



# ACE

## Engineering Academy

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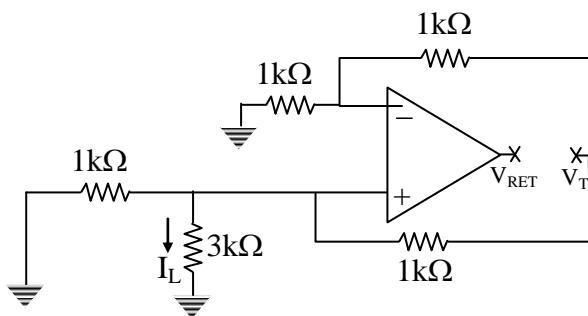
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### Branch: Electronics & Communication Engineering - SOLUTIONS

#### 01. Ans: 1

**Sol:** Step-1: We see that, both the positive and negative inputs of op-amp are connected from  $V_0$  via feedback network. Therefore, we need to find the type of feedback.

First, short circuit the 1V DC source and cut the feedback network as shown below.



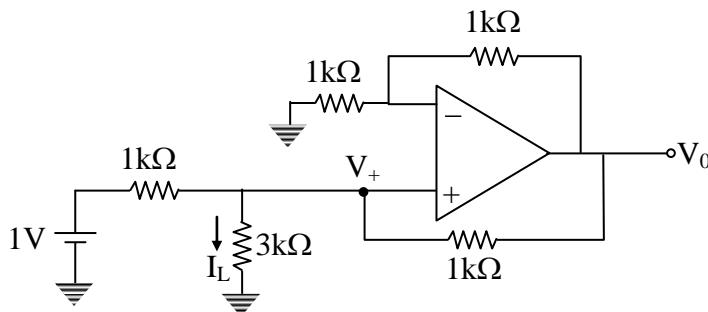
We get

$$V^- = \frac{V_T}{2}$$

$$V^+ = \frac{3}{7} V_T \Rightarrow V^- > V^+$$

∴ Negative feedback

Hence, virtual short concept is applicable.



$$V_0 = \left(1 + \frac{1k}{1k}\right) V_+ = 2V_+$$

KCL

$$\frac{1 - V_+}{1k} = I_L + \frac{(V_+) - V_0}{1k}$$

$$\frac{1 - V_+}{1k} = I_L - \frac{V_+}{1k}$$

$$\Rightarrow I_L = 1mA$$



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**02. Ans: 294.295 (Range: 293 to 296)**

**Sol:** lowest possible TM mode:  $\text{TM}_{11}$

$$a = 2.4\text{cm}, b = 1.2\text{cm}$$

Air filled rectangular waveguide

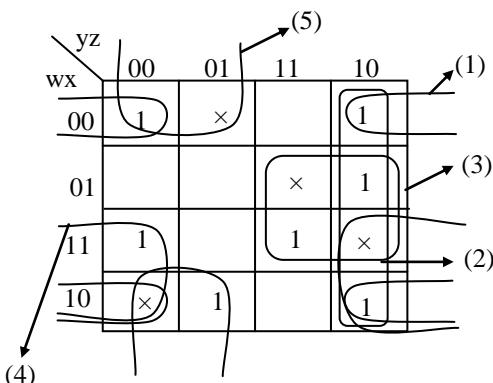
$$f = 1.6f_c(\text{TM}_{11})$$

$$\begin{aligned} \text{Wave impedance } (\eta_{\text{TM}_{11}}) &= \eta \sqrt{1 - \left(\frac{f_c}{f}\right)^2} \\ &= 120\pi \sqrt{1 - \left(\frac{1}{1.6}\right)^2} \end{aligned}$$

$$\therefore \eta_{\text{TM}_{11}} = 294.295\Omega$$

**03. Ans: (d)**

**Sol:**  $F(w,x,y,z) = \sum m(0,2,6,9,10,12,15) + d(1,7,8,14)$



EPI's are (3), (4), (5)

$$\therefore \text{No.of EPI's} = 3$$

**04. Ans: 2 no range**

**Sol:**  $R_3 \rightarrow R_3 - R_1, R_4 \rightarrow R_4 - R_2$

$$\sim \left[ \begin{array}{cccc} 1 & 2 & 3 & 4 \\ 8 & 7 & 6 & 5 \\ 8 & 8 & 8 & 8 \\ 8 & 8 & 8 & 8 \end{array} \right] \sim \left[ \begin{array}{cccc} 1 & 2 & 3 & 4 \\ 8 & 7 & 6 & 5 \\ 8 & 8 & 8 & 8 \\ 0 & 0 & 0 & 0 \end{array} \right]$$

$$R_3 \rightarrow R_3 - 8R_1, R_2 \rightarrow R_2 - 8R_1$$

$$\sim \left[ \begin{array}{cccc} 1 & 2 & 3 & 4 \\ 0 & -9 & -18 & -27 \\ 0 & -8 & -16 & -24 \\ 0 & 0 & 0 & 0 \end{array} \right] \sim \left[ \begin{array}{cccc} 1 & 2 & 3 & 4 \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{array} \right] \Rightarrow \rho(A) = 2$$



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**05. Ans: (d)**

**Sol:**  $\overline{\overline{X + \bar{Y} + \bar{X}}} = \overline{\bar{X}\bar{Y}} + \overline{\bar{X}} = X$

**06. Ans: (b)**

**Sol:**  $\because L^{-1}\left\{\frac{\bar{f}(s)}{s}\right\} = \int_0^t L^{-1}\{\bar{f}(s)\}dt$

$$\text{Now, } L^{-1}\left\{\frac{1}{s(s-1)}\right\} = L^{-1}\left\{\frac{s-1}{s}\right\} = \int_0^t L^{-1}\left\{\frac{1}{s-1}\right\}dt \Rightarrow L^{-1}\left\{\frac{1}{s(s-1)}\right\} = \int_0^t e^t dt$$

$$\therefore L^{-1}\left\{\frac{1}{s(s-1)}\right\} = (e^t)_0^t = e^t - 1$$

**07. Ans: 0.41 ( Range 0.40 to 0.42)**

**Sol:**  $I_2 = Y_{22} V_2 \Big|_{V_i=0} = \frac{V_2}{3} + \frac{V_2}{12} = \left(\frac{1}{3} + \frac{1}{12}\right) V_2$

$$Y_{22} = \frac{5}{12} = 0.41 \text{ mho.}$$

**08. Ans: (a)**

**Sol:** Edge of saturation  $V_{DS} = V_{GS} - V_{TH}$

$$I_D = \frac{1}{2} \mu_n C_{ox} \left( \frac{W}{L} \right) (V_{GS} - V_{TH})^2$$

$$K_n^1 = \mu_n C_{ox} = 450 \times 10^{-4} \times 8.6 \times 10^{-15} \times 10^{12} \text{ A/V}^2 \\ = 387 \text{ } \mu\text{A/V}^2$$

$$K_n = K_n^1 \left( \frac{W}{L} \right) = 387 \left( \frac{2}{0.18} \right) = 4.3 \text{ mA/V}^2$$

$$100 \times 10^{-6} = \frac{1}{2} \times 4.3 \times 10^{-3} (V_{GS} - V_{TH})^2$$

$$V_{GS} - V_{TH} \approx 0.22 \text{ V}$$

$$V_{GS} = 0.22 \text{ V} + V_{TH} = 0.72 \text{ V}$$

$$V_{DS} = V_{GS} - V_{TH} = 0.22 \text{ V}$$

**09. Ans: (a)**

**Sol:** It is a finite duration signal extending from 0 to 4.

All finite duration signals are energy signals but not vice-versa.

**10. Ans: 2**

**Sol:**  $p = 3, z = 1$

Number of asymptotes

$$= |p - z| = 2$$



**11. Ans: (c)**

**Sol:** Ring modulator generates DSBSC signals at ODD harmonics of carrier frequency.

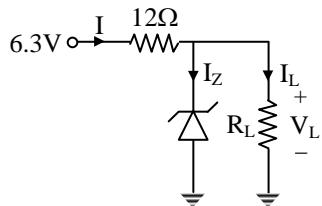
Desired carrier frequency to be generated is 12MHz. If 2MHz local oscillator frequency in ring modulator, it generates at 2MHz, 6MHz, 10MHz, 14MHz.....

If 3MHz, it generates at 3MHz, 9MHz, 15MHz.....

If 4MHz, it generates at 4MHz, 12MHz, 20MHz.....

**12. Ans: (a)**

**Sol:**



$$V_L = V_Z = 4.8V$$

$$\Rightarrow I = \frac{6.3 - 4.8}{12} = 0.125A$$

$$P_L = V_L \cdot I_L$$

For  $P_L$  to be maximum,  $I_L$  should be maximum

$$\Rightarrow I_{L,max} = I - I_{Z,min} = 0.125 - 0.005 \\ = 0.12 A$$

$$\Rightarrow P_{L,max} = 4.8 \times 0.12 = 0.576W$$

$$\therefore P_{L,max} = 576mW$$

**13. Ans: (a)**

**Sol:** Here, element cannot be resistor as  $V$  and  $i$  are not proportional. Required element is inductor

For  $0 < t < 2$  ms

$$\frac{di}{dt} = 5 \times 10^3 \text{ A/s and } V = 15 \text{ V}$$

$$\therefore L = \frac{V}{\frac{di}{dt}} = 3 \text{ mH}$$

**14. Ans: (c)**

**Sol:** Given that  $u = \frac{x^{3/2} + y^{3/2}}{4x - y}$

$\Rightarrow u(x, y)$  is a homogenous function with degree  $n = \frac{3}{2} - 1 = \frac{1}{2}$

By Euler's theorem for homogeneous functions, we have the following result.

If  $u = f(x, y)$  is a homogeneous function with degree 'n' in  $x$  and  $y$  then  $x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} = n \cdot u$

$$\therefore x \frac{\partial u}{\partial x} + y \frac{\partial u}{\partial y} = \frac{1}{2} u$$



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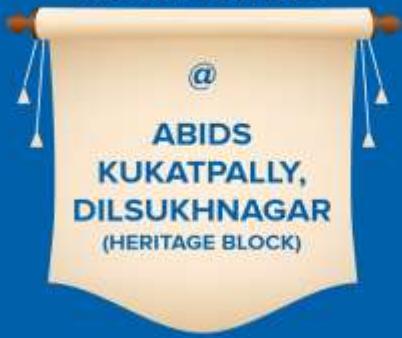
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**15. Ans: (d)**

**Sol:**

- ◆ Closed loop systems accuracy is very high due to correction of any arising error.
- ◆ Closed loop systems have high bandwidth, i.e., high operating frequency zone.
- ◆ Tendency towards oscillations if feedback is not properly utilised.

**16. Ans: (b)**

**Sol:** Given  $(4)\frac{\partial^2 u}{\partial x^2} + (-3)\frac{\partial^2 u}{\partial x \partial y} + (1)\frac{\partial^2 u}{\partial y^2} + (5)u = 0$

If we compare the given partial differential equation with general partial differential equation

$$A \frac{\partial^2 u}{\partial x^2} + B \frac{\partial^2 u}{\partial x \partial y} + C \frac{\partial^2 u}{\partial y^2} + D \frac{\partial u}{\partial x} + E \frac{\partial u}{\partial y} + Fu = Q \text{ then}$$

we get  $A = 4$ ,  $B = -3$  and  $C = 1$

If  $B^2 - 4AC < 0$  then the partial differential equation is said to be elliptic type.

Here,  $B^2 - 4AC = (-3)^2 - 4(4)(1) = -7 < 0$

∴ The given partial differential equation is elliptic type.

**17. Ans: (c)**

**Sol:**  $V_1 = 4I_1 + I_2 \dots \dots \dots \text{(i)}$

$V_2 = 3I_1 + 3I_2 \dots \dots \dots \text{(ii)}$

From (ii),

$$I_1 = \frac{V_2}{3} + (-I_2)$$

From equation (i),

$$V_1 = 4 \left[ \frac{V_2}{3} + (-I_2) \right] + I_2$$

$$V_1 = \frac{4}{3} V_2 + 3(-I_2) \Rightarrow \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 4/3 & 3 \\ 1/3 & 1 \end{bmatrix}$$

**18. Ans: (c)**

**Sol:** Given  $x(t) = 3 \sin(2t)$

Input frequency is  $\omega = 2$

$$H(2) = \frac{4}{2 + j2} = 1.4142 \angle -45^\circ$$

If input is the form  $x(t) = A \sin(\omega_0 t + \phi)$ . Then output is the form

$y(t) = A|H(\omega_0)| \sin(\omega_0 t + \phi + \angle H(\omega_0))$

$$y(t) = (3)(1.4142) \sin(2t - 45^\circ) = 4.2426 \sin(2t - 45^\circ)$$

**19. Ans: (b)**

**Sol:**  $P(x=2) = P(x=3)$

$$\frac{\lambda^2 e^{-\lambda}}{2!} = \frac{\lambda^3 e^{-\lambda}}{3!}$$



$$\frac{\lambda^2 e^{-\lambda}}{2} = \frac{(\lambda^2)(\lambda)e^{-\lambda}}{6}$$

$$\Rightarrow \lambda = 3$$

$$P(x \neq 0) = 1 - P(x = 0) = 1 - \frac{\lambda^0 e^{-\lambda}}{0!} = 1 - e^{-3}$$

**20. Ans: 0.2562 (Range: 0.24 to 0.27)**

**Sol:**  $N_D = 4.41 \times 10^{22} \times \frac{1}{10^8} \text{ atoms/cm}^3 = 4.41 \times 10^{14} \text{ atoms/cm}^3$

$$N_C = 4.82 \times 10^{15} \times \left( \frac{m_n}{m} \right)^{\frac{3}{2}} T^{\frac{3}{2}}$$

$$= 4.82 \times 10^{15} \times (0.5)^{\frac{3}{2}} (300)^{\frac{3}{2}}$$

$$= 8.8549 \times 10^{18} / \text{cm}^3$$

$$E_C - E_{Fn} = KT \ln \left( \frac{N_C}{N_D} \right) = 0.02586 \ln \left( \frac{8.8549 \times 10^{18}}{4.41 \times 10^{14}} \right) = 0.2562 \text{ eV}$$

**21. Ans: (a)**

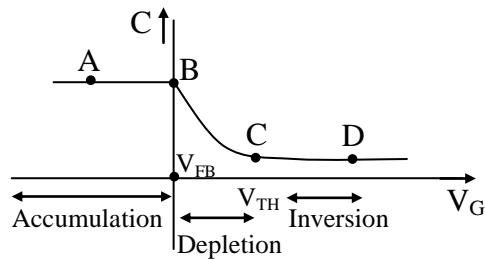
**Sol:**  $\delta = \sqrt{\frac{\omega \mu \sigma}{2}} = \sqrt{\frac{1}{0.5 \times 10^4 \pi \times 200 \times 4\pi \times 10^{-7} \times 5 \times 10^6}} = 2.25 \times 10^{-4} \text{ m} = 0.225 \text{ mm}$

**22. Ans: (b)**

**Sol:** Channel coding deliberately introduces redundancy into messages

**23. Ans: (b)**

**Sol:**



**24. Ans: (c)**

**Sol:**  $P(z) = P(x) P\left(\frac{z}{x}\right) = P(x) P\left(\frac{y}{x}\right) P\left(\frac{z}{y}\right) \quad \left( \because P\left(\frac{z}{x}\right) = P\left(\frac{y}{x}\right) P\left(\frac{z}{y}\right) \right)$

$$= [0.5 \ 0.5] \begin{bmatrix} 0.8 & 0.2 \\ 0.2 & 0.8 \end{bmatrix} \begin{bmatrix} 0.8 & 0.2 \\ 0.2 & 0.8 \end{bmatrix}$$



$$P(z) = \begin{bmatrix} 0.5 & 0.5 \\ 0.5 & 0.5 \end{bmatrix} \begin{bmatrix} 0.68 & 0.32 \\ 0.32 & 0.68 \end{bmatrix} = \begin{bmatrix} 0.5 & 0.5 \end{bmatrix}$$

**Note:** If two BSC, are cascaded then the resultant is also BSC

**25. Ans: 0.38 (Range: 0.37 to 0.39)**

$$\text{Sol: } \frac{C}{R} = \left( \frac{8}{1+8(2)} \right) \left( \frac{4}{1+4} \right) = \frac{32}{85} = 0.376$$

**26. Ans: (d)**

**Sol:** at  $f = 10\text{kHz}$

$$\text{(i.e.) } \frac{\sigma}{\omega\epsilon} = \frac{4}{2\pi \times 10 \times 10^3 \times \frac{1}{36\pi} \times 10^{-9} \times 81} = 88888.88 \gg 1$$

$$\therefore \alpha_{(f=10\text{kHz})} = \sqrt{\frac{\omega\mu\sigma}{2}} \quad \dots\dots(1) \quad \left\{ \omega = 2\pi \times 10^4 \text{ rad/sec} \right\}$$

At  $f = 10\text{GHz}$

$$\frac{\sigma}{\omega\epsilon} = \frac{4}{2\pi \times 10^{10} \times \frac{1}{36\pi} \times 10^{-9} \times 81} = 0.08888 \ll 1$$

$$\therefore \alpha_{(f=10\text{GHz})} = \frac{\sigma}{2} \sqrt{\frac{\mu}{\epsilon}} \quad \dots\dots(2)$$

$$\frac{\alpha_{(f=10\text{kHz})}}{\alpha_{(f=10\text{GHz})}} = \frac{\sqrt{\frac{\omega\mu\sigma}{2}}}{\frac{\sigma}{2} \sqrt{\frac{\mu}{\epsilon}}} = \sqrt{\frac{2\omega\epsilon}{\sigma}} = \sqrt{\frac{2 \times 2\pi \times 10^4 \times \frac{1}{36\pi} \times 10^{-9} \times 81}{4}}$$

$$\frac{\alpha_{(f=10\text{kHz})}}{\alpha_{(f=10\text{GHz})}} = 4.7 \times 10^{-3}$$

$$\alpha_{f_{10\text{kHz}}} < \alpha_{f_{10\text{GHz}}}$$

$\therefore$  we can infer that low frequencies are preferable to higher frequencies .



$$\text{For sea water, } \lambda_{f=10k} = \frac{2\pi}{\beta} = \frac{2\pi}{\sqrt{\frac{\omega\mu\sigma}{2}}} = 2\pi\sqrt{\frac{2}{\omega\mu\sigma}} \quad \because \left( \frac{\sigma}{\omega\epsilon} \gg 1 \right)$$

$$= 2\pi\delta_{\text{skin}} = 15.8\text{m} \quad \left[ \delta_{\text{skin sea water}} = \frac{1}{\sqrt{\pi \times 10^4 \times 4\pi \times 10^{-7} \times 4}} = \frac{1}{4\pi\sqrt{10^{-3}}} = 2.52 \right]$$

Frees space :

$$\lambda_{f=10k} = \frac{2\pi}{\omega\sqrt{\mu\epsilon}} = \frac{c}{f} = \frac{3 \times 10^8}{10^4} = 3 \times 10^4 \text{ m}$$

**27. Ans: (d)**

**Sol:** Let  $f(z) = \frac{e^z + \sin(z)}{\left(z - \frac{\pi}{2}\right)^4} = \frac{\phi(z)}{(z - z_o)^{n+1}}$

Then the singular point of  $f(z)$  is  $z = \frac{\pi}{2}$

Here, the singular point  $z = \frac{\pi}{2}$  lies in the given region  $\left|z - \frac{\pi}{2}\right| = 4$

Now, we can evaluate the given integral by using Cauchy's integral formula

$$\text{i.e. } \oint_C f(z) dz = \oint_C \frac{\phi(z)}{(z - z_o)^{n+1}} dz = \frac{2\pi i}{n!} \phi^{(n)}(z_o)$$

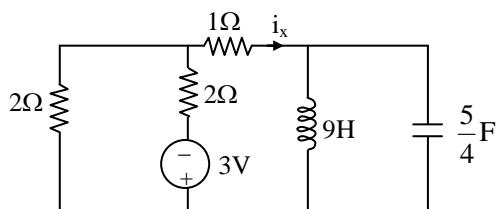
$$\Rightarrow \oint_C f(z) dz = \oint_C \frac{e^z + \sin(z)}{\left(z - \frac{\pi}{2}\right)^{3+1}} dz$$

$$\Rightarrow \oint_C f(z) dz = \frac{2\pi i}{3!} \phi''' \left( \frac{\pi}{2} \right) = \frac{2\pi i}{6} (e^z - \cos z)_{z=\frac{\pi}{2}}$$

$$\therefore \oint_C f(z) dz = \frac{\pi i}{3} e^{\pi/2}$$

**28. Ans: (d)**

**Sol:** At  $t = 0^-$ , the circuit is as shown below



Assume up to  $t = 0^-$ , the circuit is in steady state then the equivalent circuit is



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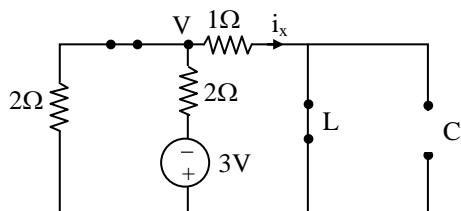
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Applying nodal analysis,

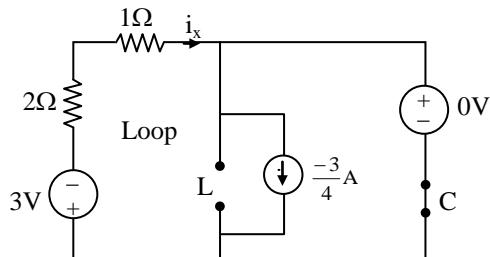
$$\Rightarrow \frac{V}{2} + \frac{V+3}{2} + \frac{V}{1} = 0$$

$$\Rightarrow V = \frac{-3}{4} V$$

$$\therefore i_x = \frac{V}{1} = \frac{-3}{4} A$$

$$\Rightarrow i_L(0^-) = i_x = \frac{-3}{4} A \text{ and } V_c(0^-) = 0V$$

At  $t = 0^+$  the circuit becomes



Applying kVL for the outer loop

$$\Rightarrow 3 + 3i_x + 0 = 0$$

$$\Rightarrow i_x = -1A$$

$\therefore i_x$  at  $t = 0^+$  is  $-1A$

## 29. Ans: (d)

**Sol:** Select line from  $\omega_2$  rise to 100 rad/sec.

$$\text{Slope} = \left( \frac{M_2 - M_1}{\log \omega_2 - \log \omega_1} \right) \Rightarrow -20 = \left( \frac{0 - 6}{\log 100 - \log \omega_2} \right)$$

$$\Rightarrow \log 100 - \log \omega_2 = \frac{-6}{-20} = 0.3$$

$$-\log \omega_2 = 0.3 - 2$$

$$\log \omega_2 = 1.7$$

$$\omega_2 = 50.11 \approx 50 \text{ rad/sec}$$

$$\Rightarrow TFG(s)H(s) = \frac{K(1 + s/20)}{s(1 + s/50)(1 + s/100)}$$

$$\omega_{gc} = 100 \text{ rad/sec} \text{ [from figure]}$$



$$PM = 180^\circ + \angle G(j\omega)H(j\omega)|_{\omega_{gc}} = 180^\circ + \left[ -90^\circ + \tan^{-1}\left(\frac{\omega_{gc}}{20}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{50}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{100}\right) \right]$$

$$PM = 180^\circ + \left[ -90^\circ + \tan^{-1}\left(\frac{100}{20}\right) - \tan^{-1}\left(\frac{100}{50}\right) - \tan^{-1}\left(\frac{100}{100}\right) \right] = 60^\circ$$

**30. Ans: (d)**

**Sol:** Excess-3 code never depends on BCO, where it was depends only on BCD and was obtained by adding 3 to each BCD digit.

Hence convert  $(100\ 101\ 011)_{BCO}$  into BCD & add 3 to each digit.

$$\begin{aligned}(100\ 101\ 011)_{BCO} &= (453)_8 = (299)_{10} \\ &= (0101\ 1100\ 1100)_{EX-3}\end{aligned}$$

**31. Ans: (a)**

$$e^{-a|t|} \leftrightarrow \frac{2a}{a^2 + \omega^2}$$

$$e^{-|t|} \leftrightarrow \frac{2}{1 + \omega^2}$$

From multiplication of 't' in time domain property

$$tx(t) \leftrightarrow j \frac{d}{d\omega} [X(\omega)]$$

$$te^{-|t|} \leftrightarrow j \frac{d}{d\omega} \left[ \frac{2}{1 + \omega^2} \right]$$

$$te^{-|t|} \leftrightarrow j \left[ \frac{-2(2\omega)}{(1 + \omega^2)^2} \right]$$

$$te^{-|t|} \leftrightarrow \frac{-4j\omega}{(1 + \omega^2)^2}$$

**32. Ans: (a)**

$$I_D = \mu_n C_{ox} \left( \frac{W}{L} \right) \left[ (V_{GS} - V_{TH})V_{DS} - \frac{1}{2} V_{DS}^2 \right]$$

Since  $V_{DS}$  is small, we can write

$$I_D = \mu_n C_{ox} \left( \frac{W}{L} \right) (V_{GS} - V_{TH}) V_{DS}$$

$$I_{D2} - I_{D1} = \mu_n C_{ox} \left( \frac{W}{L} \right) (V_{GS2} - V_{GS1}) V_{DS}$$

$$40 \times 10^{-6} = \mu_n (6.9 \times 10^{-8}) \left( \frac{15}{2} \right) (2.5 - 1.5)(0.10)$$

$$\Rightarrow \mu_n = 773 \text{ cm}^2/\text{V-s}$$





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$$\Rightarrow \frac{\partial E_x}{\partial z} = -j\omega\mu H_y$$

$$\Rightarrow \frac{5\beta \cos \beta z \sin \omega t}{-j\omega\mu} = H_y$$

$$\therefore H_y = j\frac{\beta}{\omega\mu} 5 \cos \beta z \sin \omega t$$

$$H_y = \frac{j5 \cos \beta z \sin \omega t}{\eta} \quad \left\{ \frac{\beta}{\omega\mu} = \frac{\omega\sqrt{\mu\epsilon}}{\omega\mu} = \sqrt{\frac{\epsilon}{\mu}} = \frac{1}{\eta} \right\}$$

$$\text{Where } \eta = \frac{\eta_0}{\sqrt{\epsilon_r}} = \frac{\eta_0}{\sqrt{4}} = \frac{\eta_0}{2}$$

At the planar interface,  $z = 0$ ,

$$\therefore H_y = \frac{j10 \sin \omega t}{\eta_0}$$

$$\Rightarrow H_y = \frac{j10 \sin \omega t}{120\pi} = j0.02652 \sin \omega t \text{ A/m}$$

$$\therefore \text{At the interface, } H_y = j0.02652 \sin \omega t \text{ A/m}$$

$$\text{Now, } \bar{J}_s = H_y \hat{a}_y \times (-\hat{a}_z)$$

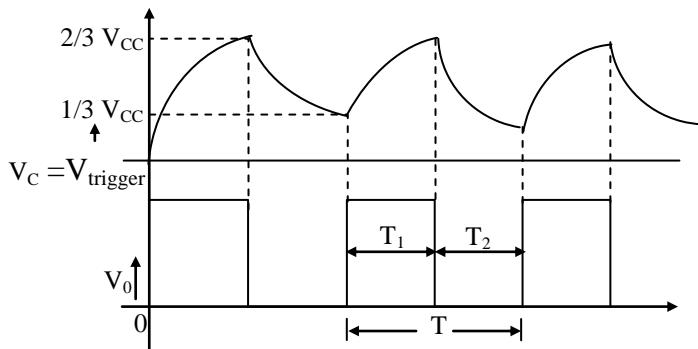
$$\bar{J}_s = H_y (-\hat{a}_x)$$

$$\bar{J}_s = -j0.02652 \sin \omega t \hat{a}_x \text{ A/m}$$

Hence the magnitude of surface current density comes out to be 0.0265 A/m (or) 26.5 mA/m

### 35. Ans: 5.65 (Range: 5.45 to 5.85 )

Sol:



$$\begin{aligned} T_1 &= 0.693 (R_A + R_B) C \\ &= 0.693 (2.2k + 4.7k) 0.022\mu \\ &= 0.1052 \text{ msec} \end{aligned}$$



$$T_2 = 0.693 R_B C \\ = 0.693 (4.7k) 0.022\mu = 0.0716562 \text{ msec}$$

Total period  $T = T_1 + T_2 = 0.1768562 \text{ msec}$

Frequency of oscillations (f),

$$= 1/T = 5.65 \text{ kHz}$$

**36. Ans: (a)**

**Sol:** Given  $f(x, y) = 4x^2 + 9y^2 + 8x - 36y + 24$

$$\Rightarrow p = f_x = 8x + 8, q = f_y = 18y - 36$$

$$\text{and } r = f_{xx} = 8, s = f_{xy} = 0, t = f_{yy} = 18$$

consider  $p = 0$  and  $q = 0$  for stationary points

$$\Rightarrow 8x + 8 = 0 \text{ & } 18y - 36 = 0$$

$$\Rightarrow x = -1 \text{ & } y = 2$$

$\therefore (x, y) = (-1, 2)$  is a critical point of  $f(x, y)$

At  $(x, y) = (-1, 2)$ ,  $r = 8$ ,  $s = 0$  &  $t = 18$

$$\text{Here, } rt - s^2 = (8)(18) - (0)^2 = 144$$

$$\text{and } r = 8 > 0$$

$\therefore (x, y) = (-1, 2)$  is a local point of minima.

Hence, the minimum value of the function

$$f(x, y) \text{ at } (-1, 2) \text{ is } f(-1, 2) = -16$$

**37. Ans: 0.43 (range 0.42 to 0.44)**

$$\frac{C(s)}{R(s)} = \frac{1}{1+Ts}$$

$$C(s) = \frac{6}{1+Ts}$$

$$C(t) = \frac{6}{T} e^{-t/T}$$

$$\text{At } t = 0, C(t) = 6/T = 4 \Rightarrow T = 3/2$$

At  $t = t_1$ ,

$$3 = \frac{6}{T} e^{-t_1/T}$$

$$3 = \frac{2}{3} \times 6 e^{-t_1/T}$$

$$3 = \frac{2}{3} \times 6 e^{-t_1^{2/3}}$$

$$\frac{3}{4} = e^{-2t_1/3}$$

$$\Rightarrow t_1 = 0.43 \text{ sec.}$$



**38. Ans: 0.4**

**Sol:**  $v_o = 10v_i + v_i^2$

$$K_a = \frac{2a_2}{a_1} = \frac{2 \times \text{coefficient of square term}}{\text{coefficient of linear term}} = \frac{2 \times 1}{10} = 0.2$$

$$\mu = |K_a m(t)|_{\max} = |0.2 \times (-2)|_{\max} = 0.4$$

**39. Ans: (d)**

**Sol:**  $\rightarrow (HL) = 1000H$

$$\rightarrow (A) = 45H$$

$$\rightarrow (B) = 96H$$

$\rightarrow (HL) = 1000H$  pushed to top of stack

$$\rightarrow (A) = 45H = 0100 0101$$

$$(B) = 96H = 1001 0110$$

$$(A) = DBH = 1101 1011$$

$$\underline{CY = 0, P = 0, AC = 0, Z = 0, S = 1}$$

$$\rightarrow (HL) = 1000H - 1 = 0FFFH$$

$\rightarrow (TOS) = 1000H$  popped into DE pair  
 $(DE) = 1000H$

$\rightarrow$  Decimal Adjust Accumulator After Addition

$$(A) = DBH = 1101 1011 + 66H = 0110 0110$$

$$(A) = 41H = 0100 0001$$

$$\underline{CY=1, P=1, AC=1, Z=0, S=0}$$

$\rightarrow$  Double Add HL to DE

$$(HL) = 0FFFH$$

$$(DE) = 1000H$$

$$\underline{(HL) = 1FFFH}$$

$$\rightarrow (\text{flag register}) = 00 \times 1 \times 1 \times 0 = 0001 0100 = 04H$$

$$(HL) = 1FFFH \& (PSW) = 4114H$$

**40. Ans: (b)**

**Sol:**  $X(z) = \frac{z}{(z-1)^3}$

$$\Rightarrow z^{n-1}X(z) = \frac{z^n}{(z-1)^3}$$

Poles of  $z^{n-1} X(z)$  are given by,

$$(z-1)^3 = 0$$

$$z = 1, z = 1, z = 1$$

i.e., 'z = 1' is a repeated pole of index 'm + 1 = 3'



Now,

$$\text{Residue of } z^{n-1} X(z) \text{ at repeated pole 'z = a' of index 'm + 1'} = \frac{1}{m!} \lim_{z \rightarrow a} \frac{d^m}{dz^m} (z-a)^{m+1} z^{n-1} X(z)$$

$$\therefore \text{Residue of } z^{n-1} X(z) \text{ at repeated pole 'z = 1' of index '3'} = \frac{1}{2!} \lim_{z \rightarrow 1} \frac{d^2}{dz^2} (z-1)^3 \frac{z^n}{(z-1)^3}$$

$$R = \frac{1}{2} \lim_{z \rightarrow 1} \frac{d^2}{dz^2} z^n$$

$$R = \frac{1}{2} \lim_{z \rightarrow 1} n(n-1)z^{n-2}$$

$$R = \frac{1}{2} n(n-1)u(n)$$

Now, By Residue method,

$Z^{-1}\{X(z)\} = \text{Sum of all the residues of } z^{n-1} X(z)$

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

**41. Ans: 216 (no range)**

**Sol:**  $W = 3 \text{ kHz}$

$$f_s = 2 \times W = 2 \times 2 \times 3 \text{ k} = 12 \text{ k samples per sec}$$

$$n = 4$$

Two extra guard bits per sample.

Since three signals are multiplexing, one frame contains three samples.

$$\therefore \text{Number of guard bits} = 2 \times 3 = 6$$

$$r_b = (nN + k)f_s = (4 \times 3 + 6) \times 12k$$

$$r_b = 216 \text{ kbps}$$

**42. Ans: (d)**

**Sol:** The power decays as  $P e^{-2\alpha z}$

at  $z = d$  power is attenuated to  $10^{-12} P$

$$\therefore P e^{-2\alpha d} = 10^{-12} P$$

$$-2\alpha d = \ell n(10^{-12})$$

$$\alpha d = 13.8155$$

$$d = \frac{13.8155}{\alpha} \quad \text{---(1)}$$

Since  $f < f_{cmn}$ ,  $\gamma_{mn}$  must be real

$$\therefore \gamma_{mn} = \alpha = \beta \sqrt{\left(\frac{f_{cmn}}{f}\right)^2 - 1}$$

$$\lambda f = 3 \times 10^8 \text{ m/sec}$$

$$\lambda = \frac{3 \times 10^8}{10^9} = 0.3 \text{ m}$$



$$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{0.3} = 20.94 \text{ rad/m}$$

$$\therefore \gamma_{mn} = \alpha = 20.94 \sqrt{(1.5)^2 - 1} = 23.41 \text{ Np/m}$$

substitute  $\alpha$  value in equation (1)

$$d = \frac{13.8155}{23.411} = 0.590 \text{ m}$$

$$d = 0.590 \text{ m}$$

**43. Ans: (b)**

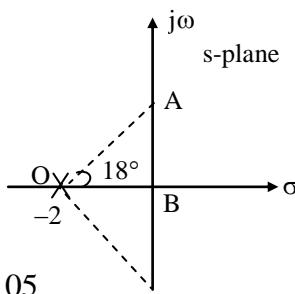
**Sol:**  $G(s)H(s) = \frac{k}{(s+2)^{10}}$

$$\text{Centroid} = \frac{\sum \text{poles} - \sum \text{zeroes}}{p-z} = \frac{(-2)10 - 0}{10} = -2$$

$$\text{Angle of asymptotes} = \frac{(2q+1)\pi}{p-z} = 18^\circ, 54^\circ \dots \dots$$

$$\cos 18^\circ = \frac{OB}{OA}$$

$$\Rightarrow OA = \frac{OB}{\cos 18^\circ} = \frac{2}{0.95} = 2.105$$

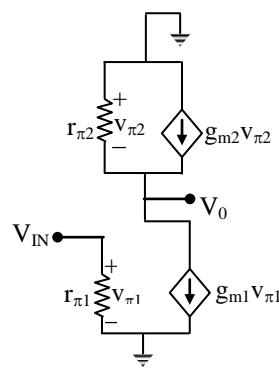


Maximum value of  $k$  for stability

$$= \frac{\text{product of distance from poles}}{\text{product of distance from zeroes}} \\ = (2.105)^{10}$$

**44. Ans: (a)**

**Sol:**





From figure,

$$V_0 = -V_{\pi 2}, V_{\pi 1} = V_{IN}$$

Apply KCL at output node:

$$\frac{V_0 - 0}{r_{\pi 2}} + g_{m1}V_{\pi 1} - g_{m2}V_{\pi 2} = 0$$

$$\Rightarrow \frac{V_0}{r_{\pi 2}} + g_{m1}V_{\pi 1} + g_{m2}V_0 = 0 \quad [\because V_{\pi 2} = -V_0]$$

$$\Rightarrow V_0 \left[ \frac{1}{r_{\pi 2}} + g_{m2} \right] = -g_{m1}V_{\pi 1}$$

$$V_0 \left[ \frac{1 + g_{m2}r_{\pi 2}}{r_{\pi 2}} \right] = -g_{m1}V_{IN} \quad [\because V_{\pi 1} = V_{IN}]$$

$$\left| \frac{V_0}{V_{IN}} \right| = \left| \frac{-g_{m1}r_{\pi 2}}{1 + g_{m2}r_{\pi 2}} \right| = \frac{g_{m1}r_{\pi 2}}{1 + g_{m2}r_{\pi 2}}$$

**45. Ans: (a)**

**Sol:**  $tu(t) \leftrightarrow \frac{1}{s^2}$

$$(t-2)u(t-2) \leftrightarrow \frac{e^{-2s}}{s^2} \left[ \because x(t-t_0) \leftrightarrow e^{-st_0}X(s) \right]$$

$$e^{-t}(t-2)u(t-2) \leftrightarrow \frac{e^{-(s+1)}}{(s+1)^2} \left[ \because e^{s_0 t}x(t) \leftrightarrow X(s-s_0) \right]$$

**46. Ans: 101.7 (Range: 99 to 103)**

**Sol:** Given that  $V_{TH0} = 0.6V$ ,  $\gamma = 0.4\sqrt{V}$  and  $\phi_F = 0.4V$

$$\begin{aligned} V_{TH} &= V_{TH0} + \gamma \left( \sqrt{2\phi_F + V_{SB}} - \sqrt{2\phi_F} \right) \\ &= 0.6 + 0.4 \left( \sqrt{0.8 + 0.5} - \sqrt{0.8} \right) \\ &= 0.698V \end{aligned}$$

Since  $V_G = V_D$ , the device is in saturation

$$I_D = \frac{1}{2} \mu_n C_{ox} \left( \frac{W}{L} \right) (V_{GS} - V_{TH})^2 = \frac{1}{2} \times 100 \mu \times 50 \times (0.9 - 0.698)^2 = 101.7 \mu A$$

**47. Ans: (b)**

**Sol:** Consider a closed surface enclosing the conductor with the charge 'Q' (but not the other conductor). We have to use ohm's and Gauss's laws

$$I = \oint \bar{J} \cdot d\bar{A} = \oint \sigma \bar{E} \cdot d\bar{A} \quad \{ \text{from ohm's law } \bar{J} = \sigma \bar{E} \}$$

$$= \sigma \oint \bar{E} \cdot d\bar{A} = \sigma \frac{Q}{\epsilon} \left\{ \text{from Gauss's law} = \oint \bar{E} \cdot d\bar{A} = \frac{Q}{\epsilon} \right\}$$

$$\therefore I = \sigma \frac{Q}{\epsilon}$$



If the potential difference between the two conductors is  $V$ , then we have  $V = IR$

$$(i.e) V = \sigma \frac{Q}{\epsilon} R \quad \left\{ \because I = \sigma \frac{Q}{\epsilon} \right\}$$

$$\therefore C = \frac{Q}{V} = \frac{Q}{\sigma \frac{Q}{\epsilon} R} = \frac{\epsilon}{\sigma R} = \frac{80\epsilon_0}{10^{-4} \times 10^5} \left\{ \epsilon_0 = \frac{1}{36\pi} \times 10^{-9} \right\}$$

$$= \frac{80 \times \frac{1}{36\pi} \times 10^{-9}}{10^{-4} \times 10^5}$$

$$C = 7.08 \times 10^{-11} F$$

**48. Ans: (d)**

**Sol:**  $N_A = 3 \times 10^{20}/cm^3$

$$\epsilon = 141.58 \times 10^{-12}$$

$$A = 0.01 cm^2$$

$$V_b = 0.1 V$$

$$V_j = V_0 - V_b = 0.2 - 0.1 = 0.1 V$$

$$w = \sqrt{\frac{2\epsilon V_j}{q}} \left( \frac{1}{N_D} + \frac{1}{N_A} \right)$$

$$w = \sqrt{\frac{2\epsilon V_j}{q N_A}} \approx \sqrt{\frac{2 \times 141.58 \times 10^{-12} \times 0.1}{1.6 \times 10^{-19} \times 3 \times 10^{20}}} \approx 0.7681 \times 10^{-6} cm$$

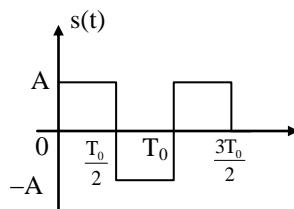
**49. Ans: (c)**

**Sol:** Maximum value of O/P = Energy of I/P signal

$$E_s(t) = \int_{-\infty}^{\infty} |s(t)|^2 dt$$

$$E = \int_0^{T_0/2} (A)^2 dt + \int_{T_0/2}^{T_0} (-A)^2 dt + \int_{T_0}^{3T_0/2} (A)^2 dt$$

$$= A^2 \cdot \frac{T_0}{2} + A^2 \cdot \frac{T_0}{2} + A^2 \cdot \frac{T_0}{2} = \frac{3A^2 T_0}{2}$$



**50. Ans: (b)**

**Sol:** Given  $f_l = 500Hz \Rightarrow \Omega_l = 1000\pi$

$$f_u = 1500Hz \Rightarrow \Omega_u = 3000\pi$$

For low pass to band pass transformation

$$s \rightarrow \Omega_p \left[ \frac{s^2 + \Omega_l \Omega_u}{s(\Omega_u - \Omega_l)} \right]$$

$$= \Omega_p \left[ \frac{s^2 + (1000\pi)(3000\pi)}{s(3000\pi - 1000\pi)} \right]$$



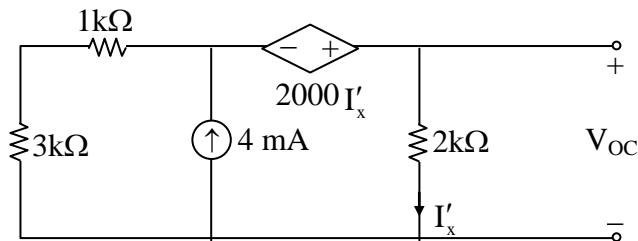
$$s \rightarrow \Omega_p \left( \frac{s^2 + 3\pi^2 \times 10^6}{2\pi s \times 10^3} \right) = \Omega_p \left( \frac{s^2 + a \times 10^6}{bs} \right)$$

$$\therefore a = 3\pi^2 \text{ and } b = 2\pi \times 10^3$$

**51.** **Ans: (a)**

**Sol:** Here,  $R_L = R_{th} + 4k\Omega$

$V_{OC}$ :



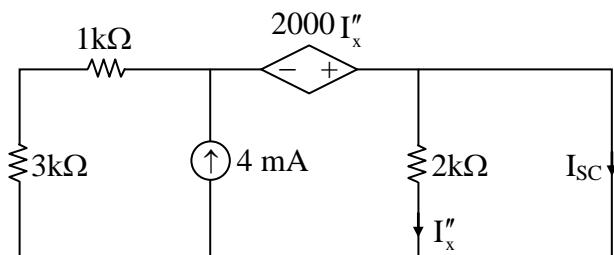
Apply KCL at super node,

$$\frac{V_{OC} - 2000I'_x}{1K + 3K} + (-4 \times 10^{-3}) + \frac{V_{OC}}{2K} = 0$$

$$\text{Also, } I'_x = \frac{V_{OC}}{2K}$$

$$\Rightarrow V_{OC} = 8 \text{ V}$$

$I_{SC}$ :

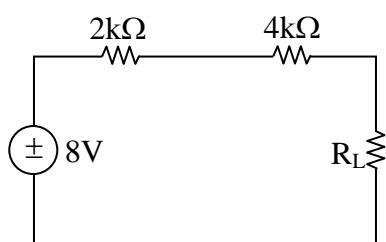


$$I''_x = 0 \text{ A}$$

$$\therefore I_{sc} = 4 \text{ mA}$$

$$R_{th} = \frac{V_{OC}}{I_{sc}} = \frac{8 \text{ V}}{4 \text{ mA}} = 2 \text{ k}\Omega$$

The circuit looks like





For maximum power transfer

$$R_L = 4 \text{ k}\Omega + R_{th}$$

$$R_L = 6 \text{ k}\Omega \quad P_L = \left( \frac{8}{12K} \right)^2 (6K) = \frac{8}{3} \text{ mW}$$

**52. Ans: (a)**

$$\text{Sol: } P(P) = P(Q) = P(R) = P(S) = \frac{1}{6}$$

$$P = P(P^C)P(Q^C)P(R^C)P(S) + P(P^C)P(Q^C)P(R^C)P(S^C)P(P^C)P(Q^C)P(R^C)P(S) + \dots$$

$$= \frac{1}{6} \left( \frac{5}{6} \right)^3 + \left( \frac{1}{6} \right) \left( \frac{5}{6} \right)^7 + \dots$$

$$= \left( \frac{1}{6} \right) \left( \frac{5}{3} \right)^3 \left\{ 1 + \left( \frac{5}{6} \right)^4 + \left( \frac{5}{6} \right)^8 + \dots \right\}$$

$$= \left( \frac{1}{6} \right) \left( \frac{5}{6} \right)^3 \left\{ \frac{1}{1 - \left( \frac{5}{6} \right)^4} \right\}$$

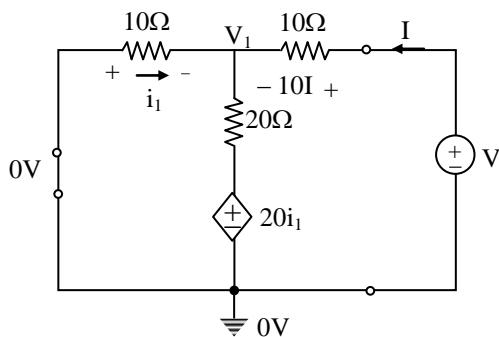
$$= \left( \frac{1}{6} \right) \left( \frac{5}{6} \right)^3 \left\{ \frac{6^4}{6^4 - 5^4} \right\}$$

$$= \left( \frac{1}{6} \right) \left( \frac{5^3}{6^3} \right) \left\{ \frac{6^4}{6^4 - 5^4} \right\} = \frac{125}{671}$$

**53. Ans: 14**

$$\tau = R_{eq} C \text{ sec}$$

Evaluation of  $R_{eq}$ :



$$\text{By KVL} \Rightarrow 0 - 10i_1 - V_1 = 0 \Rightarrow V_1 = -10i_1 \dots \quad (1)$$

$$\text{By KVL} \Rightarrow V_1 + 10I - V = 0 \Rightarrow V_1 = V - 10I \dots \quad (2)$$



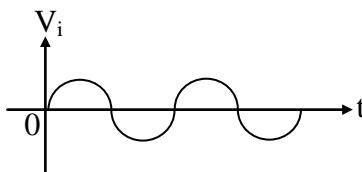
$$\text{Nodal} \Rightarrow -i_1 + \frac{V_1 - 20i_1}{20} - I = 0 \Rightarrow -40i_1 + V_1 = 20I$$

$$\Rightarrow V_1 = 4I \Rightarrow V - 10I = 4I \Rightarrow V = 14I \Rightarrow \frac{V}{I} = R_{eq} = 14$$

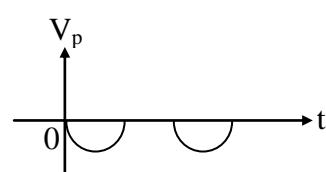
$$\text{So, } \tau = R_{eq}C = 14 \times 1 \mu\text{F} = 14 \mu\text{sec}$$

**54.** **Ans: (b)**

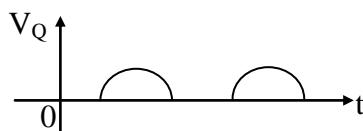
**Sol:** Let,



According to transfer characteristics for P-circuit

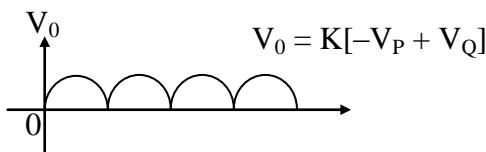


Similarly for Q-circuit



Now, let check option's

**Option-A** → To get the desired O/P of Full wave rectifier, i.e.,



Where K is the gain of Op-Amp. So, P-must be connected to inverting & Q-must be connected to Non-inverting terminals. Hence Option-A is False.

**Option-B** → Here P → connected to inverting & Q-Connected to Non-Inverting such that

$$V_0 = R/R [-V_P + V_Q]$$

⇒ Option-B is True.

**Option-C** → Here Even though it is acting as differential amplifier, but P → connected to Non-inverting & Q-connected to inverting ⇒ Wrong Option.

**Option-D** → Here it is Acting as Summing Amplifier where P & Q connected to Non-inverting terminal ⇒ Wrong option.

**55.** **Ans: (b)**

**Sol:** It is similar to JKFF where A = J, B = K

Now given that A = 1, B = 0 ⇒ J = 1, K = 0

$$\therefore \text{O/P } Q = 1, \bar{Q} = 0$$

**56.** **Ans: (c)**

**Sol:** (passive voice - verb in past participle form)

**57.** **Ans: (c)**

**Sol:** 'between.... to' is wrong. 'between.....and'.

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**58. Ans: (d)**

**Sol:** Suggestion is friendly/ smooth  
Demand is unfriendly/Rough  
Take is smooth  
Grab is Rough

**59. Ans: (c)**

**Sol:** Let the four numbers be  $x$ ,  $x + 2$ ,  $x + 4$ , and  $x + 6$ .

$$\Rightarrow x + x + 2 + x + 4 + x + 6 = 36$$

$$\Rightarrow 4x + 12 = 36$$

$$\Rightarrow x = 6$$

Therefore, the numbers are 6, 8, 10 & 12.

Therefore, the sum of their squares  $= 6^2 + 8^2 + 10^2 + 12^2 = 36 + 64 + 100 + 144 = 344$ .

**60. Ans: (a)**

**Sol:** We know that an ordinary year has 1 odd day and a leap year has 2 odd days.

During this period, namely 2005, 2006, 2007, 2008, 2009, 2010.

Total number of odd days  $= (1 + 1 + 1 + 2 + 1 + 1)$  days  $= 7 = 0$  odd days.

Hence, the calendar for 2005 will serve for the year 2011 too.

**61. Ans: (d)**

**Sol:** The solution to this problem can be obtained only with more information like ratio of the length of the rectangle to its breadth.

**62. Ans: (b)**

**Sol:** Amount  $= \left[ 7500 \times \left( 1 + \frac{4}{100} \right)^2 \right] = \left( 7500 \times \frac{26}{25} \times \frac{26}{25} \right) = 8112$

So, compound interest  $= (8112 - 7500) = 612$

**63. Ans: (c)**

**Sol:** Let their present ages be  $6x$  and  $7x$  respectively. Then, their age difference = 'x' years  
i.e.  $4 = 'x'$  years

$\therefore$  Their present ages are 24 & 28 respectively

Ratio of ages after 4 years  $= 24 + 4 : 28 + 4 = 7 : 8$

**64. Ans: (b)**

**Sol:** Expenditure in year 2016 (in 000') = 3800

Expenditure in year 2015 (in 000') = 3075

$$\Rightarrow \text{Required \% increase} = \frac{(3800 - 3075)}{3075} \times 100 = \frac{725}{30.75} = \frac{29}{1.23} = 23.57\%$$

**65. Ans: (b)**