$= 3V$$

$$V_{B_{pnp}} = V_{E_{pnp}} - 0.6V = 3V - 0.6V = 2.4V$$

current through 1.8kΩ resistor

$$\frac{6V - V_{B_{pnp}}}{1.8k\Omega} = \frac{6V - 2.4V}{1.8k\Omega} = 2mA$$

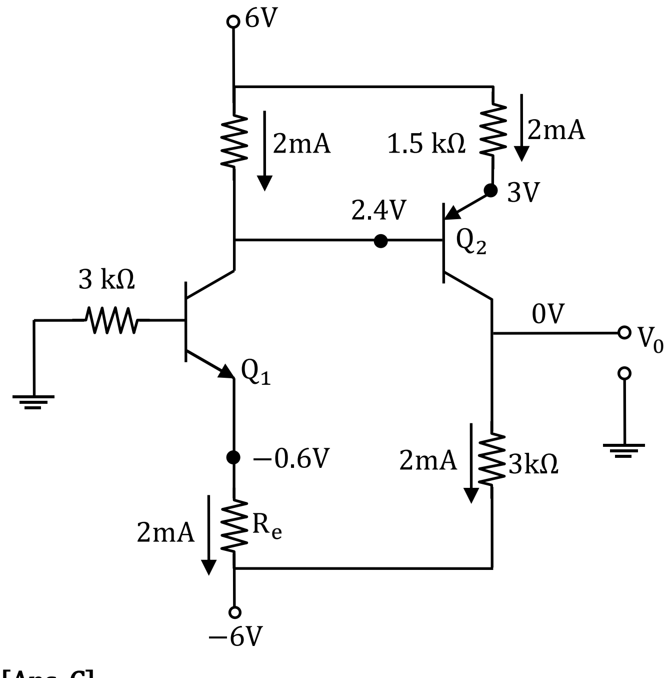
Now for $V_S = 0V$ Base of npn transistor is grounded i.e at 0V

Therefore $V_{E_{npn}} = 0V - 0.6V = -0.6V$

Voltage drop across $R_e = -0.6V - (-6V) = 5.4V$

Current through $R_e = 2mA$

$$\therefore \text{Required value of } R_e = \frac{5.4V}{2mA} = 2.7k\Omega$$



39. [Ans. C]

$$f_0 = \frac{1}{2\pi\sqrt{R_1C_1R_2C_2}} \quad \text{or} \quad R_1 = R_2 = R; C_1 = C_2 = C$$
$$= \frac{1}{2\pi\ RC}$$
$$= \frac{1}{2\pi(51 \times 10^3)(0.001 \times 10^{-6})}$$
$$= 3120.7\ Hz$$

40. [Ans. *]Range: 3.7 to 4

For proper functioning the clock period should be equal to or greater than all t_{pd}'s

MOD – 12 ⇒ 4 FF's

$\therefore 4 \times 60 = 240$ ns

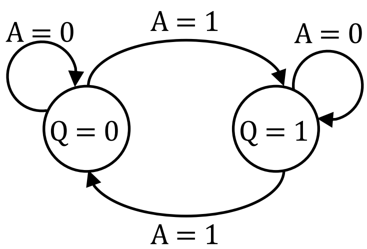
t_{pd} of NAND = 25 ns

$\therefore$ Total $t_{pd} = 265$ ns

$$\therefore f_e = \frac{1}{265}\text{Hz} = 3.774\ \text{MHz}$$

41. [Ans. *] Range: 1 to 1

A	Q	X_1	X_0	Y	J	K	Q^+
0	0	1	0	0	0	1	0
0	1	0	1	1	1	0	1
1	0	1	1	1	1	0	1
1	1	0	1	0	0	1	0



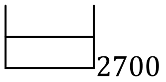
State changes when A = 1

42. [Ans. B]

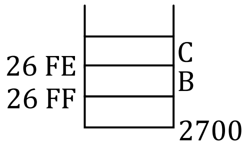
LXI B, 2100 H $B \leftarrow 21$
$C \leftarrow 00$

LXI D, 0200 H $D \leftarrow 02$
$E \leftarrow 00$

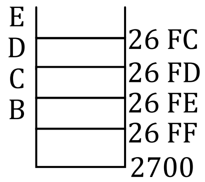
LXI SP, 2700



PUSH B



PUSH D



LXI H, 0100 $H \leftarrow 01$
$L \leftarrow 00$

XTHL $H \leftarrow 02$
$L \leftarrow 00$

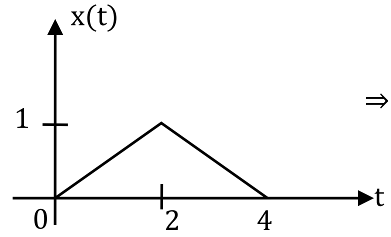
DAD D

$$\begin{array}{rcc} & 02 & 00 \\ + & 02 & 00 \\ \hline & 04 & 00 \\ & \uparrow & \uparrow \\ & H & L \end{array}$$

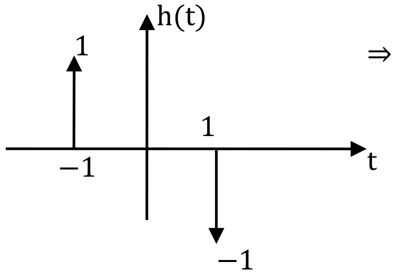
HLT

D,E pair remains unchanged

43. [Ans. B]



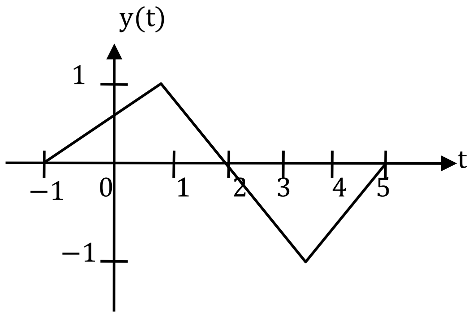
$$\Rightarrow x(n) = \left\{\underset{\uparrow}{0}, \frac{1}{2}, 1, \frac{1}{2}, 0\right\}$$



$$\Rightarrow h(n) = \{1, \underset{\uparrow}{0}, -1\}$$

h(n) \ x(n)	0	1/2	1	1/2	0
1	0	1/2	1	1/2	0
→ 0	0	0	0	0	0
−1	0	−1/2	−1	−1/2	0

$$y(n) = \left\{0, \underset{\uparrow}{\frac{1}{2}}, 1, 0, -1, -\frac{1}{2}, 0\right\} \Rightarrow$$



$$\therefore \int_{-\infty}^{\infty} y(t)dt = 0 \text{ (from the figure)}$$

44. [Ans. *] Range: 7.9 to 8.1

To solve this problem we could compute the analytical expression for the inverse Z-T , and then we could evaluate that expression at k=3. An alternative method to recall that

$F(z) = f[0] + f[1]z^{-1} + f[2]z^{-2} + f[3]z^{-3} + f[4]z^{-4} + \cdots \ldots \ldots$

i.e., f[k] can be computed by expanding the fraction in power of z^{-1}. This can be done by dividing n(z) by d(z) upto the term z^{-3}, its coefficient is equal to f[3]

$$z^7 + 2z^6 + z^5 + z^4 + 0.5) \quad 2z^6 - z^5 + 3z^3 + 2z^2 \quad (2z^{-1} - 5z^{-2} + 8z^{-3}$$

$$2z^6 + 4z^5 + 2z^4 + 2z^3 + z^{-1}$$

$$-5z^5 - 2z^4 + z^3 + 2z^2 - z^{-1}$$

$$-5z^5 - 10z^4 - 5z^3 - 5z^2 - 2.5z^{-2}$$

$$8z^4 + 6z^3 + 7z^2 - z^{-1} + 2.5z^{-2}$$

$$8z^4$$

So, coefficient is 8

45. [Ans. C]

By stokes theorem, $I = \iint_s (\nabla \times \vec{F})\, d\vec{s} = \oint_c \vec{F} \cdot d\vec{R}$

$$\nabla \times F = \begin{vmatrix} i & j & k \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ 3y & -xz & yz^2 \end{vmatrix}$$

$$= i(z^2 + x) + k(-z - 3)$$

$$= \iint [i(z^2 + x) + k(-z - 3)]\, k = -(z + 3)$$

$$= -\iint (z + 3) ds$$

$$= -(z + 3) \iint ds$$

$$= -5 \times \pi \times z^2 = -20\pi$$

46. [Ans. D]

$$\dot{x}_1 = -3x_1 + x_2 + (4 - 3(1))u$$

$$\dot{x}_2 = -2x_1 + x_3 + (6 - 2(1))u$$

$$\dot{x}_3 = -x_1 + (2 - 1(1))u$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -3 & 1 & 0 \\ -2 & 0 & 1 \\ -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 4 \\ 1 \end{bmatrix} [u], y = x_1$$

47. [Ans. *] Range: 30 to 30

Standard form of Phase Lead Compensator $G_C(s) = \dfrac{1 + T_1 s}{1 + \alpha T_1 s}$

Or, $T_1 = 3T$ ……… ①

$\alpha T_1 = T$ ……… ②

by comparing equation ① and ②

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

$$\therefore \phi_{max} = \sin^{-1}\left[\frac{1 - \alpha}{1 + \alpha}\right]$$

$$= \sin^{-1}\left[\frac{1 - \frac{1}{3}}{1 + \frac{1}{3}}\right]$$

$$= \frac{\pi}{6} \text{rad} = 30°$$

48. [Ans. D]

For stable system $|sI - A| = 0$ should have roots in left half s – plane.

$$|sI - A| = \begin{vmatrix} s-x & 0 & 0 \\ 0 & s-y & -1 \\ 0 & 1 & s+2 \end{vmatrix} = (s-x)[(s-y)(s+2)+1]$$

$$= (s-x)[s^2 + s(2-y) + 1 - 2y]$$

The roots to lie in left hand plane,

$x < 0$

$2 - y > 0$

And $1 - 2y > 0$

$\therefore y < 2$ and $y < \frac{1}{2}$

$\therefore x < 0$

$y < 1/2$

49. [Ans. D]

For a single tone SSB-SC signal the waveform after carrier reinsertion becomes

$$s'(t) = s(t) + c(L) = \cos(\omega_c t + \omega_m t) + A\cos\omega_c t$$

$$= (A + \cos\omega_m t)\cos\omega_c t - \sin\omega_c t \sin\omega_m t$$

The output of the demodulation is given by [the envelope will be]

$$V(t) = \sqrt{[A + \cos\omega_m t]^2 + [\sin\omega_m t]^2}$$

$$= \sqrt{A^2 + 1 + 2A\cos\omega_m t}$$

$$= \sqrt{A^2+1}\left[1 + \frac{2A}{1+A^2}\cos\omega_m t\right]^{1/2}$$

$$= \sqrt{A^2+1}\left[1 + \frac{A}{A^2+1}\cos\omega_m t\right] \text{ [Binomial expansion]}$$

$$= \sqrt{A^2+1} + \frac{A}{\sqrt{A^2+1}}\cos\omega_m t$$

Neglecting d.c component the normalized power of detected signal will be

$$P_d = \frac{1}{2}\left[\frac{A^2}{A^2+1}\right]$$

Given, $P_d = 90\% \times 0.5$

$$\frac{1}{2}\left[\frac{A^2}{A^2+1}\right] = 90\% \times 0.5$$

$$\Rightarrow \frac{A^2}{1+A^2} = 0.9$$

$\Rightarrow A = 3$

50. [Ans. A]

$X_C(t) = A[1 + x(t)]\text{Cos}\,\omega_C t$

$S_X = E[x^2(t)] = \int_{-\infty}^{\infty} x^2 f_x(x)dx = 2\int_0^t x^2(-x+1)dx = \frac{1}{6}$

For m=1,

$\left(\frac{S}{N}\right)_0 = \frac{S_x}{1+S_x}\left(\frac{S}{N}\right)_{input}$

$= \frac{\frac{1}{6}}{1+\frac{1}{6}}\left(\frac{S}{N}\right)_{input} = \frac{1}{7}\left(\frac{S}{N}\right)_{in}$

$\therefore \frac{1}{7}\left(\frac{S}{N}\right)_{input} \geq 10^4$

$\Rightarrow \left(\frac{S}{N}\right)_{input} \geq 7\times 10^4$

$\Rightarrow \frac{A^2\left(1+\frac{1}{6}\right)}{4(10^{-12})4(10^3)} \geq 7\times 10^4$

$\Rightarrow A \geq 31\times 10^{-3}$ V

=31 mV

51. [Ans. *] Range: 247 to 247

Let the image frequency rejection ratio of the RF amplifier to be added be α'

The rejection ratio (α) at 1100 kHz:

$f_{si} = f_s + 2f_{if} = 1100 + 2\times 455 = 2010$ kHz

$\therefore \rho = \frac{f_{si}}{f_s} - \frac{f_s}{f_{si}} = \frac{2010}{1100} - \frac{1100}{2010} = 1.28$

$\therefore \alpha = \sqrt{1+\rho^2 Q^2} = \sqrt{1+(1.28)^2(100)^2} = 128$

The rejection ratio (α) at 25 MHz:

$f_{si} = 25000 + 2\times 455 = 25910$ kHz

$\therefore \rho = \frac{f_{si}}{f_s} - \frac{f_s}{f_{si}} = \frac{25910}{25000} - \frac{25000}{25910} = 0.0715$

$\therefore \alpha = \sqrt{1+\rho^2 Q^2} = \sqrt{1+(0.0715)^2(100)^2} = 7.22$

According to requirement

$(\alpha)_{25MHz} \times \alpha' = (\alpha)_{1100kHz}$

$\Rightarrow \alpha' = \frac{128}{7.22} = 17.72$

$\therefore$ So, loaded Q' required for the RF stage

$\alpha' = \sqrt{1+(Q')^2\rho^2}$

$\Rightarrow 17.72 = \sqrt{1+(Q')^2(0.0715)^2}$

$\Rightarrow Q' = 247$

52. [Ans. C]

BW of voice signal $= 3500 - 300 = 3200$ Hz

The number of quantizing levels $= 128 = 2^7$

$\therefore$ Number of bits required for sampling + supervision $= 7 + 1 = 8$

$\therefore$ Number of the bits in each frame $= 32 \times 8 + \underset{\uparrow \text{ For synchronization}}{1} = 257$

$\therefore$ Required BW $= \dfrac{3200 \times 2 \times 257}{2} = 822.4$ kHz

53. [Ans. *] Range: 240 to 240

$\overline{E}(x,t) = 60\cos(\omega t - 2x)$

Average power density $= \dfrac{E^2}{2\eta} = \dfrac{(60)(60)}{2(120\pi)}$

$$\text{Average power} = \frac{E^2}{2\eta}\pi r^2$$
$$= \frac{60(60)}{2(120\pi)}\pi(4)^2$$
$$= 240 \text{ watts}$$

54. [Ans. D]

Airline can be regarded as a loss less line

$\therefore\ \alpha = 0, R = 0 = G$

$$Z_O = R_O = \sqrt{\frac{L}{C}} = 70\Omega \quad \ldots (1)$$

$$\beta = \omega\sqrt{LC} = 3 \text{ rad/m} \quad \ldots (2)$$

Dividing by equation (1) and (2)

$$\frac{R_O}{\beta} = \frac{1}{\omega C}$$

$$C = \frac{\beta}{\omega R_O} = \frac{3}{2\pi \times 100 \times 10^6 (70)} = 68.2 \text{ pF/m}$$

From equation (1)

$$L = R_O^2 C = (70)^2(682 \times 10^{-12})$$
$$= 334.2 \text{ nH/m}$$

55. [Ans. *] Range: 8.81 to 8.86

$E = -\frac{dv}{dx} = -\frac{d}{dx}(10^5 x) = -10^5 V/m$

$\text{Energy density} = \frac{\text{Enegry}}{\text{volume}} = \frac{1}{2} \epsilon_0 \, E^2$

$\frac{\text{Energy}}{\text{volume}} = \frac{1}{2} \times \frac{1}{36\pi} \times 10^{-9} \times (-10^5)^2$

$\text{Energy} = \frac{1}{2} \times \frac{1}{36\pi} \times 10^{-9} \times (-10^5)^2 \, [Ad]$

$= \frac{1}{2} \times \frac{1}{36\pi} \times 10^{-9} \times 10^{10} [100 \times 0.2 \times 10^{-2}]$

$= 8.84 mJ = 8.84 \times 10^{-3} J$

56. [Ans. D]

They will chime together after the time in minutes equal to LCM of 18, 24, 32.

$18 = 2 \times 3 \times 3$

$24 = 2 \times 2 \times 2 \times 3$

$32 = 2 \times 2 \times 2 \times 2 \times 2$

$\therefore$ LCM $= 2 \times 2 \times 2 \times 3 \times 3 \times 2 \times 2 = 288$

288 min = 4 hrs 48 min.

57. [Ans. C]

According to the statement, 80% of the total runs were made by spinners. So, conclusion I does not follow. Nothing about the opening batsmen is mentioned in the statement. So, conclusion II also does not follow

58. [Ans. D]

1 km = 1000 meter

1 min = 60 second

$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$

Total distance = 12 km = 12000 meter

Total time = 6 + 6 +12 minute = 24 × 60 = 1440 seconds

$\text{Average speed} = \frac{12000}{1440} = 8.33 \, m/s$

59. [Ans. A]

60. [Ans. C]

CEPQS - E cannot go with S.

AEPQS - C and P have to be together. E cannot go with S.

ACPRS -It satisfies all the conditions and also there are two boys in the team.

BDPRS - C and P have to be together.

Hence, C

61. [Ans. A]

Number of males in U.P $= \left[\frac{3}{5} \text{ of } (15\% \text{ of N})\right] = \frac{3}{5} \times \frac{15}{100} \times N = \frac{9N}{100}$

Total population, N $= 3276000$

Number of males in M.P $= \left[\frac{3}{4} \text{ of } (20\% \text{ of N})\right] = \frac{3}{4} \times \frac{20}{100} \times N = \frac{15N}{100}$

Number of males in Goa $\left[\frac{3}{8} \text{ of } (12\% \text{ of N})\right] = \frac{3}{8} \times \frac{12}{100} \times N = \frac{4.5N}{100}$

Total males in these 3 states $= \frac{(9 + 15 + 4.5)N}{100} = \frac{28.5N}{100}$

Required % $= \left(\frac{28.5 \times \frac{N}{100} \times 100}{N}\right)\% = 28.5\%$

62. [Ans. C]

A cube is cut into 125 smaller cubes.

∴ Length of cube $= \sqrt[3]{125}$

∴ $l = 5$ unit

Let upper face be coloured red.

Then bottom face will be coloured green, two adjacent faces are coloured yellow and blue respectively.

Two faces are uncoloured.

Number of cubes uncoloured on all faces $= (n - 2)^3 = (5 - 2)^3 = 27$

Now there are two surfaces which are not coloured.

∴ There will be 9 cubes at centre on both the uncoloured surfaces each.

3 cubes at the common edge of both uncoloured surfaces.

∴ Total number of uncoloured cubes $= 27 + 9 + 9 + 3 = 48$

63. [Ans. C]

64. [Ans. B]

The passage clearly states the unawareness of teachers regarding population education. Thus, the teachers should be given a proper orientation on the same.

65. [Ans. C]

In statement I nothing is given about c. Hence it is not enough to answer the question.

In statement II nothing is mentioned about a. Hence this statement alone cannot answer the question.

Combining both the statements we get

$a : b : c = 3 : 15 : 10$

$\therefore\ a : c = 3 : 10$

$$\frac{a}{c} = \frac{3}{10}$$

$$\frac{a + c}{c} = \frac{3 + 10}{10} = \frac{13}{10}$$

$\therefore$ Question can be answered using both the statements.

Hence, C.