



# ACE

## Engineering Academy

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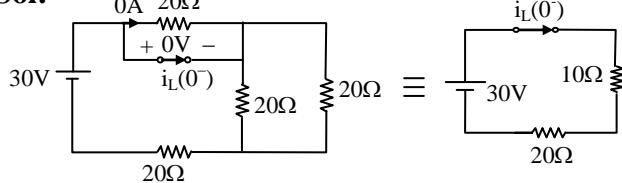
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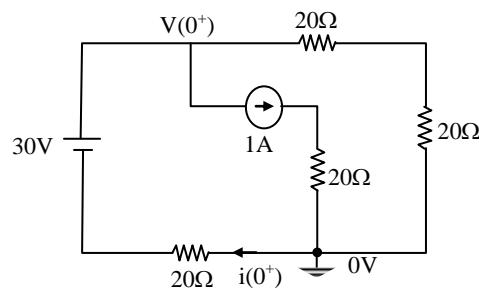
### Branch: Electronics & Communication Engineering - SOLUTIONS

**01. Ans: (C)**

**Sol:**



$$\text{So, } i_L(0^-) = \frac{30}{30} = 1\text{A} = i_L(0^+)$$



$$\text{Nodal: } \frac{V_L(0^+) - 30}{20} + 1 + \frac{V_L(0^+)}{40}$$

$$= 0 \Rightarrow V_L(0^+) = \frac{20}{3} \text{V}$$

$$\text{So, } i(0^+) = \frac{30 - V_L(0^+)}{20} = \frac{7}{6} \text{A}$$

**02. Ans: - 3.33 (Range -3 to -4)**

**Sol:**  $A_V \approx -g_m R_D$

$$g_m = \sqrt{2I_D \mu_n C_{ox} \left(\frac{W}{L}\right)} = \frac{1}{300}$$

$$A_V = -3.33$$

**03. Ans: 4**

$$\text{Sol: } G(s) = \frac{\left(1 + \frac{s}{2}\right)2}{\left(1 + \frac{s}{8}\right)8} = \left(\frac{1}{4}\right) \frac{\left(1 + \frac{s}{2}\right)}{\left(1 + \frac{s}{8}\right)}$$

$$\text{But } G(s) = \frac{1+s\tau}{1+\alpha s\tau}$$

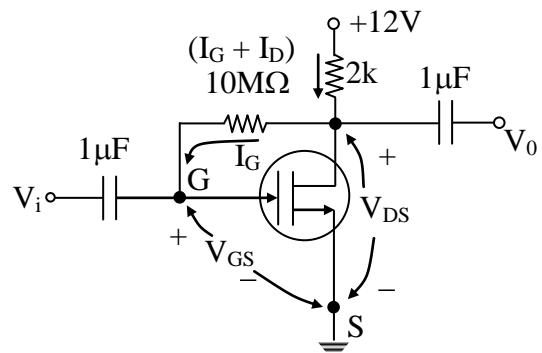
$$\text{By comparing } \tau = \frac{1}{2}$$

$$\alpha\tau = \frac{1}{8} \Rightarrow \alpha = \frac{1}{4}$$

$$\omega_m = \frac{1}{\tau\sqrt{\alpha}} = \frac{1}{\frac{1}{2}\sqrt{\frac{1}{4}}} = 4 \text{ rad/sec}$$

**04. Ans: (a)**

**Sol:**



$$\text{Step (1): Consider } k = \frac{I_{D(ON)}}{[V_{GS(ON)} - V_{Th}]^2}$$



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$$= \frac{6\text{mA}}{(8V - 3V)^2} = 0.24\text{mA/V}^2 \quad (1)$$

$$\text{Step (2): } I_D = k(V_{GS} - V_{Th})^2 \quad (2)$$

$$= (0.24\text{mA/V}^2)[6.4V - 3V]^2 \quad (3)$$

$$\therefore I_{DQ} = 2.7744\text{mA} \quad (4)$$

Step (3): KVL for output section

$$V_{DS} = 12V - (I_D + I_G)2k = 0 \quad (5)$$

$$= 12V - I_D \times 2k \quad (6) \quad (\because I_G = 0)$$

$$\therefore V_{DSQ} = 6.45\text{ V} \quad (7)$$

**05. Ans: (a)**

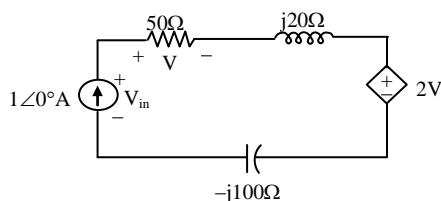
**Sol:** Dynamic power dissipation

$$P_{\text{Dynamic}} = fCV_{DD}^2 = 10^8(100 \times 10^{-15}) \times (1.8)^2 = 32.4\mu\text{W}$$

**06. Ans: 170 (range: 169 to 171)**

**Sol:**  $2\text{mH} \rightarrow j\omega L = j(10 \times 10^3)(2 \times 10^{-3}) = j20$

$$1\mu\text{F} \rightarrow \frac{1}{j\omega C} = \frac{1}{j(10 \times 10^3)(1 \times 10^{-6})} = -j100$$





$$V = (1 \angle 0^\circ) (50) = 50$$

$$V_{in} = (1 \angle 0^\circ) (50 + j20 - j100) + (2) (50)$$

$$V_{in} = 50 - j80 + 100 = 150 - j80$$

$$Z_{in} = \frac{V_{in}}{1 \angle 0^\circ} = 150 - j80 \Omega$$

$$= 170 \Omega$$

**07. Ans: (b)**

**Sol:** The L.T of periodic signal  $x(t)$ , with period 'T' is

$$X(s) = \frac{1}{1 - e^{-sT}} \int_0^T x(t) e^{-st} dt$$

**08. Ans: 2.585 (2.3 to 2.8)**

**Sol:** Here monostable multivibrator is implemented with 555 timer,  
pulse width =  $1.1RC$

$$\begin{aligned} &= 1.1 \times 4.7K \times 0.5\mu \\ &= 2.585 \text{ms} \end{aligned}$$

**09. Ans: (c)**

$$\text{Sol: } G(s) = \frac{k(s+2)(s+3)}{(s+1)(s+4)}$$

$$\text{CLTF} = \left. \frac{G(s)}{1+G(s)} \right|_{k=1} = \frac{(s+2)(s+3)}{(s+1)(s+4)+(s+2)(s+3)}$$

**10. Ans: 2.12 (Range: 2 to 2.3 )**

$$\text{Sol: } \frac{d\phi}{ds} = \hat{a} \cdot \text{grad } \phi$$

$$\phi = 2y + z$$

$$\hat{a} = \hat{j} + \hat{k}$$

$$\hat{a} = \frac{\bar{a}}{|\bar{a}|} = \frac{j+k}{\sqrt{1^2 + 2^2}} = \frac{j+k}{\sqrt{2}}$$

$$\begin{aligned} \text{grad } \phi &= \nabla \phi = \left( i \frac{\partial}{\partial x} + j \frac{\partial}{\partial y} + k \frac{\partial}{\partial z} \right) (2y + z) \\ &= j(2y) + k(z) \end{aligned}$$

$$\frac{d\phi}{ds} = \frac{(j+k)}{\sqrt{2}} \{ 2y \hat{j} + \hat{k} z \} = 2\hat{j} + \hat{k}$$

$$\begin{aligned} &= \frac{\hat{j} + \hat{k}}{\sqrt{2}} (2\hat{j} + \hat{k}) = \frac{3}{\sqrt{2}} \\ &= 2.12 \end{aligned}$$

**11. Ans: (b)**

$$\text{Sol: } f(A, B, C, D) = A + B\bar{C} + A\bar{B}\bar{D} + ABCD$$

$$\begin{aligned} &= A\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}D + A\bar{B}CD + A\bar{B}CD \\ &+ ABC\bar{D} + AB\bar{C}D + ABC\bar{D} + ABCD \\ &+ \bar{A}BC\bar{D} + \bar{A}B\bar{C}D + \bar{A}BC\bar{D} + AB\bar{C}D \\ &+ ABC\bar{D} + ABCD + ABCD \end{aligned}$$

$$\begin{aligned} &= \sum m(4, 5, 8, 9, 10, 11, 12, 13, 14, 15) \\ &= \prod M(0, 1, 2, 3, 6, 7) \end{aligned}$$

**12. Ans: (b)**

**Sol:** For  $t \geq 0^+$ ; KVL gives

$$E = \frac{1}{C} \int_{0^-}^t i(t) dt + (E/2)$$

$$\text{Laplace transforming, } \frac{1}{Cs} I(s) + \frac{E}{2} \frac{1}{s} = E \frac{1}{s};$$

$$\text{from which } I(s) = \frac{CE}{2}$$

$$\text{Hence } i(t) = \frac{CE}{2} \delta(t) \text{ A.}$$

**13. Ans: (c)**

$$\text{Sol: } \beta_1 = 2 \quad f_{m_1} = 1 \text{ kHz}$$

$$\beta_2 = 4 \quad f_{m_2} = 10 \text{ kHz}$$

$$\beta_3 = 5 \quad f_{m_3} = 20 \text{ kHz}$$

$$\begin{aligned} \Delta f &= \beta_1 f_{m_1} + \beta_2 f_{m_2} + \beta_3 f_{m_3} \\ &= 2 \text{ kHz} + 40 \text{ kHz} + 100 \text{ kHz} = 142 \text{ kHz} \end{aligned}$$

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**14. Ans: (c)**

**Sol:** Given

$$\eta = 0.9$$

$$U_{\max} = 0.6 \text{W/Sr}$$

$$P_{\text{rad}} = 0.4$$

$$\text{Directivity, } D = 4\pi \frac{U_{\max}}{P_{\text{rad}}} = 4\pi \times \frac{0.6}{0.4}$$

$$\therefore D = 18.849$$

**15. Ans: 1.22 (No range)**

$$\frac{dy}{dx} = y + x$$

$$x_0 = 0, y_0 = 1$$

$$x_1 = x_0 + h = 0.1$$

$$x_2 = x_0 + 2h = 0.2$$

$$y_1 = y_0 + h f(x_0, y_0) = 1 + (0.1)(1+0) \\ = 1.1$$

$$y_2 = y_1 + h f(x_1, y_1) \\ = 1.1 + 0.1 [0.1 + 1.1] \\ = 1.1 + 0.12 \\ = 1.22$$

**16. Ans: (a)**

$$\text{Sol: } X(s) = \frac{2s e^{-2s}}{s^2 + 4s + 3}$$

$$\text{Assume } X_1(s) = \frac{2s}{s^2 + 4s + 3} = \frac{2s}{(s+1)(s+3)} \\ = \frac{-1}{s+1} + \frac{3}{s+3}$$

Apply ILT

$$x_1(t) = -e^{-t} u(t) + 3e^{-3t} u(t)$$

$$X(s) = e^{-2s} \cdot X_1(s)$$

Apply ILT

$$x(t) = x_1(t-2)$$

$$x(t) = -e^{-(t-2)} u(t-2) + 3e^{-3(t-2)} u(t-2)$$

**17. Ans: (a)**

$$\text{Sol: } d_{\min} = \sqrt{2}$$

$$\frac{N_0}{2} = \frac{1}{2}$$

$$P_e = Q \left[ \sqrt{\frac{d_{\min}^2}{2N_0}} \right] = Q \left[ \sqrt{\frac{2}{2}} \right] \\ = Q(1)$$

**18. Ans: (d)**

**Sol:** The potential due to a dipole can be written as

$$V = \frac{\bar{P} \cdot \bar{a}_r}{4\pi \epsilon_0 r^2}$$

(where  $\bar{P}$  = dipole moment and  $|\bar{P}| = Qd$ )

$$\bar{P} = (2\hat{a}_x + 1.5\hat{a}_y + 3\hat{a}_z) \times 10^{-9} \text{C-m}$$

$$\bar{a}_r = \frac{2\hat{a}_x + \hat{a}_y + 5\hat{a}_z}{\sqrt{4+1+25}} = \frac{2\hat{a}_x + \hat{a}_y + 5\hat{a}_z}{\sqrt{30}}$$

$$V = \frac{(2\hat{a}_x + 1.5\hat{a}_y + 3\hat{a}_z) \cdot (2\hat{a}_x + \hat{a}_y + 5\hat{a}_z)}{4\pi \times 8.854 \times 10^{-12} \times 30\sqrt{30}} \times 10^{-9}$$

$$= \frac{(4+1.5+15)}{4\pi \times 8.854 \times 10^{-12} \times 30\sqrt{30}} \times 10^{-9}$$

$$= 1.12 \text{V}$$

**19. Ans: (b)**

**Sol:** Let  $X$  = Amount the player wins in rupees  
The probability distribution for  $X$  is given below.

Number of heads	0	1	2
X	x	1	3
P(X)	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{1}{4}$

For the game to be fair we have to find  $x$ , so that  $E(X) = 0$

$$\Rightarrow x \cdot \left(\frac{1}{4}\right) + 1 \cdot \left(\frac{2}{4}\right) + 3 \cdot \left(\frac{1}{4}\right) = 0$$

$$\Rightarrow x = -5$$

∴ Number of rupees, the player has to lose if no head occur = 5.

**20. Ans: 6.2 ( no range )**

**Sol:**  $V_{\text{out}} = 0.4 \text{V}$  for input  $(00010)_2 = (2)_{10}$



$$\text{Step size} = \frac{0.4}{2} = 0.2$$

$$V_{\text{out}} \text{ for input } (11111)_2 = 0.2 \times 31_{10} = 6.2V$$

**21. Ans: 4 No range**

**Sol:** The constant term in the characteristic equation of a matrix is equal to the determinant of a matrix

$$\therefore \det(A) = 4$$

**22. Ans: (d)**

$$\text{Sol: Frequency deviation} = \frac{f_{\max} - f_{\min}}{2}$$

$$f_{\max} = 100.01 \text{ MHz}$$

$$f_{\min} = 99.97 \text{ MHz}$$

$$= \left( \frac{100.01 - 99.97}{2} \right) \text{MHz}$$

$$= 0.02 \times 10^6$$

$$= 20 \text{ kHz}$$

**23. Ans: 5 to 5.2**

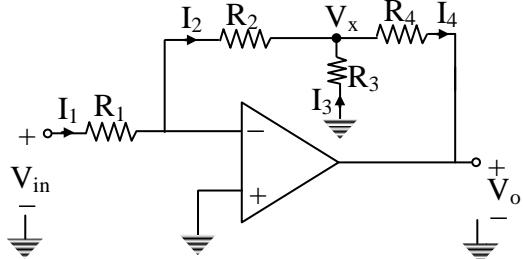
$$\text{Sol: } \frac{P_r}{P_t} = G_t G_r \left( \frac{\lambda}{4\pi R} \right)^2, \lambda = \frac{3 \times 10^8}{6 \times 10^8} = 0.5 \text{ m}$$

$$P_t = \left( \frac{4\pi R}{\lambda} \right)^2 \frac{P_r}{G^2} = \left( \frac{4\pi \times 450}{0.5} \right)^2 \times \frac{4 \times 10^{-3}}{(316.23)^2}$$

$$P_t = 5.116 \text{ W}$$

**24. Ans: (a)**

**Sol:**



$$V^- = V^+ = 0 [\because \text{Virtual ground}]$$

$$I_1 = \frac{V_{\text{in}}}{R_1} \quad (1)$$

$I_1 = I_2$  [ $\because$  current entering into the inverting terminal is zero]

$$I_2 + I_3 = I_4 \quad (2) \text{ and}$$

$$V_x = 0 - I_2 R_2 = -\frac{R_2}{R_1} V_{\text{in}} \quad (3)$$

$$\frac{V_{\text{in}}}{R_1} + \frac{0 - V_x}{R_3} = \frac{V_x - V_0}{R_4} \quad (4)$$

Solving (3) and (4), we get

$$\frac{V_0}{V_{\text{in}}} = -\frac{R_2}{R_1} \left[ 1 + \frac{R_4}{R_2} + \frac{R_4}{R_3} \right]$$

**25. Ans: 24 No range**

**Sol:** Given that  $F(x) = f(g(x))$

$$\Rightarrow F'(x) = f'(g(x)). g'(x) \quad (\because \text{by chain rule})$$

$$\Rightarrow F'(5) = f'(g(5)). g'(5)$$

$$\Rightarrow F'(5) = f'(-2) . 6$$

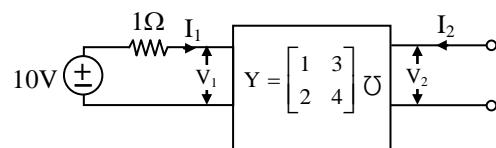
$$\therefore F'(5) = (4)(6) = 24$$

**26. Ans: 25 (range:25 to 25)**

**Sol:** Maximum power transferred to load resistance  $R_L$  is

$$= \frac{V_{\text{Th}}^2}{4R_{\text{Th}}}$$

Calculation of  $V_{\text{Th}}$ : (open the load resistance)



From Y-parameters

$$I_1 = V_1 + 3V_2 \quad (1)$$

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

$$\text{But } I_2 = 0, \text{ so } -2V_1 = 4V_2$$

$$V_1 = -2V_2 \quad (3)$$

$$\text{And } I_1 = 10 - V_1$$

$$\text{From}(1), 10 - V_1 = V_1 + 3V_2$$

$$10 - 2V_1 = 3V_2$$

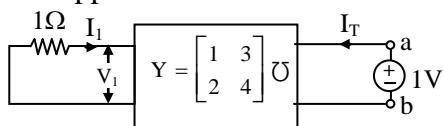


From(3),  $10 - 2(-2V_2) = 3V_2$

$$V_2 = -10V$$

Calculation of  $R_{Th}$ : (deactivate all independent sources)

if 1V is applied across a-b then



$$I_2 = I_T$$

$$V_2 = 1V$$

From (1) & (2)

$$I_1 = V_1 + 3(1) \dots\dots\dots(4)$$

$$I_T = 2V_1 + 4(1) \dots\dots\dots(5)$$

But  $V_1 = -I_1$ ,  $I_1 = -V_1$

$$-V_1 = V_1 + 3$$

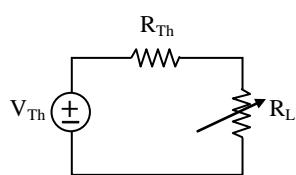
$$V_1 = \frac{-3}{2}$$

$$\text{From (5)} I_T = 2\left(\frac{-3}{2}\right) + 4$$

$$I_T = 1$$

$$R_{Th} = \frac{1}{I_T} = 1\Omega$$

∴



$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{100}{4 \times 1} = 25W$$

**27. Ans: 63.2 (Range 62 to 64)**

**Sol:** Propagation delay  $t_p = \frac{1}{2}(t_{PHL} + t_{PLH})$

$$t_{PHL} = 0.69 R_N C, t_{PLH} = 0.69 R_P C.$$

Empirical values for  $R_N$  and  $R_P$  are,

$$R_N = \frac{12.5}{\left(\frac{W}{L}\right)_n} k\Omega, R_P = \frac{30}{\left(\frac{W}{L}\right)_P} k\Omega$$

$$R_N = 8.33k\Omega, R_P = 10k\Omega$$

$$t_{PHL} = 57.5\text{ps}, t_{PLH} = 69\text{ps}$$

$$t_p = \frac{1}{2}(57.5 + 69)\text{ps} = 63.2\text{ps}$$

**28. Ans: (a)**

$$\begin{aligned} \text{Sol: } \frac{E(s)}{R(s)} &= \frac{1\left\{1 - \left\{\frac{2}{3} - \frac{3}{2}\right\} + \left\{\frac{2}{3} \times \frac{-3}{2}\right\}\right\}}{1 - \left\{\frac{2}{3} - \frac{3}{2} - 3\right\} + \left\{\frac{2}{3} \times \frac{-3}{2}\right\}} \\ &= \frac{1\left\{1 - \frac{2}{3} + \frac{3}{2} - 2 \times 3 \times \frac{1}{2} \times \frac{1}{3}\right\}}{1 - \frac{2}{3} + \frac{3}{2} + 3 - 2 \times 3 \times \frac{1}{2} \times \frac{1}{3}} \\ &= \frac{1 + \frac{5}{6} - 1}{1 + \frac{5}{6} + 3 - 1} \\ &= \frac{5}{6} \end{aligned}$$

$$\frac{E(s)}{R(s)} = \frac{5}{23}$$

**29. Ans: (b)**

**Sol:** line equation of AB is,

Here A = (1, 1) B = (3, 2)

$$y - 1 = \frac{1}{2}(x - 1) \Rightarrow y = \frac{x + 1}{2}$$

$$dy = \frac{dx}{2}$$

$$\therefore \int_C \operatorname{Re} z dz = \int_1^3 x(dx + idy)$$

$$\begin{aligned} &= \int_1^3 x \left( dx + i \frac{dx}{2} \right) = \left( 1 + \frac{i}{2} \right) \left[ \frac{x^2}{2} \right]_1 \\ &= 4 + 2i \end{aligned}$$

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(EE: **9**, E&T: **8**, ME: **9**, CE: **7**)

and many more...



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**30. Ans: (C)**

**Sol:**  $s \omega(s) = -\omega(s) + i_a(s)$

$$\Rightarrow \omega(s)[s+1] = i_a(s) \Rightarrow \omega(s) = \frac{i_a(s)}{s+1} \dots (1)$$

$$s i_a(s) = -\omega(s) - 10 i_a(s) + 10 U(s)$$

$$i_a(s)[s+10] + \omega(s) = 10 U(s)$$

$$i_a(s) \left[ s + 10 + \frac{1}{s+1} \right] = 10 U(s) [\because \text{eq (1)}]$$

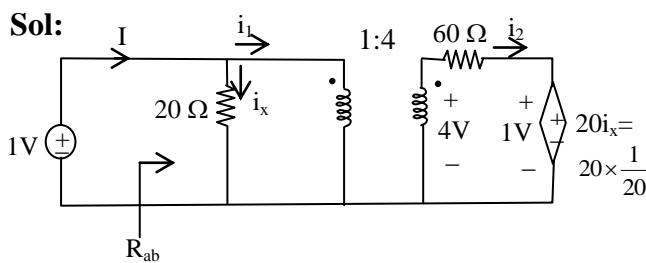
$$\Rightarrow \frac{i_a(s)}{U(s)} = \frac{10(s+1)}{s^2 + 11s + 11}$$

**31. Ans: (a)**

$$\begin{aligned} \text{Sol: } PDP &= \frac{1}{2} CV_{DD}^2 = \frac{1}{2} (6.25f)(2.5)^2 \\ &= 19.5fJ \end{aligned}$$

$$\begin{aligned} EDP &= \frac{1}{2} CV_{DD}^2 t_p \\ &= 5.6 \times 10^{-25} \text{ J-s} \end{aligned}$$

**32. Ans: (c)**



$$i_x = 1/20$$

$$i_2 = \frac{4-1}{60} = \frac{3}{60} = \frac{1}{20}$$

$$\frac{i_1}{i_2} = 4 \Rightarrow i_1 = \frac{4}{20}$$

$$I = \frac{1}{20} + \frac{4}{20} = \frac{1}{4}$$

$$R_{ab} = 4 \Omega$$

**33. Ans: (d)**

$$\text{Sol: } h(n) = 2^n u(n) - \left(\frac{1}{2}\right)^n u(-n-1)$$

$$\text{ROC1 is } |z| > 2 \quad \text{ROC2 is } |z| < \frac{1}{2}$$

$$\text{R.O.C. of } H(z) = R = R_1 \cap R_2 = \{ \} = \emptyset$$

$\therefore$  There is no R.O.C. of  $H(z)$

$\therefore H(z)$  does not exist.

**34. Ans: 25.06 (Range 24.5 to 25.5)**

**Sol:**  $W = 4.5 \text{ kHz}$

$$NR = 2W = 9 \text{ kHz}$$

$$\begin{aligned} SR &= 2(N.R) = 2 \times 9 \text{ kHz} \\ &= 18 \text{ k samples / sec} \end{aligned}$$

$$L = \text{number of quantization levels} = 128$$

$$\text{Number of bits } n = \log_2 L = \log_2 128 = 7$$

$$\text{SNR (dB)} = 10 \log_{10} \text{SNR}$$

$$\text{SNR} \Rightarrow 10^{15/10}$$

$$\text{SNR} = 31.62$$

$$R_b = \text{bit rate} = nf_s$$

$$= n \times (SR)$$

$$= 7 \times 18000$$

$$= 126000 \text{ bps}$$

$$R_b = 126 \text{ kbps}$$

Shannon Hartley law

$$C = B \log_2 (1 + S/N)$$

B = transmission bandwidth of channel

For error free transmission of messages

$$C \geq R_b$$

$$B \log_2 (1 + S/N) \geq 126 \text{ kbps}$$

$$B \geq \frac{126 \text{ kbps}}{\log_2 (1 + S/N)} \Rightarrow B \geq 25.06 \text{ kHz}$$

$$B_{\min} = 25.06 \text{ kHz}$$

**35. Ans: (a)**

**Sol:**  $J_1 = X, K_1 = \bar{X}$

from the truth table of JK flip-flop

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



When  $X = 0$   $J_1 = 0, K_1 = 1$   $Q_{n+1} = 0 = X$   
When  $X = 1$   $J_1 = 1, K_1 = 0$   $Q_{n+1} = 1 = X$

X	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>3</sub>	Z
0	0	0	0	0
1	1	1	1	1

Finally  $Z = X$ , the given circuit is a shift register.

### 36. Ans: 71.56 (70 to 73)

Sol:

$$\frac{30\angle 0 + \bar{V}_{NS}}{-j30} + \frac{30\angle -120^\circ + \bar{V}_{NS}}{30} + \frac{30\angle 120^\circ + \bar{V}_{NS}}{30} = 0$$

$$\bar{V}_{NS} \left[ \frac{1}{15} + j \frac{1}{30} \right] = -30 [1\angle -120^\circ + 1\angle 120^\circ + j1]$$

$$= -30[-1\angle 0 + j1] = 1 - j1$$

$$\bar{V}_{NS} = \frac{30(1-j1)}{\frac{1}{15} + j \frac{1}{30}} \angle \bar{V}_{NS} = -45^\circ - \tan^{-1} \frac{1}{2} = 71.56^\circ$$

### 37. Ans: 70 (No range)

Sol:  $X(e^{j\omega}) = e^{6j\omega} - 3e^{-j2\omega} + 5e^{j\omega} + 5 - 2e^{-j6\omega} - 3e^{-j4\omega}$

Apply IDTFT

$$x(n) = \{1, 0, 0, 0, 0, 5, 5, 0, -3, 0, -3, 0, -2\}$$

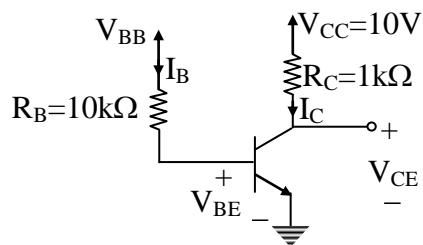
$$x(4) = -3;$$

$$\sum_{n=-\infty}^{\infty} |x(n)|^2 = 1 + 25 + 25 + 9 + 9 + 4 \\ = 50 + 18 + 5 = 73$$

$$x(4) + \sum_{n=-\infty}^{\infty} |x(n)|^2 = -3 + 73 = 70$$

### 38. Ans: (d)

Sol:



- i) Operating at the edge of saturation is obtained with  $V_{CE} = 0.3V$ . Thus

$$I_C = \frac{10 - 0.3}{1k\Omega} = 9.7mA$$

Since, at the edge of saturation,  $I_C$  and  $I_B$  are still related by  $\beta$ ,

$$I_B = \frac{9.7mA}{50} = 0.194mA$$

$$V_{BB} = (0.194 \times 10) + 0.7 = 2.64V$$

- ii) To operate deep in saturation,

$$V_{CE} = V_{CEsat} \approx 0.2V$$

$$I_C = \frac{10 - 0.2}{1k\Omega} = 9.8mA$$

$$I_B = \frac{I_C}{\beta_{forced}} = \frac{9.8}{10} = 0.98mA$$

$$V_{BB} = (0.98 \times 10) + 0.7 = 10.5V$$

### 39. Ans: (a)

Sol:

ABC	D = 0	D = 1	
000	(0)	(1)	= 1 = I <sub>0</sub>
001	(2)	(3)	= 1 = I <sub>1</sub>
010	(4)	5	= $\bar{D}$ = I <sub>2</sub>
011	6	7	= 0 = I <sub>3</sub>
100	8	9	= 0 = I <sub>4</sub>
101	(10)	(11)	= 1 = I <sub>5</sub>
110	12	13	= 0 = I <sub>6</sub>
111	(14)	(15)	= 1 = I <sub>7</sub>



**40. Ans: 0.75 (No range)**

**Sol:** From the given circuit

$$\rightarrow V_C = 2V$$

$$I_C = \frac{10 - V_C}{R_{C1}}$$

$$R_{C1} = \frac{10 - 2}{I_C} = \frac{8}{I_C}$$

$$\rightarrow V_C = 4V$$

$$I_C = \frac{10 - V_C}{R_{C2}}$$

$$R_{C2} = \frac{10 - 4}{I_C} = \frac{6}{I_C}$$

$$\frac{R_{C2}}{R_{C1}} = \frac{\frac{6}{I_C}}{\frac{8}{I_C}} = \frac{6}{8} = \frac{3}{4} = 0.75$$

**41. Ans: (d)**

**Sol:**  $\rightarrow (A) = XXH \oplus XXH = 00H$

$$\rightarrow (HL) = 4000H$$

$$\rightarrow (SP) = 3000H$$

$$\rightarrow (A) = 35 H$$

$$\rightarrow (M) = (4000H) = 36H$$

$$\rightarrow (A) = 35H = 0011\ 0101$$

$$(M) = 36H = 0011\ 0110$$

$$(A) = 6BH = 0110\ 1011$$

$$CY = 0, P = 0, AC = 0, Z = 0, S = 0$$

$\rightarrow$  Decimal Adjust Accumulator

06H is added to lower digit since it is  $> 9$

$$(A) = 6BH = 0110\ 1011$$

$$= 06H = 0000\ 0110$$

$$(A) = 71H = 0111\ 0001$$

$$CY = 0, P = 1, AC = 1, Z = 0, S = 0$$

$$(PSW) = 0111\ 0001\ 0001\ 0100$$

$$= 7114H$$

**42. Ans: 20.106 (range 18 to 22)**

**Sol:** Given  $f = 60\text{GHz}$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{60 \times 10^9} = 0.005\text{m}$$

Minimum detectable signal power:

$$S_{\min} = 10^{-12}\text{W}$$

$$P_{\text{rad}} = 250\text{ W}$$

$$R_{\max} = 200\text{km}$$

$$A_{\text{emax}} = 10\text{m}^2$$

$$R_{\max} = \left[ \frac{P_{\text{rad}} A_e^2 \sigma}{4\pi \times \lambda^2 \times S_{\min}} \right]^{1/4}$$

$$\sigma = \frac{R_{\max}^4 \times 4\pi \times \lambda^2 \times S_{\min}}{P_{\text{rad}} \times A_e^2}$$

$$= \frac{(200 \times 10^3)^4 \times 4\pi \times (0.005)^2 \times 10^{-12}}{250 \times (10)^2}$$

$$\therefore \sigma = 20.106\text{m}^2$$

Therefore the smallest radar cross section detectable is  $20.106\text{m}^2$

**43. Ans: (c)**

**Sol:** To obtain the loop gain, we break the positive feedback at the positive input terminal of the op-amp where the input impedance is infinite, apply an input voltage  $V_i$ , and find its output voltage,  $V_0$

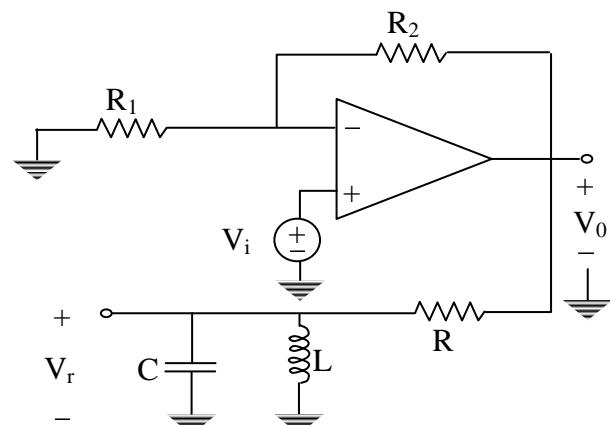


Fig. Breaking the feedback loop at the input of the op-amp



$$A(s) = \frac{V_o}{V_i} = 1 + \frac{R_2}{R_1}$$

$$\beta(s) = \frac{V_r}{V_o} = \frac{s \frac{1}{CR}}{s^2 + s \frac{1}{CR} + \frac{1}{LC}}$$

$$A(s)\beta(s) = \frac{s \frac{1}{CR} \left(1 + \frac{R_2}{R_1}\right)}{s^2 + s \frac{1}{CR} + \frac{1}{LC}}$$

$$A(j\omega)\beta(j\omega) = \frac{j \frac{\omega}{CR} \left(1 + \frac{R_2}{R_1}\right)}{\left(-\omega^2 + \frac{1}{LC}\right) + j \frac{\omega}{CR}}$$

From this expression, we see that the phase angle of  $A(j\omega)$   $\beta(j\omega)$  will be zero at the value of  $\omega$  that makes the real part of denominator zero,

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

At this frequency, the magnitude of the loop gain is given by

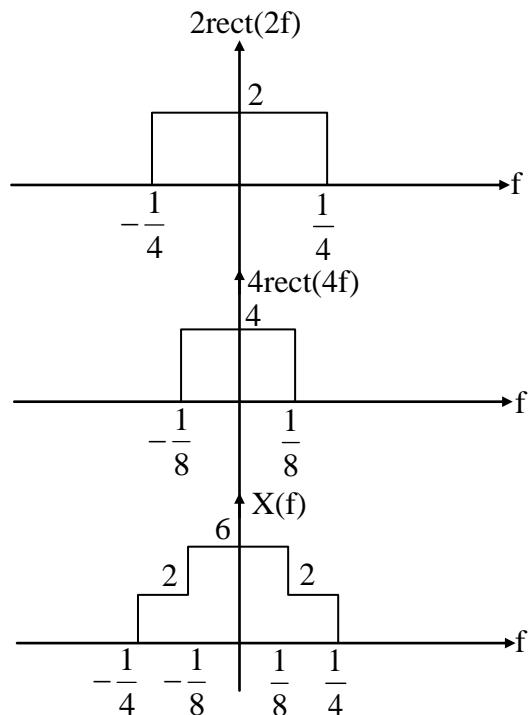
$$|A(j\omega_0)\beta(j\omega_0)| = 1 + \frac{R_2}{R_1} = 1 + \frac{10k}{1k} = 11$$

#### 44. Ans: 1

Sol:  $\text{Sinc}(t) \leftrightarrow \text{rect}(f)$

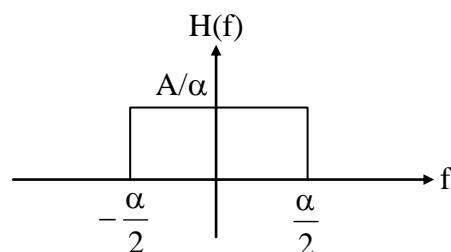
$\text{Sinc}(t/2) \leftrightarrow 2 \text{ rect}(2f)$

$\text{Sinc}(t/4) \leftrightarrow 4 \text{ rect}(4f)$



Given  $h(t) = A \text{ Sinc}(\alpha t)$

$$H(f) = \frac{A}{\alpha} \text{ rect}\left(\frac{f}{\alpha}\right)$$



$Y(f) = X(f) \cdot H(f) = X(f)$  only when

$$\frac{-\alpha}{2} = \frac{-1}{4} \Rightarrow \alpha = \frac{1}{2}$$

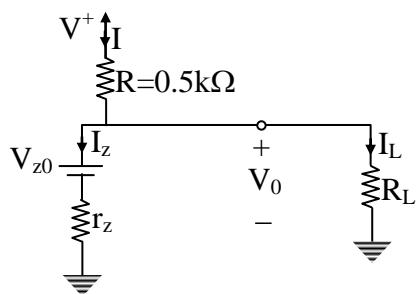
$$\frac{A}{\alpha} = 1 \Rightarrow A = \alpha = \frac{1}{2}$$

$$A + \alpha = 1$$



**45. Ans: 6.83 (6.75 to 6.9)**

**Sol:**



$$V_z = V_{z0} + r_z I_z$$

$$6.8 = V_{z0} + (20\Omega \times 5\text{mA})$$

$$\Rightarrow V_{z0} = 6.7\text{V} \quad (1)$$

With no load connected, the current through the zener is given by

$$I_z = I = \frac{V^+ - V_{z0}}{R + r_z} = \frac{10 - 6.7}{0.5k + 0.02k}$$

$$I_z = 6.35\text{mA} \quad (2)$$

$$\rightarrow V_0 = V_{z0} + I_z r_z = 6.7 + (6.35 \times 0.02) \\ = 6.83\text{V}$$

**46. Ans: 3.5 (No range)**

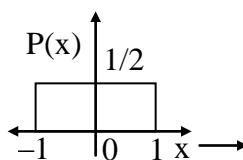
**Sol:** The directivity of broad side array is given by

$$D = \frac{2L}{\lambda} = \frac{2(N-1)d}{\lambda} = \frac{2(10-1)\times \frac{\lambda}{8}}{\lambda} = 2.25$$

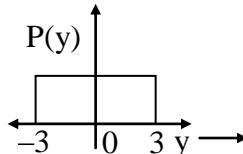
$$D_{(\text{dB})} = 10 \log 2.25 = 3.5\text{dB}$$

**47. Ans: (b)**

**Sol:**  $P(x) = \begin{cases} \frac{1}{2}; & |x| < 1 \\ 0; & \text{otherwise} \end{cases}$



$P(y) = \begin{cases} \frac{1}{6}; & |y| < 3 \\ 0; & \text{otherwise} \end{cases}$



$$H(X) = \int_{-1}^1 \frac{1}{2} \log_2 2 dx = 1\text{bit}$$

$$H(Y) = \int_{-3}^3 \frac{1}{6} \log_2 6 dx = 2.584\text{bit}$$

**48. Ans: 4 (No range)**

**Sol:**  $X(k) = \sum_{n=0}^{N-1} x(n) e^{-j2\pi kn/N}$

$$= \sum_{n=0}^{\frac{N}{2}-1} x(2n) e^{-j2\pi k(2n)/N} + \sum_{n=0}^{\frac{N}{2}-1} x(2n+1) e^{-j2\pi k(2n+1)/N}$$

$$= \sum_{n=0}^{\frac{N}{2}-1} x(2n) W_{N/2}^{kn} + W_N^k \sum_{n=0}^{\frac{N}{2}-1} x(2n+1) W_{N/2}^{kn}$$

$$X(0) = \sum_{n=0}^{\frac{N}{2}-1} x(2n) W_{N/2}^0 + W_N^0 \sum_{n=0}^{\frac{N}{2}-1} x(2n+1) W_{N/2}^0$$

$$X(0) = \sum_{n=0}^{\frac{N}{2}-1} x(2n) + \sum_{n=0}^{\frac{N}{2}-1} x(2n+1)$$

$$X(N/2) = \sum_{n=0}^{\frac{N}{2}-1} x(2n) W_{N/2}^{\frac{Nn}{2}} + W_N^{\frac{N}{2}} \sum_{n=0}^{\frac{N}{2}-1} x(2n+1) W_{N/2}^{\frac{Nn}{2}}$$

$$= \sum_{n=0}^{\frac{N}{2}-1} x(2n) - \sum_{n=0}^{\frac{N}{2}-1} x(2n+1)$$

$$X(0) + X(N/2) = 2 \sum_{n=0}^{\frac{N}{2}-1} x(2n)$$

$$\Rightarrow \sum_{n=0}^3 x(2n) = \frac{1}{2} [X(0) + X(N/2)] = \frac{1}{2} [X(0) + X(4)]$$

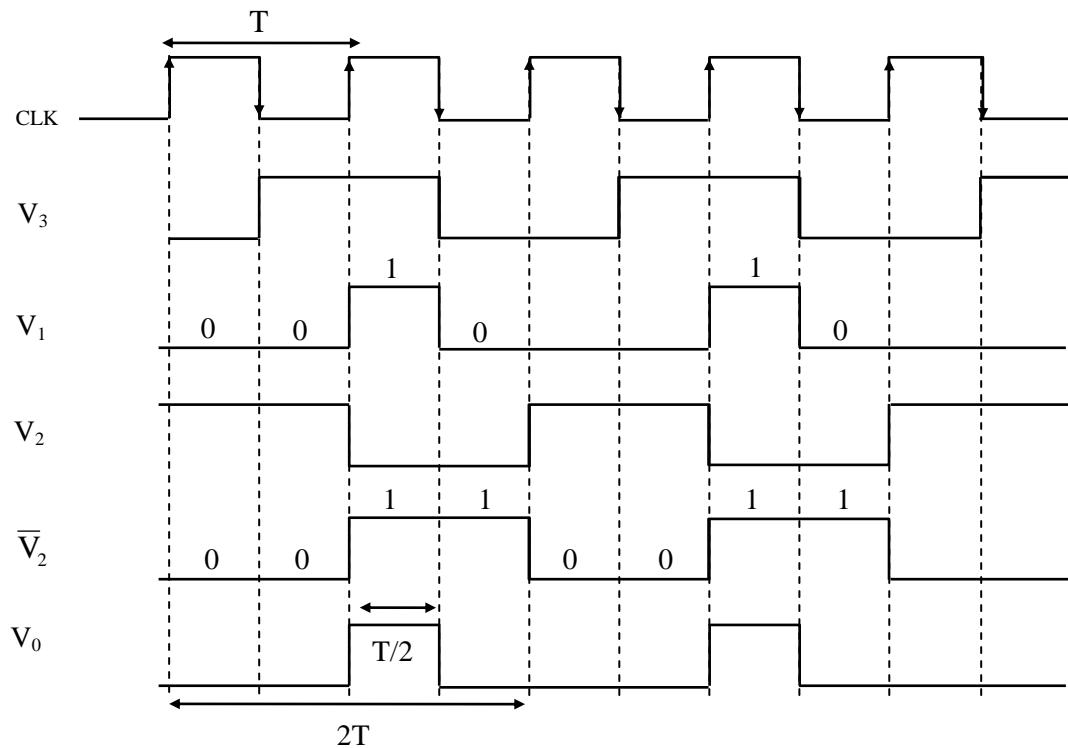
$$= \frac{1}{2} [(0+8)] = 4$$



**49. Ans: 25**

(No range)

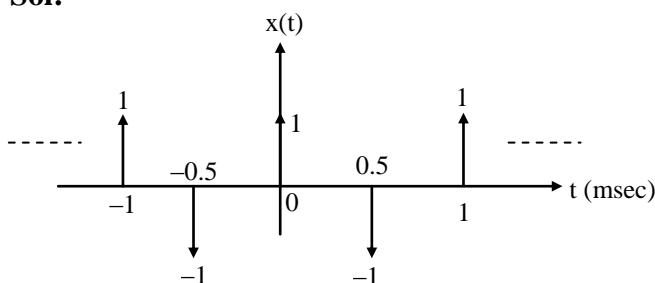
Sol:



$$\text{Duty cycle} = \frac{\frac{T}{2}}{2T} \times 100 = 25\%$$

**50. Ans: (c)**

Sol:



$$C_n = \frac{1}{T_0} \int_0^{T_0} x(t) e^{-j n \omega_0 t} dt$$

$$C_n = \frac{1}{1 \times 10^{-3}} \left[ \int_0^1 x(t) e^{-j n \omega_0 t} dt \right]$$

$$C_n = 10^3 [1 - e^{-j n \omega_0 (0.5 \times 10^{-3})}]$$

$$C_n = 10^3 \left[ 1 - e^{-j n \left( \frac{2\pi}{1 \times 10^{-3}} \right) (0.5 \times 10^{-3})} \right]$$

$$C_n = 10^3 [1 - e^{-j n \pi}] = 1000 [1 - (-1)^n]$$

Fourier transform of periodic signal is

$$X(\omega) = 2\pi \sum_{n=-\infty}^{\infty} C_n \delta(\omega - n\omega_0)$$

$$X(\omega) = 2000\pi \sum_{n=-\infty}^{\infty} [1 - (-1)^n] \delta(\omega - 2000n\pi)$$

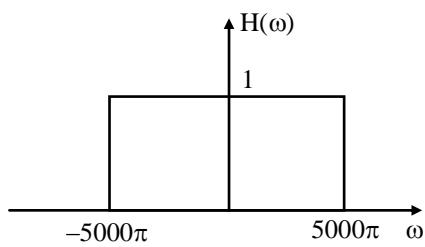
$$X(\omega) = 2000\pi [.....2\delta(\omega + 2000\pi) + 2\delta(\omega - 2000\pi) + .....]$$

$$x(t) = 4000\pi [\delta(\omega + 2000\pi) + \delta(\omega - 2000\pi) + .....]$$

$$X(\omega) = 4000[\cos(2000\pi t)]$$



$$+ \cos(6000\pi t) + \dots]$$



The output of low pass filter is  
 $y(t) = 4000 \cos(2000\pi t)$

**51. Ans: 1200**

**Sol:**  $m(t) = \sin(250\pi t) + \cos(250\pi t)$   
 $= \sqrt{2} \cos[250\pi t - 45^\circ]$

$$f_m = \frac{250\pi}{2\pi} = 125 \text{ Hz}$$

$$\begin{aligned} SR &= 1.2 (\text{NR}) \\ &= 1.2 \times 2 \times 125 \\ &= 300 \text{ samples/sec} \end{aligned}$$

Step size  $\Delta = 0.4$

$$\frac{\Delta}{2} = Q_e = \frac{(V_{\max} - V_{\min})}{2^n};$$

$$0.40 = \frac{\sqrt{2} - (-\sqrt{2})}{2^n}$$

$$2^n = \frac{2\sqrt{2}}{0.4}$$

$$n = 3.82 \Rightarrow n = 4$$

$$\therefore R_b = n f_s = 4 \times 300 \text{ bps} = 1200 \text{ bps}$$

$$R_b = 1200 \text{ bps}$$

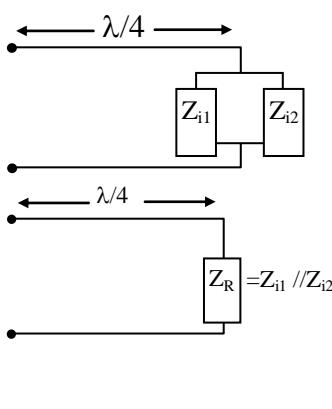
**52. Ans: (a)**

**Sol:** Where

$$\begin{aligned} Z_{i1} = Z_{i2} &= \frac{Z_0^2}{Z_R} \\ &= \frac{(50)^2}{74} \end{aligned}$$

$$Z_{i1} = 33.78 \Omega$$

$$\begin{aligned} Z_R &= \frac{33.78}{2} \\ &= 16.89 \Omega \end{aligned}$$



$$\begin{aligned} Z_{in} &= \frac{Z_0^2}{Z_R} = \frac{(50)^2}{16.89} \\ \therefore Z_{in} &= 148 \Omega \end{aligned}$$

**53. Ans: (b)**

**Sol:** For eigen vector,  $AX = \lambda X$

$$\begin{bmatrix} 1 & 1 & 3 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{pmatrix} -2 \\ x_2 \\ x_3 \end{pmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

$$\Rightarrow x_1 + x_2 + 3x_3 = -2x_1 \rightarrow (1)$$

$$\Rightarrow x_1 + 5x_2 + x_3 = -2x_2 \rightarrow (2)$$

$$\Rightarrow 3x_1 + x_2 + x_3 = -2x_3 \rightarrow (3)$$

$$(1) \Rightarrow 3(x_1 + x_3) = -x_2 \rightarrow (4)$$

$$(2) \Rightarrow x_1 + x_3 = -7x_2 \rightarrow (5)$$

$$(3) \Rightarrow 3(x_1 + x_3) = -x_2 \rightarrow (6)$$

$$\text{From (4)&(5)} \rightarrow x_1 + x_3 - 7(3(x_1 + x_3)) = 0$$

$$\Rightarrow x_1 + x_3 = 0$$

Suppose  $x_1 = k \Rightarrow x_3 = -k$

$$\therefore x_2 = -3(x_1 + x_3) = 0$$

$$\therefore \text{Eigen vector } \begin{bmatrix} k \\ 0 \\ -k \end{bmatrix}$$

$$\text{For } k = 1 \Rightarrow \text{eigen vector} = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$$

**54. Ans: 45°**

**Sol:**  $\left| \frac{(50)\sqrt{50}}{(j\omega_{gc} + 5)^3} \right| = 1$

$$\left( \sqrt{\omega_{gc}^2 + 5^2} \right)^3 = 50\sqrt{50}$$

$$\omega_{gc} = 5 \text{ rad/sec}$$

$$\text{PM} = 180^\circ + \angle G(j\omega_{gc})H(j\omega_{gc})$$

$$= 180^\circ - 3 \tan^{-1} \frac{\omega_{gc}}{5} = 180 - 135 = 45^\circ$$

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**55. Ans: 0.2 No range**

**Sol:** Given that  $\frac{dy}{dx} = x^3 - 2y$  ( $\because \frac{dy}{dx} = f(x, y)$ )  
with  $y(0) = 0.25$  ( $\therefore y(x_0) = y_0$ )  
Let  $x_0 = 0$ ,  $y_0 = 0.25$  &  $h = 0.1$   
Then  $x_1 = x_0 + h = 0.1$

The formula for Euler's forward method is

$$\begin{aligned} y(x_1) &\approx y_1 = y_0 + h f(x_0, y_0) \\ \Rightarrow y(0.1) &\approx y_1 = 0.25 + (0.1)(x_0^3 - 2y_0) \\ \Rightarrow y(0.1) &\approx y_1 = 0.25 + (0.1)[0 - 2(0.25)] \\ \therefore y(0.1) &\approx y_1 = 0.25 - (0.1)(0.5) \\ &= 0.25 - 0.05 = 0.2 \end{aligned}$$

**56. Ans: (a)**

**Sol:** The right choice is 'on'. 'Tell on' means 'to affect'. 'Tell against' means 'to go against'. 'Tell of' means 'to tell about something'.

**57. Ans: (c)**

**Sol:** 'is' tired verb must agree with the first subject when 'as well as' is used.

**58. Ans: (a)**

**59. Ans: (d)**

**Sol:**  $L = \frac{5}{2}B$

Area =  $L \times B = 1000$

$$L \times \frac{2L}{5} = 1000$$

$$L^2 = 2500 \Leftrightarrow L = 50 \text{ m}$$

**60. Ans: (b)**

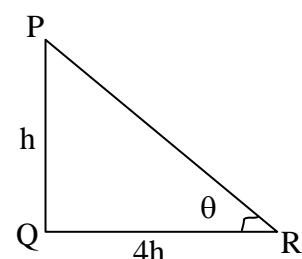
**Sol:** Supplement of  $80^\circ = 180^\circ - 80^\circ = 100^\circ$ .

**61. Ans: (d)**

**Sol:** Let the height of tower be 'PQ', 'QR' be the length of shadow to tower in  $\Delta PQR$ .

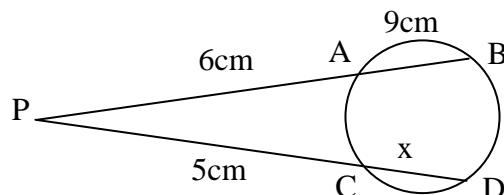
$$\tan \theta = \frac{PQ}{QR} = \frac{h}{4h}$$

$$\therefore \theta = \tan^{-1}\left(\frac{1}{4}\right)$$



**62. Ans: (a)**

**Sol:** If two chords of a circle, intersect inside a circle (outside a circle) at any point. Then,



$$PA \times PB = PC \times PD$$

$$\Rightarrow 6 \times 15 = 5 \times (x + 5)$$

$$\Rightarrow x + 5 = 18 \Rightarrow x = 13 \text{ cm}$$

**63. Ans: (a)**

**Sol:** Total time between 10 pm to 6 am = 8 hours  
% time spent in Light sleep or in Extreme sleep =  $30 + 25 = 55\%$

$$\begin{aligned} \Rightarrow \text{Time spent in Light sleep or in Extreme sleep} &= \frac{55}{100} \times 8 \\ &= \frac{22}{5} = 4.4 \text{ hours} \end{aligned}$$

**64. Ans: (b)**

**Sol:** Total cost of mobiles =  $99 \times 15000$   
= Rs. 14,85,000

$$\begin{aligned} \text{Total cost of cameras} &= 53 \times 13000 \\ &= \text{Rs. } 6,89,000 \end{aligned}$$

$$\begin{aligned} \text{Total cost of TVs} &= 29 \times 59000 \\ &= \text{Rs. } 17,11,000 \end{aligned}$$

$$\begin{aligned} \text{Total cost of Refrigerator} &= 21 \times 56000 \\ &= \text{Rs. } 11,76,000 \end{aligned}$$



$$\begin{aligned}\text{Total cost of AC} &= 97 \times 25000 \\ &= \text{Rs. } 24,25,000\end{aligned}$$

$$\begin{aligned}\text{Total cost} &= 14,85,000 + 6,89,000 \\ &\quad + 17,11,000 + 11,76,000 \\ &\quad + 24,25,000 = \text{Rs. } 74,86,000\end{aligned}$$

Total cost in lakhs = Rs. 74.86 lakhs

**65. Ans: (a)**

**Sol:** An assumption is an unstated premise. So, we are looking for something that is implied in the argument, and if wrong, will undermine the argument. All that the speaker implies is that Josh is efficient because he has twenty years of practice, and so answer (A) is correct.

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