$\Rightarrow I_B = \frac{2mA}{50} = 0.04\ mA$

From (1)

$$R_B = \frac{V_{CC} - V_{BE}}{I_B}$$

$$R_B = \frac{12-0.7}{0.04m} = 283\ k\Omega$$

40. Ans: (A)

Sol: R_2/ph = 0.025Ω, X_2/ph=0.12Ω, $T_{st} = \frac{3}{4}T_{max}$

$$\frac{2a}{1+a^2} = \frac{3}{4}$$

$\Rightarrow 8a = 3 + 3a^2$

$\Rightarrow 3a^2 - 8a+3 = 0$

a = 2.21, 0.451

For motor operation slip range is 0 to 1

∴ a = 0.451

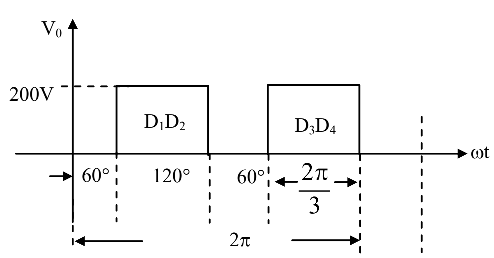
$$\frac{R_2+R_e}{X_2} = 0.451$$

$$\frac{0.025+R_e}{0.12} = 0.451$$

R_e = 0.029 Ω / ph.

41. Ans: 2000

Sol: output voltage of rectifier is shown below



Average output voltage, $V_0 = 200 \times \frac{2\pi/3}{\pi}$

$= \frac{400}{3}$ V ,$P_0 = V_0.I_0$

$= \frac{400}{3} \times 15 = 2000$ W

42. Ans: (C)

Sol: $\left|\frac{k}{s^2}\right| = 1$ at ω = 4

$$\frac{k}{\omega^2} = 1$$

$k = \omega^2 = 16$

For a type-2 system k_a = k =16

43. Ans: (A)

Sol: Power delivered by salient pole motor,

$$P = \frac{E_f.V_t}{X_d}.\sin\delta + \frac{V_t^2}{2}.\left(\frac{X_d - X_q}{X_d\ X_q}\right)\sin 2\delta$$

In the above equation, the second term indicates reluctance power, which is independent on field excitation and would be present even if field is fails or unexcited.

This reluctance power is maximum at,

δ = 45°

$\Rightarrow P_{max}$

When excitation fails = $\frac{V_t^2}{2}\left(\frac{X_d - X_q}{X_d X_q}\right)$

$$= \frac{(6.6)^2}{2} \times \left(\frac{23.2-14.5}{23.2\times14.5}\right)$$

P_{max} = 563 kW

44. Ans: 83° range (82° to 84°)

Sol: $P_s = P_{e1} = 1.0$

$$P_{m1} = \frac{EV}{X_{1eq}} = \frac{1.1\times1.0}{0.5} = 2.2$$

$P_{m2} = 0$

$P_{m3} = P_{m1} = 2.2$

$$\delta_0 = \sin^{-1}\left(\frac{P_s}{P_{m1}}\right) = \sin^{-1}\left(\frac{1.0}{2.2}\right)$$

$$= 27° = 0.47 \text{ rad}$$

$$\delta_m = 180 - \sin^{-1}\left(\frac{P_s}{P_{m3}}\right) = 180 - \sin^{-1}\left(\frac{P_s}{P_{m1}}\right)$$

$\delta_m = 180 - 27°$

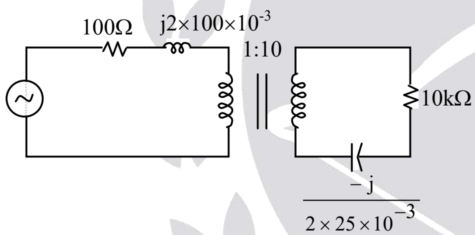
$$\delta_c = \cos^{-1}\left(\frac{1.0(2.7-0.47)+2.2\cos 153°}{2.2}\right)$$

$$\delta_c = \cos^{-1}\left(\frac{1.0(2.7-0.47)-1.96}{2.2}\right)$$

$$= \cos^{-1}(0.122) = 83°$$

45. Ans: (C)

Sol:



By transferring secondary impedance to primary then

$$z_2' = \frac{z_2}{k^2} \qquad k = \frac{10}{1} = 10$$

$$z_2' = \frac{10k\Omega - \dfrac{j}{2\times 25\times 10^{-3}}}{100}$$

$$= 100 - \frac{j}{5} = 100 - j0.2$$

$$I_1 = \frac{50}{100 + j0.2 + 100 - j0.2}$$

$$= \frac{50}{200} = \frac{1}{4} = 250\,\text{mA}$$

$$I_2 = \frac{I_1}{k} = \frac{I_1}{10} = 25\,\text{mA}$$

So power dissipated in the 10kΩ resistor is

$$P = (25\times 10^{-3})^2\ 10k\Omega$$

$$= 6.25 \text{ W}$$

46. Ans: 69.77 (Range 68 to 71)

Sol: Given data, $R_a = 0.1\ \Omega$, $V_b = 2V$,

$N_1 = 1000$rpm, $I_{a1} = 100$A, $V_{t1} = 250$V, $N_2 = 700$rpm

$E_{g1} = R_a I_{a1} + V_b + 250$

$= 0.1\times100+2+250$

$= 262$V

Now $N_2 = 700$ rpm

$$\frac{Eg_1}{Eg_2} = \frac{N_1}{N_2}$$

$$E_{g2} = \frac{700\times 262}{1000} = 183.4\text{V}$$

And $R_L = \frac{V_{t1}}{I_{a1}} = \frac{250}{100} = 2.5\Omega$

Therefore $E_{g2} = I_{a2}R_a + V_b + I_{a2}\times R_L$

$183.4 = I_{a2}\times0.1 + 2 + I_{a2}\times 2.5$

$\Rightarrow I_{a2} = 69.769$A

47. Ans: 0.89 (Range: 0.85 to 0.95)

Sol: $H(z) = \frac{z}{z-0.5} \quad \omega = \frac{\pi}{2} \quad z = e^{j\omega} = j$

$$\Rightarrow H(z)\big|_{z=j} = \frac{j}{j-0.5}$$

$$A = \frac{1}{\sqrt{1^2 + (0.5)^2}} = 0.8944$$

48. Ans: (B)

Sol: Characteristic equation $= |SI - A| = 0$

$$\begin{vmatrix} s & -1 \\ 3 & s+4 \end{vmatrix} = 0$$

$s^2 + 4s + 3 = 0$

$\omega_n = \sqrt{3}$ and $2\zeta\omega_n = 4$

$$\zeta = \frac{2}{\omega_n} = \frac{2}{\sqrt{3}}$$

$$\zeta = \frac{2}{\sqrt{3}}$$

49. Ans: 2.83 (Range 2 to 3)

Sol: $V = \int \frac{\rho_s dS}{4\pi\varepsilon_0 |\bar{r}_2 - \bar{r}_1|}, \rho_s = \frac{1}{\rho} nC/m^2$

The surface charge density lies in z=0 plane. To this plane $\pm \hat{a}_z$ are perpendicular . hence

$d\bar{S} = \pm(\rho d\rho d\phi)\hat{a}_z$ or $dS = \rho d\rho d\phi$

Point 2 is that point at which potential is desired. Hence 2(0,0,z).point 1 is the general point in z=0 plane, hence point 1(ρ,ϕ,0).

$\bar{R}_{12} = \bar{r}_2 - \bar{r}_1 = z\hat{a}_z - \rho\hat{a}_\rho$

$|\bar{r}_2 - \bar{r}_1| = \sqrt{z^2 + \rho^2}$

$$\therefore V = \frac{1}{4\pi\varepsilon_0}\int_0^{0.01}\int_0^{2\pi} \frac{\rho d\rho d\phi \times 10^{-9}}{\rho\sqrt{z^2+\rho^2}}$$

$$= \frac{10^{-9}}{4\pi\varepsilon_0} \times \ln\left[\frac{\rho + \sqrt{\rho^2 + z^2}}{z}\right]_0^{0.01} [\phi]_0^{2\pi}$$

$$= \frac{10^{-9}}{4\pi \times \frac{10^{-9}}{36\pi}} \times \left[\ln\left[\frac{0.01 + \sqrt{(0.01)^2 + (0.2)^2}}{0.2}\right] - 0\right] \times 2\pi$$

= 2.83V

50. Ans: (C)

Sol: Given $\bar{F} = 3x\bar{i} + y^2\bar{j}$

Along y –axis , $x = 0 \Rightarrow dx = 0$

$$\int_c \bar{F}.dr = \int_c 3xdx + y^2 dy$$

$$= \int_2^3 y^2 dy$$

$$= \left[\frac{y^3}{3}\right]_2^3$$

$$= \frac{27-8}{3} = \frac{19}{3}$$

51. Ans: (B)

Sol:

x	1	2	3
f(x)	1	1/4	1/9

Simpson's rule

$$= \frac{h}{3}[y_o + 4y_1 + y_2]$$

$$= \frac{1}{3}\left[1 + 4 \times \frac{1}{4} + \frac{1}{9}\right]$$

$$= \frac{1}{3}\left[2 + \frac{1}{9}\right]$$

$$= \frac{19}{27}$$

52. Ans: (B)

Sol: $x(t) = \text{rect}(t) \Rightarrow C_n \propto \frac{1}{n}$

For the system transfer function $\frac{1}{n}$ dependency is there

$\therefore$ Output coefficient $\propto \frac{1}{n^2}$

53. Ans: 3

Sol: $P = x \oplus y \oplus xy$

$P = (x \oplus y)\overline{xy} + (\overline{x \oplus y})\, xy$

$= (\bar{x}y + x\bar{y})(\bar{x} + \bar{y}) + (\bar{x}\,\bar{y} + xy)xy$

$= \bar{x}y + x\bar{y} + xy$

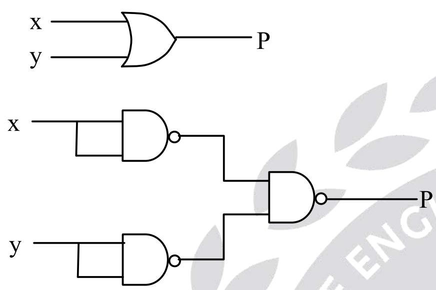
$= \bar{x}y + x(y+\bar{y})$

$= x + \bar{x}y$

$= (x+\bar{x})(x+y)$

$\therefore\ P = x + y$

Since it is an OR operation, 3 NAND gates are required to implement the given Boolean function



54. Ans: (A)

Sol: point P is above conducting plane z = 2 . If we drop a perpendicular from point P on the plane z = 2, the coordinate of the foot of the perpendicular will be (2,–3,2). Hence the distance of point P from the z=2 plane is

$$\sqrt{(2-2)^2+(-3+3)^2+(5-2)^2} = 3.$$

Consider a point P′ which is mirror image of point P.The distance of point P′ from the plane z=2 will be 3.Hence the co ordinate of point p′ be (2,–3,-1).If a perpendicular is dropped from P′ on plane z=2, the co ordinates of foot of perpendicular will be (2,–3,2). At this point P′, the charge of –25nC(which is image of 25nC) is located.

V at (3,2,4) is = V due to 25nC+V due to –25nC

$$= \frac{25\times10^{-9}}{4\pi\varepsilon_0\sqrt{(3-2)^2+(2+3)^2+(4-5)^2}} + \frac{-25\times10^{-9}}{4\pi\varepsilon_0\sqrt{(3-2)^2+(2+3)^2+(4+1)^2}}$$

= 11.7789V

55. Ans: (C)

Sol: $\tan\phi = \dfrac{\sqrt{3}(W_1-W_2)}{W_1+W_2}$

Power consumed by load,

$P = W_1 + W_2$

$$= \frac{\sqrt{3}(W_1-W_2)}{\tan\phi}$$

$$= \frac{\sqrt{3}\times50}{\left[\frac{50}{100}\right]} = 100\sqrt{3}\text{W}$$