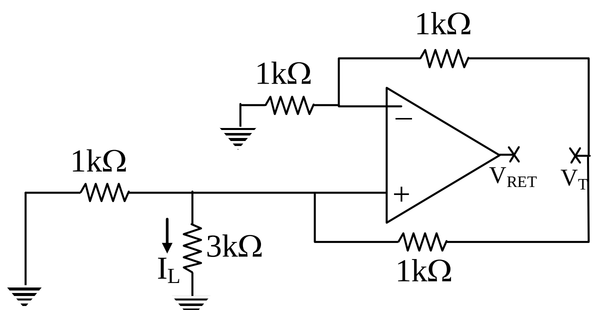
Branch: Electronics & Communication Engineering - SOLUTIONS

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.

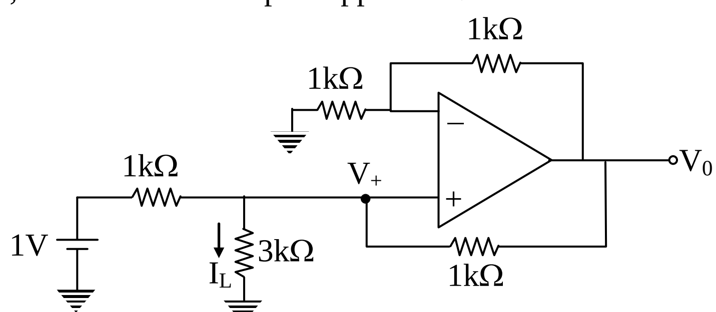


We get

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

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

$\therefore$ 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: TM_{11}

$a = 2.4cm$, $b = 1.2cm$

Air filled rectangular waveguide

$f = 1.6f_{c\,(TM11)}$

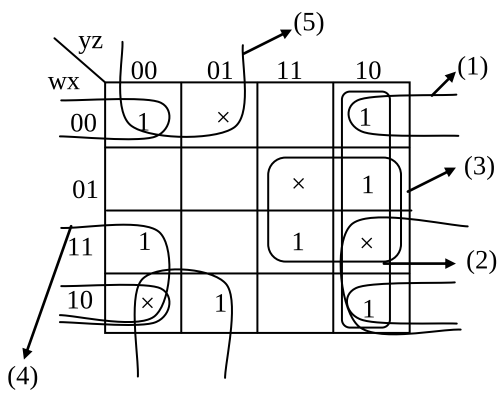
$$\text{Wave impedance } \left(\eta_{TM_{11}}\right) = \eta\sqrt{1-\left(\frac{f_c}{f}\right)^2}$$

$$= 120\pi\sqrt{1-\left(\frac{1}{1.6}\right)^2}$$

$$\therefore \eta_{TM_{11}} = 294.295\,\Omega$$

03. Ans: (d)

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



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

$\therefore$ No.of EPI's = 3

04. Ans: 2 no range

Sol: $R_3 \to R_3 - R_1$, $R_4 \to R_4 - R_2$

$$\sim \begin{bmatrix} 1 & 2 & 3 & 4 \\ 8 & 7 & 6 & 5 \\ 8 & 8 & 8 & 8 \\ 8 & 8 & 8 & 8 \end{bmatrix} \sim \begin{bmatrix} 1 & 2 & 3 & 4 \\ 8 & 7 & 6 & 5 \\ 8 & 8 & 8 & 8 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

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

$$\sim \begin{bmatrix} 1 & 2 & 3 & 4 \\ 0 & -9 & -18 & -27 \\ 0 & -8 & -16 & -24 \\ 0 & 0 & 0 & 0 \end{bmatrix} \sim \begin{bmatrix} 1 & 2 & 3 & 4 \\ 0 & 1 & 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \Rightarrow \rho(A) = 2$$

05. Ans: (d)

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

06. Ans: (b)

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

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

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

07. Ans: 0.41 (Range 0.40 to 0.42)

Sol: $I_2 = Y_{22} V_2\big|_{V_1=0} = \frac{V_2}{3}+\frac{V_2}{12} = \left(\frac{1}{3}+\frac{1}{12}\right)V_2$

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

08. Ans: (a)

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

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

$K_n^1 = \mu_n C_{ox} = 450\times10^{-4}\times8.6\times10^{-15}\times10^{12}$ A/V^2

$= 387\ \mu A/V^2$

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

$100\times10^{-6} = \frac{1}{2}\times4.3\times10^{-3}(V_{GS}-V_{TH})^2$

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

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

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

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

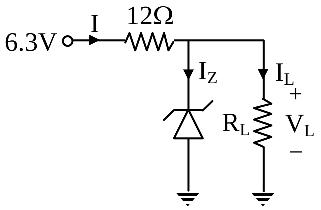
$= |p - z| = 2$

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:



$V_L = V_Z = 4.8V$

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

$P_L = V_L.I_L$

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

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

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

14. Ans: (c)

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

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

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 $x\dfrac{\partial u}{\partial x} + y\dfrac{\partial u}{\partial y} = n.u$

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

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

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

we get A = 4, B = – 3 and C = 1

If $B^2 - 4AC < 0$ then the partial different 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: $V_1 = 4I_1 + I_2$ ……….(i)

$V_2 = 3I_1 + 3I_2$ ………(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 ω = 2

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

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

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

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

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: $N_D = 4.41\times10^{22} \times \frac{1}{10^8}\,\text{atoms}/\text{cm}^3 = 4.41\times10^{14}\,\text{atoms}/\text{cm}^3$

$$N_C = 4.82\times10^{15}\times\left(\frac{m_n}{m}\right)^{\frac{3}{2}} T^{\frac{3}{2}}$$

$$= 4.82\times10^{15}\times(0.5)^{\frac{3}{2}}(300)^{\frac{3}{2}}$$

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

$$E_C - E_{Fn} = KT\ln\left(\frac{N_C}{N_D}\right) = 0.02586\ln\left(\frac{8.8549\times10^{18}}{4.41\times10^{14}}\right) = 0.2562\text{ eV}$$

21. Ans: (a)

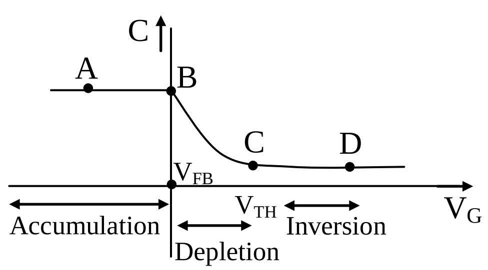
Sol: $$\delta = \frac{1}{\sqrt{\frac{\omega\mu\sigma}{2}}} = \frac{1}{\sqrt{0.5\times10^4\pi\times200\times4\pi\times10^{-7}\times5\times10^6}} = 2.25\times10^{-4}\text{ m} = 0.225\text{mm}$$

22. Ans: (b)

Sol: Channel coding deliberately introduces redundancy into messages

23. Ans: (b)

Sol:



24. Ans: (c)

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

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

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

$$= [0.5 \quad 0.5]$$

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

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

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 = 10kHz

$$\text{(i.e.)} \frac{\sigma}{\omega\varepsilon} = \frac{4}{2\pi\times10\times10^3\times\frac{1}{36\pi}\times10^{-9}\times81}$$

$$= 88888.88 >> 1$$

$$\therefore \alpha_{(f=10k)} = \sqrt{\frac{\omega\mu\sigma}{2}} \text{ ------(1)} \qquad \{\omega = 2\pi\times10^4 \text{ rad/sec}\}$$

At f = 10GHz

$$\frac{\sigma}{\omega\varepsilon} = \frac{4}{2\pi\times10^{10}\times\frac{1}{36\pi}\times10^{-9}\times81}$$

$$= 0.08888 << 1$$

$$\therefore \alpha_{(f=10GHz)} = \frac{\sigma}{2}\sqrt{\frac{\mu}{\varepsilon}} \text{ -----(2)}$$

$$\frac{\alpha_{(f=10kHz)}}{\alpha_{(f=10GHz)}} = \frac{\sqrt{\frac{\omega\mu\sigma}{2}}}{\frac{\sigma}{2}\sqrt{\frac{\mu}{\varepsilon}}} = \sqrt{\frac{2\omega\varepsilon}{\sigma}} = \sqrt{\frac{2\times2\pi\times10^4\times\frac{1}{36\pi}\times10^{-9}\times81}{4}}$$

$$\frac{\alpha_{(f=10kHz)}}{\alpha_{(f=10GHz)}} = 4.7\times10^{-3}$$

$$\alpha_{f_{10k}} < \alpha_{f_{10\,GHz}}$$

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

For sea water, $\lambda_{f=10k} = \frac{2\pi}{\beta} = \frac{2\pi}{\sqrt{\frac{\omega\mu\sigma}{2}}} = 2\pi\sqrt{\frac{2}{\omega\mu\sigma}}$ $\qquad \because \left(\frac{\sigma}{\omega\varepsilon} >> 1\right)$

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

Frees space :

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

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

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

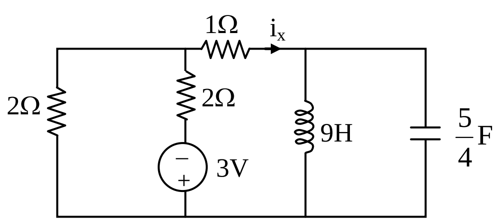
$\Rightarrow \oint_C f(z)dz = \oint_c \frac{e^z+\sin(z)}{\left(z-\frac{\pi}{2}\right)^{3+1}}dz$

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

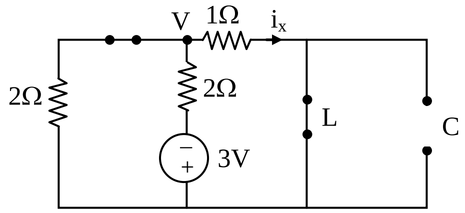
$\therefore \oint_c f(z)dz = \frac{\pi i}{3}e^{\pi/2}$

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



Applying nodal analysis,

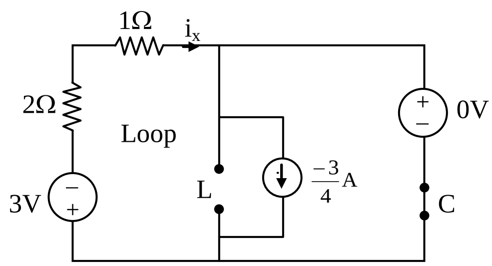
$$\Rightarrow \frac{V}{2}+\frac{V+3}{2}+\frac{V}{1}=0$$

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

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

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

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 ω_2 rise to 100 rad/sec.

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

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

$-\log\omega_2 = 0.3-2$

$\log\omega_2 = 1.7$

$\omega_2 = 50.11 \approx 50$ rad/sec

$$\Rightarrow TF\,G(s)H(s)=\frac{K(1+S/20)}{S(1+S/50)(1+S/100)}$$

ω_{gc} = 100rad/sec [from figure]

$$PM = 180^0 + \angle G(j\omega)H(j\omega)|_{\omega_{gc}} = 180^0 + \left[-90^0 + \tan^{-1}\left(\frac{\omega_{gc}}{20}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{50}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{100}\right)\right]$$

$$PM = 180^0 + \left[-90^0 + \tan^{-1}\left(\frac{100}{20}\right) - \tan^{-1}\left(\frac{100}{50}\right) - \tan^{-1}\left(\frac{100}{100}\right)\right] = 60^0$$

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.

$(100\ 101\ 011)_{BCO} = (453)_8 = (299)_{10}$

$= (0101\ 1100\ 1100)_{EX\text{-}3}$

31. Ans: (a)

Sol: $e^{-a|t|} \leftrightarrow \dfrac{2a}{a^2+\omega^2}$

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

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)

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

Since V_{DS} is small, we can write

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

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

$$40\times10^{-6} = \mu_n(6.9\times10^{-8})\left(\frac{15}{2}\right)(2.5-1.5)(0.10)$$

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

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

$$35 \times 10^{-6} = 773 \times 6.9 \times 10^{-8} \times \frac{15}{2} \times (1.5 - V_T)\ (0.10)$$

$\Rightarrow V_{TH} = 0.625V$

33. Ans: (a)

Sol: Given $(x^2D^2 - 2\,x\,D + 2)\,y = 8$ ----- (1),

where $D = \frac{d}{dx}$

Let $x = e^z$ (or) $\log x = z$
and $xD = \theta,\ x^2 D^2 = \theta\,(\theta - 1)$ } .... (2)

where $\theta = \frac{d}{dz}$

Put (2) in (1), we get

$[\theta(\theta - 1) - 2\theta + 2]\ y = 8$

$\Rightarrow (\theta^2 - 3\theta + 2)\ y = 8$

$\Rightarrow f(\theta)\ y = Q\ (z)$

Where $f\ (\theta) = \theta^2 - 3\ \theta + 2$ & $Q(z) = 8$

C.F:

Consider auxiliary equation $f(m) = 0$

$\Rightarrow m^2 - 3m + 2 = 0$

$\Rightarrow m = 1, 2$

$\therefore$ The complementary function is

$y_c = c_1e^z + c_2e^{2z} = c_1\ x + c_2\ x^2$

P.I:

$\because\ Q(z) = 8 = 8\ e^{0z + 0}$ $(\therefore\ Q(z) = ke^{az+b})$

Here, $f(\theta) = f(a) = f(0) = (0)^2 - 3(0) + 2 = 2 \neq 0$

$\therefore$ The particular integral is

$$y_p = \frac{1}{f(a)}Q(z) = \frac{1}{2}(8) = 4$$

Hence, the general solution of the given differential equation is $y = y_c + y_p = c_1x + c_2x^2 + 4$

34. Ans: 26.5 (25 to 28)

Sol: Given $\overline{E}_x = 5\sin\beta z\sin\omega t\hat{a}_x$ -----(1)

From (1) , it is clear that E_x is a function of z and t.

$\therefore\ \frac{\partial}{\partial x} = \frac{\partial}{\partial y} = 0$

From Maxwell's equation $\nabla\times\overline{E} = \frac{-\partial\overline{B}}{\partial t}$

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

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

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

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

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

At the planar interface, z = 0,

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

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

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

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

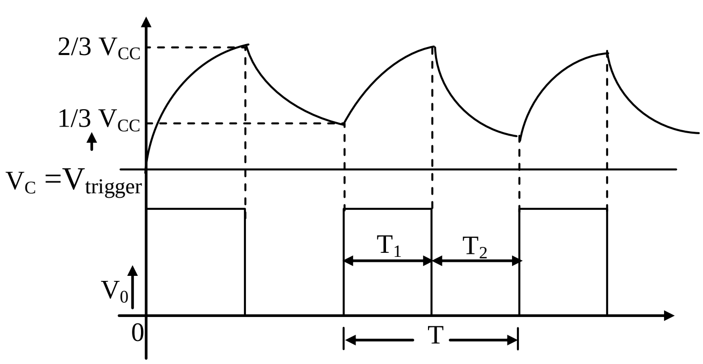
$$\bar{J}_s = H_y(-\hat{a}_x)$$

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

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:



$T_1 = 0.693 (R_A + R_B) C$

$= 0.693 (2.2k + 4.7k) 0.022\mu$

$= 0.1052$msec

$T_2 = 0.693\ R_BC$

$= 0.693\ (4.7k)\ 0.022\mu = 0.0716562msec$

Total period $T = T_1 + T_2 = 0.1768562msec$

Frequency of oscillations (f),

$= 1/T = 5.65kHz$

36. Ans: (a)

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

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

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

consider p = 0 and q = 0 for stationary points

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

$\Rightarrow x = -1$ & $y = 2$

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

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

Here, $rt - s^2 = (8)(18) - (0)^2 = 144$

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) at (–1, 2) is f(–1, 2) = –16

37. Ans: 0.43 (range 0.42 to 0.44)

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

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

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

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

At $t = t_1$,

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

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

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

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

$\Rightarrow t_1 = 0.43$ 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: → (HL) = 1000H
→ (A) = 45H
→ (B) = 96H
→ (HL) = 1000H pushed to top of stack

→ (A) = 45H = 0100 0101
(B) = 96H = 1001 0110
(A) = DBH = 1101 1011
CY = 0, P = 0, AC = 0, Z = 0, S = 1

→ (HL) = 1000H–1= 0FFFH
→ (TOS) = 1000H popped into DE pair
(DE) = 1000H
→Decimal Adjust Accumulator After Addition

(A) = DBH = 1101 1011
+ 66H = 0110 0110
(A) = 41H = 0100 0001
CY=1, P=1, AC=1, Z=0, S=0

→ Double Add HL to DE

(HL) = 0FFFH
(DE) = 1000H
(HL) = 1FFFH

→ (flag register) = 00×1 ×1×0 = 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,

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

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

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

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

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

Now, By Residue method,

$Z^{-1}\{X(z)\}$ = 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 kHz

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

n = 4

Two extra guard bits per sample.

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

$\therefore$ Number of guard bits = 2×3 = 6

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

r_b = 216 kbps

42. Ans: (d)

Sol: The power decays as $Pe^{-2\alpha z}$

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

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

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

$\alpha d = 13.8155$

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

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

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

$\lambda f = 3\times 10^8$ 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 α value in equation (1)

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

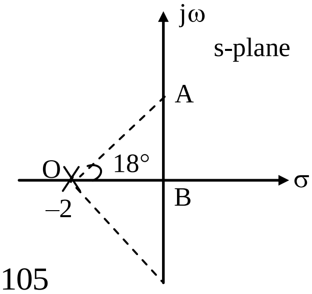
d = 0.590m

43. Ans: (b)

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

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

Angle of asymptotes $= \dfrac{(2q+1)\pi}{p-z} = 18^\circ, 54^\circ$……...



$$\cos 18° = \frac{OB}{OA}$$

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

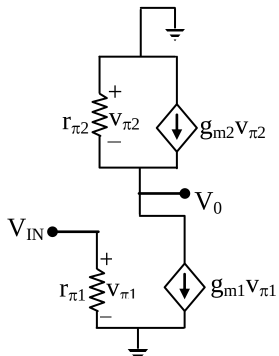
Maximum value of k for stability

$$= \frac{\text{product of distance from poles}}{\text{product of distance from zeroes}}$$

$$= (2.105)^{10}$$

44. Ans: (a)

Sol:



From figure,

$V_0 = -V_{\pi2}$, $V_{\pi1} = V_{IN}$

Apply KCL at output node:

$$\frac{V_0 - 0}{r_{\pi2}} + g_{m1}V_{\pi1} - g_{m2}V_{\pi2} = 0$$

$$\Rightarrow \frac{V_0}{r_{\pi2}} + g_{m1}V_{\pi1} + g_{m2}V_0 = 0 \quad [\because V_{\pi2} = -V_0]$$

$$\Rightarrow V_0\left[\frac{1}{r_{\pi2}} + g_{m2}\right] = -g_{m1}V_{\pi1}$$

$$V_0\left[\frac{1 + g_{m2}r_{\pi2}}{r_{\pi2}}\right] = -g_{m1}V_{IN} \quad [\because V_{\pi1} = V_{IN}]$$

$$\left|\frac{V_0}{V_{IN}}\right| = \left|\frac{-g_{m1}r_{\pi2}}{1 + g_{m2}r_{\pi2}}\right| = \frac{g_{m1}r_{\pi2}}{1 + g_{m2}r_{\pi2}}$$

45. Ans: (a)

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

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

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

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

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

$$V_{TH} = V_{TH0} + \gamma\left(\sqrt{2\phi_F + V_{SB}} - \sqrt{2\phi_F}\right)$$

$$= 0.6 + 0.4\left(\sqrt{0.8 + 0.5} - \sqrt{0.8}\right)$$

$$= 0.698V$$

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

$$I = \oiint \bar{J}.\overline{dA} = \oiint \sigma\bar{E}.\overline{dA} \ \{\text{from ohm's law } \bar{J} = \sigma\bar{E}\}$$

$$= \sigma\oiint \bar{E}.\overline{dA} = \sigma\frac{Q}{\varepsilon}\left\{\text{from Gauss's law} = \oiint \bar{E}.\overline{dA} = \frac{Q}{\varepsilon}\right\}$$

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

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

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

$$\therefore C = \frac{Q}{V} = \frac{Q}{\sigma \frac{Q}{\varepsilon} R} = \frac{\varepsilon}{\sigma R} = \frac{80\varepsilon_0}{10^{-4} \times 10^{5}} \quad \left\{ \varepsilon_0 = \frac{1}{36\pi} \times 10^{-9} \right\}$$

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

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

48. Ans: (d)

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

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

$A = 0.01\ cm^2$

$V_b = 0.1$ V

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

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

$$w = \sqrt{\frac{2\varepsilon V_j}{qN_A}} \simeq \sqrt{\frac{2 \times 141.58 \times 10^{-12} \times 0.1}{1.6 \times 10^{-19} \times 3 \times 10^{20}}} \simeq 0.7681 \times 10^{-6} \text{ cm}$$

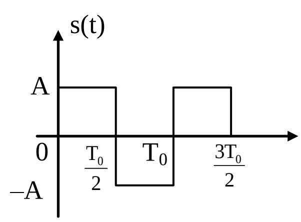
49. Ans: (c)

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

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

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

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



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

$$s \to \Omega_p \left[\frac{s^2 + \Omega_\ell \Omega_u}{s(\Omega_u - \Omega_\ell)} \right]$$

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

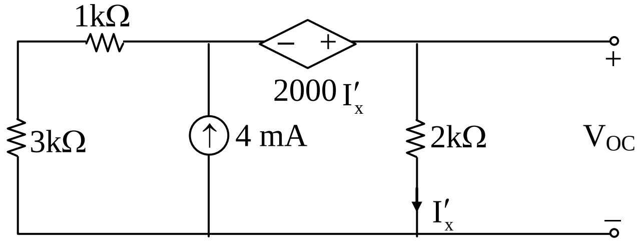
$$s \rightarrow \Omega_p\left(\frac{s^2 + 3\pi^2 \times 10^6}{2\pi s \times 10^3}\right) = \Omega_p\left(\frac{s^2 + a \times 10^6}{bs}\right)$$

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

51. Ans: (a)

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

V_{OC}:



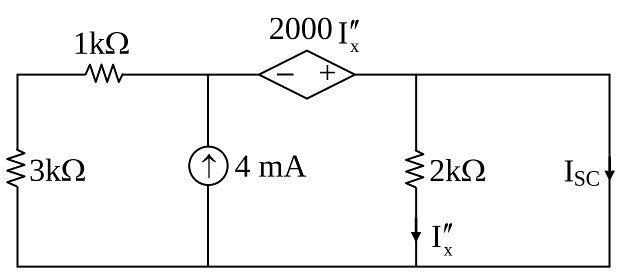
Apply KCL at super node,

$$\frac{V_{OC} - 2000I'_x}{1K + 3K} + (-4\times10^{-3}) + \frac{V_{OC}}{2K} = 0$$

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

$\Rightarrow V_{OC} = 8$ V

I_{SC}:

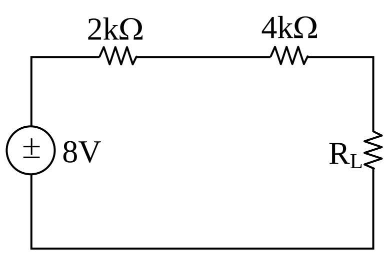


$I''_x = 0$ A

$\therefore I_{sc} = 4$ mA

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

The circuit looks like



For maximum power transfer

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

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

52. Ans: (a)

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

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

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

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

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

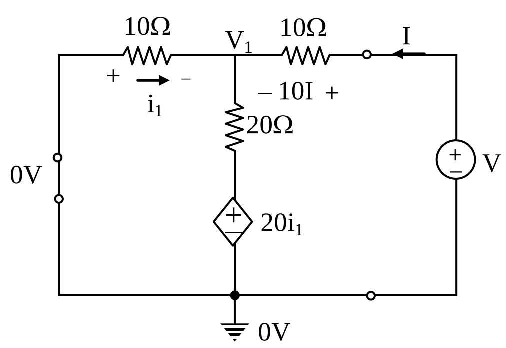
$$= \left(\frac{1}{6}\right)\left(\frac{5}{6}\right)^3 \left\{\frac{6^4}{6^4 - 5^4}\right\}$$

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

53. Ans: 14

Sol: $\tau = R_{eq}\, C$ sec

Evaluation of R_{eq}:



By KVL $\Rightarrow 0 - 10i_1 - V_1 = 0 \Rightarrow V_1 = -10i_1$ …… (1)

By KVL $\Rightarrow V_1 + 10I - V = 0 \Rightarrow V_1 = V - 10I$…… (2)

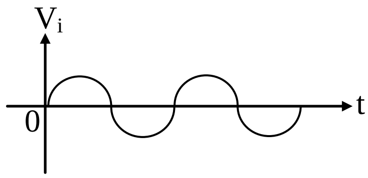
$$\text{Nodal} \Rightarrow -i_1 + \frac{V_1 - 20i_1}{20} - I = 0 \Rightarrow -40i_1 + V_1 = 20I$$

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

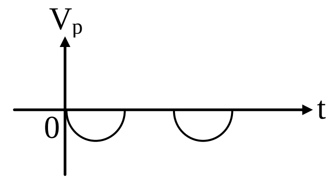
So, $\tau = R_{eq}C = 14 \times 1\mu F = 14\mu sec$

54. **Ans: (b)**

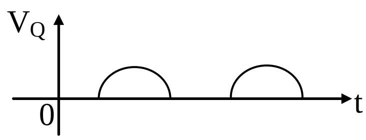
Sol: Let,



According to transfer characteristics for P-circuit

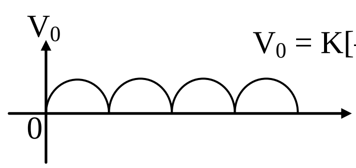


Similarly for Q-circuit



Now, let check option's

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



$V_0 = K[-V_P + V_Q]$

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

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

56. **Ans: (c)**

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

57. **Ans: (c)**

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

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 4years = 24 + 4 : 28 + 4 = 7 : 8

64. **Ans: (b)**

Sol: Expenditure in year 2016 (in 000') = 3800
Expenditure in year 2015 (in 000') = 3075

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

65. **Ans: (b)**