HINTS & SOLUTIONS

1. **(a)** Distend means to expand or stretch or swell. Hence, the opposite meaning is diminish.
2. **(d)** Frugal means saving, not wasteful.
3. **(a)** The word **nondescript** and the phrase **easily recognized** make for just the sort of contrast that lends coherence to the sentence as a whole.
4. **(a)** Let number of 1 rupee coin is x, 50 paisa coin is y, and 25 paisa coin is z. According to question

$$x+\frac{y}{2}+\frac{z}{4}=51$$

Again y = 2x and y = 4z or $x=\frac{y}{2}$ and $z=\frac{y}{4}$

Thus, $\frac{y}{2}+\frac{y}{2}+\frac{y}{16}=51$

$\Rightarrow$ y=48, y = 24, z = 12

5. **(a)** Sum of the digits of a number with any number of digits, which is divisible by 9 is 9. Working in options wages. Thus, x = 9. And hence y = 9 and z = 9.
6. **(a)** Honeybees, unlike many other varieties of bees, are able to live through the winter by clustering together in a dense ball for body warmth.
Main ideas are unlike other bees, honey bees form cluster in winter to gain body warmth for survival. The numbers, how they eat, how they move are secondary ideas according to the passage.
7. **(a)** Total number of steps elapsed in both the case is same as speed of escalator is constant. Hence according to question
26 + 30x = 34 + 18x

$\Rightarrow$ $x=\frac{2}{3}$ steps

Thus, required number of steps = 26 + 30x

$26+30x\times\frac{2}{3}=46$ steps

8. **(b)** Total travel time including rest time according to watch at home from 2 : 35 pm to 4 : 00 pm = 1 h 25 min.
Total travel time excluding rest time = 1 h 25 min – 25 min
= 1 h 60 min
The ratio of time for going to office and coming from office = 2 : 1 and total time taken only for travelling = 60 min $\Rightarrow$ 3x = 60 min be 2x = 40 min.
He took 40 min to go to office. Thus the time while he reached at office must be 2.35 + 40 min = 3 : 15.
But the time at office watch was 3 : 10. Hence the office watch was 5 min late.
9. **(c)** Considering relative speed, as A meets C every 88 seconds then if C is at a constant point then A covers the circular track in each 88 seconds same for B also which covers the distance in 110 seconds.

With respect to C speed of A is $2\times\pi\times\frac{r}{88}$ and that of B is $2\times\pi\times\frac{r}{110}$.

Relative speed of A and B is

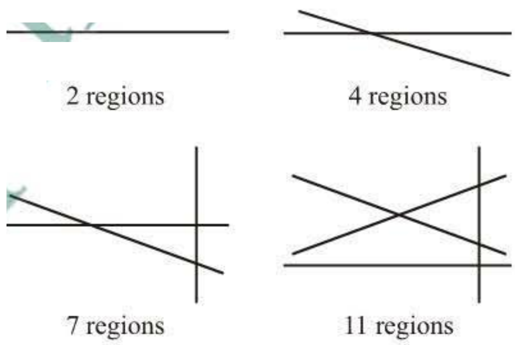
$$\left(2\times\pi\times\frac{r}{88}-2\times\pi\times\frac{r}{110}\right)=2\times\pi\times\frac{r}{t}$$

where, t is the time after which A meets B

Thus $\left(\frac{1}{88}\right)-\left(\frac{1}{110}\right)=\frac{1}{t}$

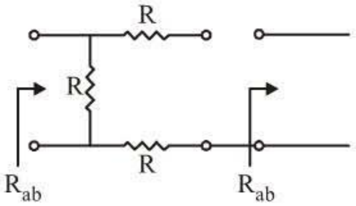
$\Rightarrow$ t = 440

10. **(c)** One line divides the whole space into two and two lines into 4.



If no two lines are parallel and no three are concurrent, then 3rd line can cut the existing lines atmost two places or three extra spaces are added. Thus 3 lines divide the whole space into 4 + 3 = 7.
One more line can intersect at most 3 points and will provide additional 4 spaces. The n^{th} line can increase the region by k if and only if it divides k of the old regions and it divides k (regions) if and only if it intersects the existing lines at atmost k – 1 points.
1 line = 2 region
2 lines = 2 + 2 = 4 regions = 1 + 1
3 lines = 2 + 2 + 3 = 7 regions = 1 + 1 + 2
4 lines = 2 + 2 + 3 + 4 = 11 regions = 1 + 1 + 2 + 3
n lines = 2 + 2 + 3 + 4 + ... n regions
= 1 + 1 + 2 + ... n – 1 regions
= $S_n + 1$
where, S_n is sum of n natural numbers. n = 12 $\Rightarrow$ number of non-overlapping regions inside the circle (as all intersects are inside the circle, the total regions are inside the circle) = 1 + S_{12} = 1 + 78 = 79.

11. (d)
12. (a) $R_{ab}=R\parallel(R+R_{ab}+R)$



$R_{ab} = R \,\|\, (2R + R_{ab})$

$$R_{ab} = \frac{1}{R} + \frac{1}{2R + R_{ab}}$$

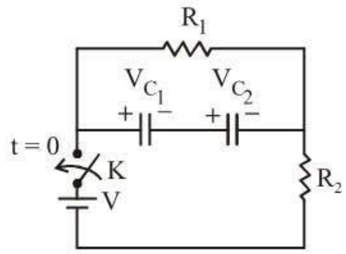
$$R_{ab} = \frac{2R + R_{ab} + R}{(R)(2R + R_{ab})}$$

$$R_{ab} = \frac{3R}{2R^2 + (R_{ab} + R)}$$

After solving

$R_{ab} = (-1+3)\,R$

13. (b) Given

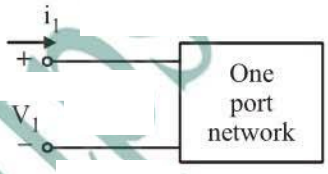


$$V_{R_1} = \frac{VR_1}{R_1 + R_2} \text{ [at t = 0] by voltage divider rule}$$

Now at $t \to \infty$

$$V_{C_2}(\infty) = \frac{VR_1}{R_1 + R_2} \times \frac{C_1}{C_1 + C_2}$$

14. $V_i = 5\sin(20t + 10°) + 3\cos(30t - 20°) + 4\sin(40t + 45°)$
$i_1 = 2\cos(20t + 30°) - 4\sin(30t + 60°) - 3\sin(40t - 45°)$



$P = P_1 + P_2 + P_3$
$= V_1 I_1 \cos\theta_1 + V_2 I_2 \cos\theta_2 + V_3 I_3 \cos\theta_3$

$$= \frac{5}{\sqrt{2}} \times \frac{2}{\sqrt{2}} \cos 110 + \frac{3}{\sqrt{2}} \times \frac{4}{\sqrt{2}} \cos 10 + \frac{4}{\sqrt{2}} \cdot \frac{3}{\sqrt{2}} \cos 90°$$

$= 4.198$ W

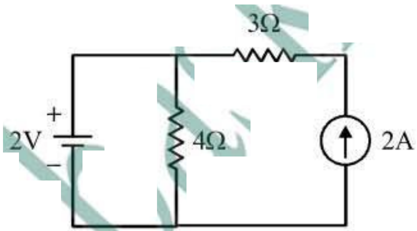
15. (c) Given $y(t)\frac{d^2y(t)}{dt^2} + 3t\frac{dy(t)}{dt} + y(t) = x(t)$

1. The element $\frac{d}{dt}$ indicates dynamic, so the system is dynamic.

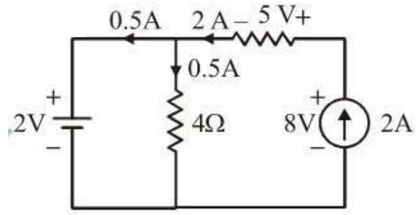
2. $y(t)\frac{d^2y(t)}{dt^2}$ is non-linear function, so the above DE is non-linear.

3. $3t\frac{dy(t)}{dt}$ is a time varying function. So the above system is time variant.

16. (a)



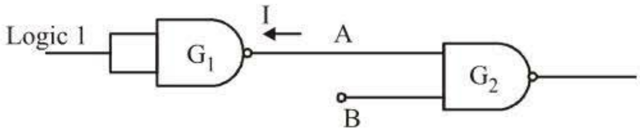
Power supplied by 2V source
$= 2 \times (-1.5)$
$= -3$W.



Power supplied by 2 A source $= 2 \times 8 = 16$ W

17. (b)

18. I = 1.6 mA when terminal B is left unconnected.



Gate G_1 will sink same current irrespective of terminal B. Hence, I will remains same.

19. both base.

$$H_{a_1} \text{ new} = 9 \times \frac{100}{150} = 6$$

$$H_{a_2} \text{ new} = 6 \times \frac{300}{150} = 12$$

$$H_{e_p} = H_{a_1} \times e_p + H_{a_2} \times e_p$$

$$H_{e_p} = (6 \times 4) + (12 \times 3)$$

$$H_{e_p} = 60$$

10. (d) (i) $E_f = V_t$
(ii) $E_f > V_t$
(iii) $E_f < V_t$ just like DC motor
(iv) E_f behind V_t

21. Efficiency $\eta = \frac{x\,kVA\,pF}{x\,kVA\,pF + x^2 P_{CU}}$

Where, P_i = iron loss of transformer, P_{CU} = Cu loss at full load x = percentage loading of transformer

At maximum efficiency (η_{max})

$$x = 1 = \sqrt{\frac{P_{CM}}{P_i}}$$

$\therefore \quad P_{CU} = P_i$

$\therefore \quad 90\% = \frac{kVA \times 1 \times 1}{kVA + 2P_i}$

$\Rightarrow \quad P_i = 0.555\,kVA$

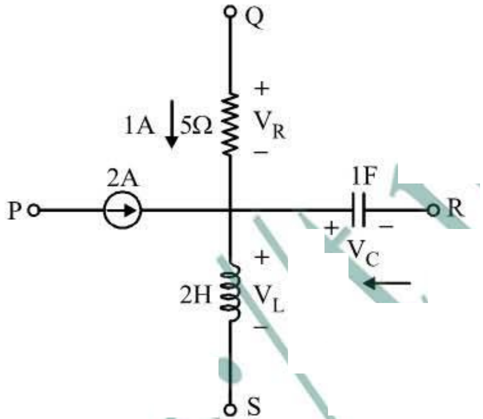
At half load i.e., x = 0.5

$$\Rightarrow \quad \eta = \frac{kVA \times 0.5}{kVA \times 0.5 + 0.01389\,MVA + 0.0555\,MVA}$$

$$\Rightarrow \quad \eta = \frac{0.5}{0.5 + 0.0694} \times 100$$

$$\eta = 87.8\%$$

22. (a)



By KCL, $I_P + I_Q + I_C + I_L = 0$

$2 + 1 + I_C + I_L = 0$

But, $I_C = C \times \frac{dV}{dt}$

$I_C = 1 \times \frac{d}{dt}(4\sin 2t) = 8\cos 2t$

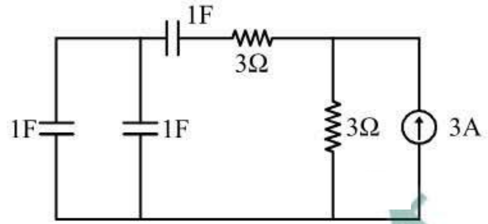
$\therefore \quad I_L = -(2 + 1 + 8\cos 2t)$

$I_L = -3 - 8\cos 2t$

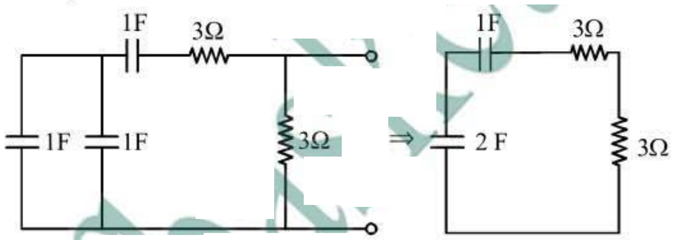
$\therefore \quad V_L = L\frac{dI}{dt} = 2 \times 2 \times 8 \sin 2t$

$V_L = 32 \sin 2t$

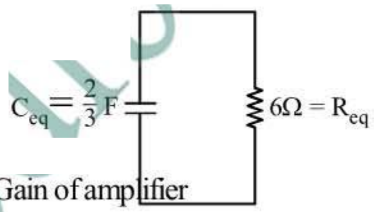
23.



For finding time constant, we neglect current source as a open circuit becomes

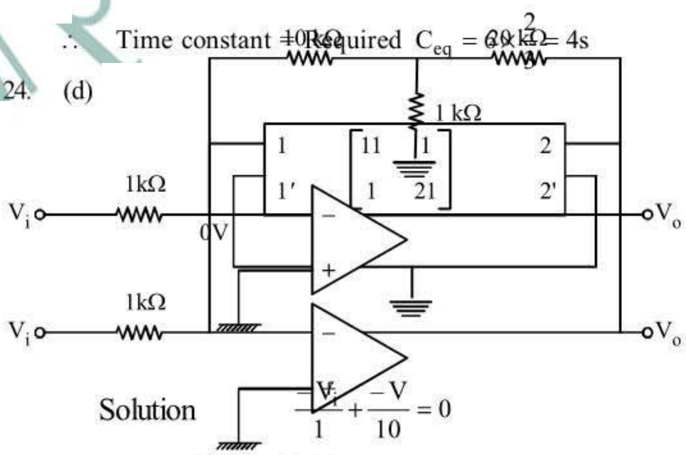


∴



$\therefore$ Time constant = Required $C_{eq} = 6 \times \frac{2}{3} = 4s$

24. (d)



Solution $\frac{V_i}{1} + \frac{-V}{10} = 0$

$\Rightarrow \quad V = -10\,V_i$

Now, $\frac{V}{10} + \frac{V}{1} + \frac{V - V_o}{20} = 0$

$1.15\,V = \frac{V_o}{20}$

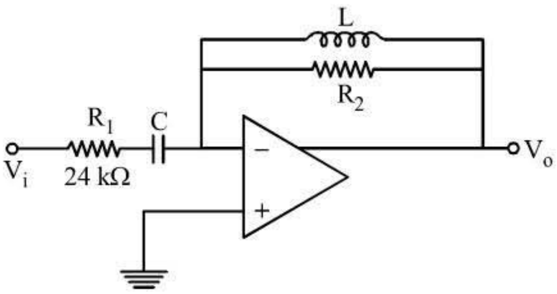
$\Rightarrow \quad \frac{V_o}{V_i} = -230$

25. (d)

	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7
D^I	(0)	2	4	6	8	10	12	(14)
D	(1)	(3)	5	7	9	11	(13)	15
	1	D	D	0	D^I	0	D	D^I

$Y = \Sigma\, m(0, 1, 3, 5, 8, 13, 14)$

26. (a)



$$Z_2 = R_2 \| sL = \frac{R_2 sL}{R_2 + sL}$$

and $Z_1 = \left(R_1 + \frac{1}{sC}\right) = \frac{sR_1C+1}{sC}$

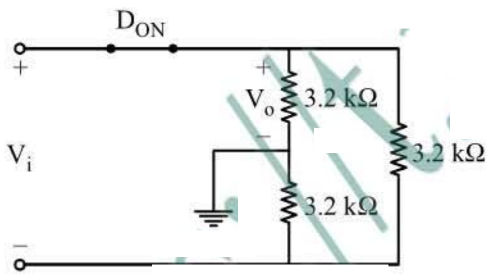
$$\therefore \quad \frac{V_o(s)}{V_i(s)} = \left(\frac{sR_2L}{sL+R_2}\right) \bigg/ \left(\frac{sR_1L+1}{sC}\right)$$

$$\Rightarrow \quad \frac{V_o(s)}{V_i(s)} = \frac{s^2R_2LC}{(R_2+sL)(sR_1C+1)}$$

By observing this equation and by plotting bode plot we get it is a expression of high pass filter.

27. (c) The thyristor is a device in which the holding current is associated with the turn-off process and the latching current is associated with turn-on process.

28. (d) During the positive half-cycle of V_i



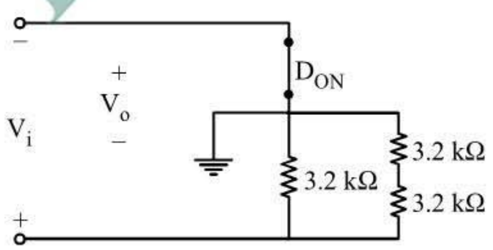
Applying voltage divider rule,

$$V_{o\,max} = \frac{3.2 \times V_{i\,max}}{3.2+3.2}$$

$$= \frac{3.2 \times 150}{3.2+3.2}$$

$V_{o\,max} = 75$ V

During the negative half cycle of V_i



Applying voltage-divider rule

$$V_{o\,max} = \frac{3.2 \times V_{i\,max}}{3.2+3.2} = \frac{3.2 \times 150}{6.4}$$

$= 75$ V

Hence, $V_{DC} = 0.636\, V_{o\,max}$
$= 0.636 \times 75 = 47.7$ V

29. $I_a = \frac{400}{\sqrt{3} \times 11}$
$= 20.99$A

$$\therefore \quad \text{Losses} = 3\left(\frac{I_a}{2}\right)^2 \times 5$$

$$= 3\left(\frac{20.99}{2}\right)^2 \times 5$$

$= 1652.9$ W

30. (a) As we know

$$I \propto \frac{P}{V\cos\phi}$$

$$\text{Loss} \propto I^2 \frac{PI}{a}$$

$$\therefore \quad \text{Volume} \propto a \propto \frac{I^2}{\text{loss}} \propto \frac{1}{\cos^2\phi}$$

31. (d) $(D-1)^2\, y = xe^x$

$$\text{P.I.} = \frac{1}{(D-1)^2} xe^x$$

$$= e^x \cdot \frac{x^3}{6}$$

32. P (number of heads = number of tails)

$$= \frac{{}^6C_3}{2^6} = 0.3125$$

33. (a) $f(x, y) = x^2 + y^2 + \frac{2}{x} + \frac{2}{y}$

$$\frac{\partial f}{\partial x} = 2x - \frac{2}{x^2} = 0$$

$$\frac{\partial f}{\partial y} = 2y - \frac{2}{y^2} = 0$$

At point (1, 1), $r = 8, t = 8, s = 0, rt - s^2 > 0, r > 0$ minimum at (1, 1).

34. (b) $\begin{bmatrix} p & 0 \\ -2q & 14 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 6 & -1+3r \end{bmatrix}$

$\Rightarrow \quad p = 1, q = -3$
$-1 + 3r = 14$
$\Rightarrow \quad r = +5$

35. $\left[\begin{array}{ccccc|c} 0 & 1 & -2 & 3 & 5 & -7 \\ 0 & 0 & 1 & 0 & 1 & 10 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{array}\right]$ is the augmented matrix of a system of linear equations.

Number of variables = 5

$\rho(A/B) = \rho(A) = 2 < 5$

$n - r = 5 - 2 = 3$

Variables are assumed as arbitrary constants.

36. $Z_P = \frac{V}{I} = \frac{60}{4} = 15\Omega$

$R_P = \frac{100}{4^2} = 6.25\Omega,\ R_S = 0.25$

$X_P = \sqrt{(Z_P)^2 - (R_P)^2} = \sqrt{(15)^2 - (6.25)^2}$

$= 13.635\,\Omega$

$X_g = 0.54$

$I_{FL} = \frac{10 \times 10^3}{400} = 25A$

Voltage drop $= IR_S \cos\theta + I X_g \sin\theta$

$= 25 \times 0.25 \times 0.8 + 25 \times 0.54 \times 0.6$

$= 13.16\ V$

Voltage drop with respect to primary

$= 13.16 \times 5 = 65.8\ V$

Voltage to be apply $= 2000 + 65.8$

$= 2065.8\ V$

37. $V_1 = 400\ V$

$F_1 = 50\ Hz$

$Ns_1 = \frac{12F_1}{P_1} = 1500$

$N_{r_1} = 1470$

$S_1 = \frac{1500 - 1470}{1500} = 0.02$

$\frac{V_1}{F_1} \to$ constant

$V_2 = ?$

$F_2 = 40$

$N_{S_2} = \frac{120 \times 40}{4} = 1200$

As ϕ is constant

$\frac{V_1}{f_1} = \frac{V_2}{f_2} \Rightarrow \frac{400}{50} = \frac{V_2}{40}$

$V_2 = 320\ V$

$T = \frac{KSV^2}{R_2} = \frac{180}{2\pi N_S}\frac{V^2}{R_2}$

$T \propto \frac{SV^2}{f}, \frac{S_1V_1^2}{f_1} = \frac{S_2V_2^2}{f_2}$

$S_2 = 0.025$

$N_{r_2} = N_{S_2}(1 - S_2)$

$= 1200\,(1 - 0.25) = 1170$ rpm

38. (b) $P_r = \frac{|V_S||V_r|}{(B)}\cos(\beta - \delta) - \frac{|A|}{|B|}|V_r|^2\cos(\beta - \alpha)$

$150 = \frac{(275)^2}{200}\cos(75 - \delta) - \frac{0.85}{200}(275)^2\cos(75 - 5)$

$\delta = 28.46$

$\theta_r = \frac{|V_S||V_r|}{(B)}\sin(\beta - \delta) - \frac{|A|}{|B|}(V_r)^2\sin(\beta - \alpha)$

After solving, we get

$= -27.6$ MVAR

39. (b) $I = \frac{10 - 6}{4 \times 10^3} = 1\text{mA}$

$I = I_B + 0.5$ mA

$\Rightarrow I_B = 0.5$ mA

Apply KVL

$6 - 0.7 - 265\, I_E = 0$

$\Rightarrow 265\, I_E = 5.3$

$I_E = \frac{5.3}{265} = 20\,\text{mA}$

$I_E = (1 + \beta) I_B \Rightarrow (1 + \beta) = \frac{I_E}{I_B} \Rightarrow 40$

$\frac{I_E}{I_B} = (39 + 1) = 40$

$I_C = \beta\, I_B = 19.5$ mA

Apply KVL to output terminals

$10 - 200\, I_C - V_{CE} - 265\, I_E = 0$

$V_{CE} = 10 - 200 \times 19.5 \times 10^{-3} - 265 \times 20 \times 10^{-3}$

$= 10 - 3.9 - 5.3 = 0.8$ volts

40. (a) The ammeter reading A_2 in figure records the resultant of the components current I_1, I_3, I_5 and I_7.

$\therefore \quad \sqrt{I_1^2 + I_3^2 + I_5^2 + I_7^2} = 0.46A$

The third harmonic current and its multiples can flowin the delta, But not in the lines,

$\therefore \quad I_{\text{line}} =$ Reading of Ammeter A_1

(or) $\quad \sqrt{3} \cdot \sqrt{I_1^2 + I_5^2 + I_7^2} = 0.75A$

(or) $\quad \sqrt{I_1^2 + I_5^2 + I_7^2} = \frac{0.75}{\sqrt{3}}A = 0.433A$

$I_3 = \sqrt{(0.46)^2 - (0.433)^2}$

$= 0.1553$ A

With the transformer in star/star with four wire supply, the neutral wire will carry three times I_3.

$\therefore$ Current in the neutral wire $= 3\, I_3$

$= 3\ (0.155) = 0.4659$ A

$\therefore$ The line current $= \sqrt{I_1^2 + I_3^2 + I_5^2 + I_7^2} = 0.46$ A

41. (d) $X_S = 0.8$ pu
$r_a = 0$
$E_f = 1.2$ pu
$V_t = 1.00$ pu
For an input kVA of 100% at $V_t = 1.00$
$V_t I_a = 1.00$ and $I_a = 1.00$ pu
As $E_f = 1.2$ pu is more that $V_t = 1.00$
Synchronous motor is working at a leading power factor

$$E_{f^2} = (V_t \cos\theta - I_a r_a)^2 + (V_t \sin\theta - I_a X_S)^2$$

$$1.2^2 = \cos^2\theta + (\sin\theta - 0.8)^2$$

$$1.44 = \cos^2\theta + \sin^2\theta + 0.64 - 1.6\sin\theta$$

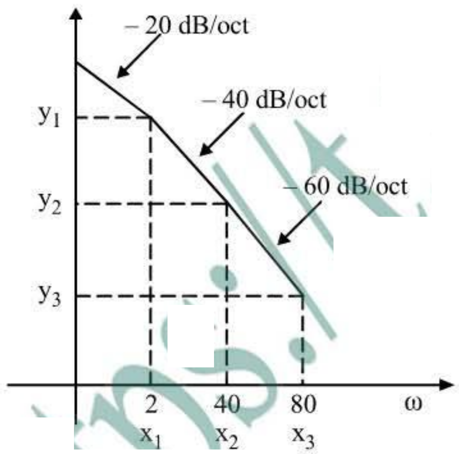
$$\sin\theta = \frac{0.2}{1.6} = 0.125,\ \cos\theta = 0.992 \text{ lead}$$

Mechanical power developed by the motor
$= V_t I_a \cos\theta = 1 \times 1 \times 0.992 = 0.992$ pu

42. $i_C(0^-) = 0,\ \tau = \dfrac{1}{RC} = \dfrac{1}{2}$

$i_C(0^+) = 2 \times 2 = 4$A
$i_C(\infty) = 0$,
$i_C(t) = 4e^{-2t}$,
$i_C(1^-) = 4e^{-2} = 0.54$
$V_C(0^-) = 0, V_C(0^+) = 0$,
$V_C(\infty) = 2$V, $V_C(t) = 2(1 - e^{-2t})$
$V_C(1^-) = 1.732, i_C(1^+) = -1.732 \times 2 = -3.464$
$V_C(1^+) = 1.732$

42. (a) – 6 dB/oct = – 20 dB/decade



$$\frac{y_2 - 6}{\log 40 - \log 2} = \frac{-40\text{dB}}{1}$$

$$y_2 = -46\text{dB}\,|_{\text{at } \omega = 40\text{rad/s}}$$

$$\frac{y_3 - (-46)}{\log 80 - \log 40} = \frac{-60\text{dB}}{1},$$

$y_3 = -64|$at $\omega = 80$ rad/s

44. (a) RMS value of output voltage,
$V_{or} = V_S = 220$ V
RMS value of fundamental component of output voltage

$$V_{01} = \frac{4 \times 220}{\sqrt{2} \times \pi}$$

$= 198.07$ V
RMS value of all harmonic voltages

$$V_{oh} = \sqrt{V_{or}^2 - V_{01}^2}$$

$$= \sqrt{(220)^2 - (198.07)^2}$$

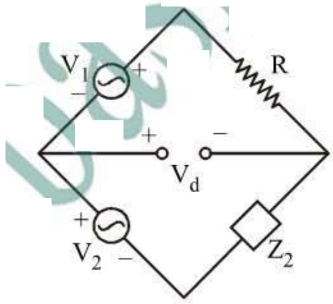
$= 95.151$ V

$$\text{THD} = \frac{V_{oh}}{V_{01}} = \frac{95.751}{198.07} = 0.4834$$

or $= 48.34\%$

$$\text{Distortion factor, } \mu = \frac{V_{01}}{V_{or}} = \frac{198.07}{220} = 0.9$$

45. (c)



Let the value of R be R+X after connecting some components to R for making the bridge balance. Under balanced condition, voltage V_1 appears across R + X(x) and voltage V_2 appears across Z_2.

$$\therefore \quad \frac{V_1}{R + K} = \frac{V_2}{Z_2}$$

$$\Rightarrow \quad (R + X) = \frac{V_1}{V_2} Z_2$$

$$\Rightarrow \quad X = \frac{V_1}{V_2} Z_2 - R$$

$$X = \frac{5\angle 0°}{10\angle 45°} \times 111.8\angle(63.44° - 50)$$

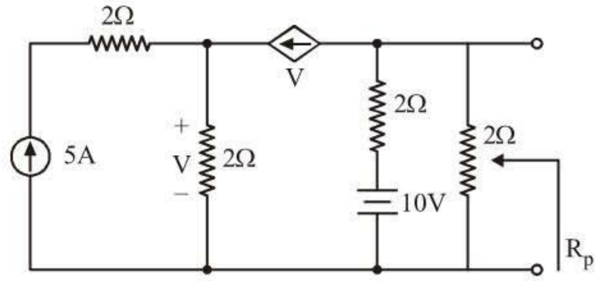
$X = (3.03 + j\,17.68)$
Comparing X with $(R_1 + j\omega L)$,

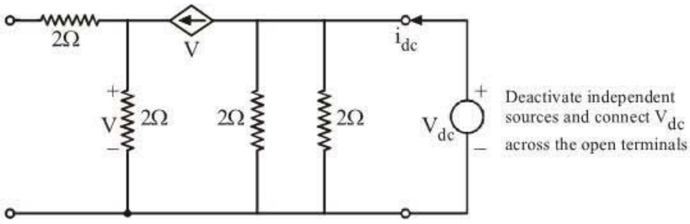
Then $R_1 = 3.03\Omega$, $L = \dfrac{17.68}{\omega}$

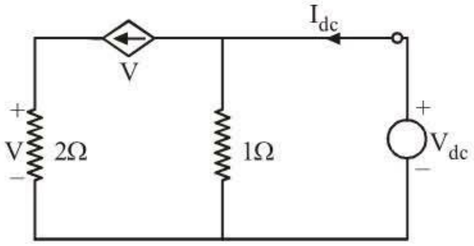
$$= \frac{17.68}{500} = 35.36\text{mH}$$

∴ A resistor of 3.03 Ω and inductor of 35.16 mH are connected series with the resistor R = 50 Ω.

46. $[h] = \begin{bmatrix} 5 & 0.01 \\ 10 & 0.2 \end{bmatrix}$ Input impedance of network N
= input impedance seen by short circuiting V_2
$= h_{11} = 5$
For the primary circuit





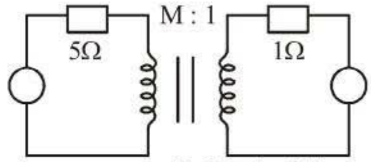


$$V+\frac{V_{dc}}{1}=I_{dc}$$

Also, V = 2 V

⇒ V = 0

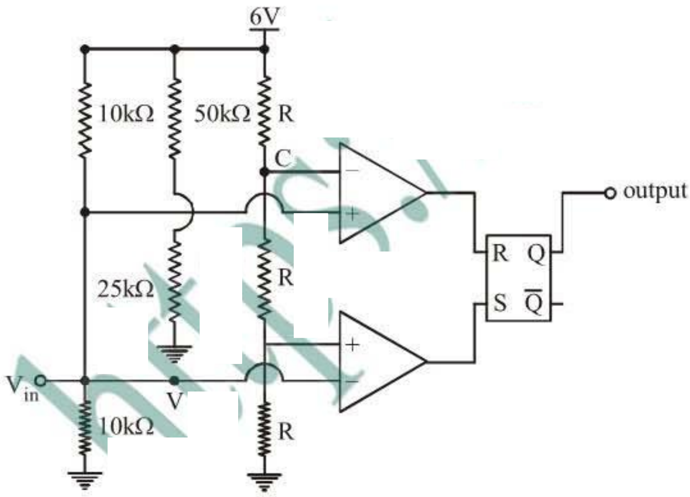
$\therefore \quad \frac{V_{dc}}{I_{dc}}=1\Omega$



For maximum power transfer 5Ω should be matched with 1Ω.

$\therefore \quad \frac{5}{1}=\frac{M^2}{1^2}\Rightarrow M=\sqrt{5}=2.236$

47. (d) Internal circuit of the 555 timer is



Voltage at node C is $=6\times\frac{25}{25+50}=2\text{V}$

$\therefore$ Voltage at node × is $\frac{2}{2}=1\text{V}$

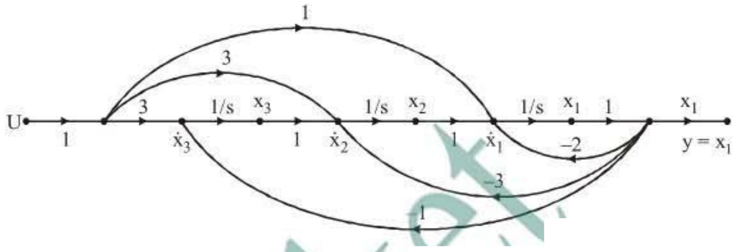
$\therefore$ Two decision boundaries of the Schmitt trigger are 1V & 2 V

It is a Schmitt trigger. It is readily shown that for very small V_{in}, S = 1 and R = 0, thus making ouput high.

Hence the correct hysteresis loop is (d)

48. (b) Signal Flow graphs and state space analysis

$\dot{x}=Ax+BU$



$$\dot{x}_1=-2x_1+x_2+U$$
$$\dot{x}_2=-3x_1+x_3+3U$$
$$\dot{x}_3=-x_1+3U$$

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

$\dot{X}=AX+BU,\ Y=CX+DU$

$$[Y]=[1\quad 0\quad 0]\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

49. (c) $S_2=P_2+jQ_2=\frac{1}{3}(15+j10)$

$S_2=5+j\,3.33$ MVA

$$V_r=\frac{110}{\sqrt{3}}=63.5\text{kV}$$

$$Q_C=(V_r)^2\frac{\omega C}{2}=\frac{1}{2}\times(63.5)^2\times 219\times 10^{-6}$$

$Q_C=0.441$ MVAR

$S'=S_2-j\,Q_C=5+j\,3.33-j.0.441$

$S'=(5+j\,2.89)$ MVA

$$\text{Power loss in line }=\frac{|S'|^2}{|V_r|^2}R$$

$$=\frac{\left[5^2+(2.89)^2\right]\times 26.4}{(63.5)^2}=0.218\text{ MW}$$

$$\Delta Q_L=\frac{|S'|^2}{|V_r|^2}X$$

$$=\frac{\left[5^2+(2.89)^2\right]}{(63.5)^2}\times 33.9=0.279\text{ MVAR}$$

$S''=S'+\Delta P_L+j\Delta Q_l=(5.22+j\,3.169)$ MVA

$S_1=S''-jQ_C=5.22+j\,3.169-j\,0.441$

$S_1=(5.22+j\,2.73)$ MVA

$S=3S_1=(15.66+j\,8.19)$ MVA

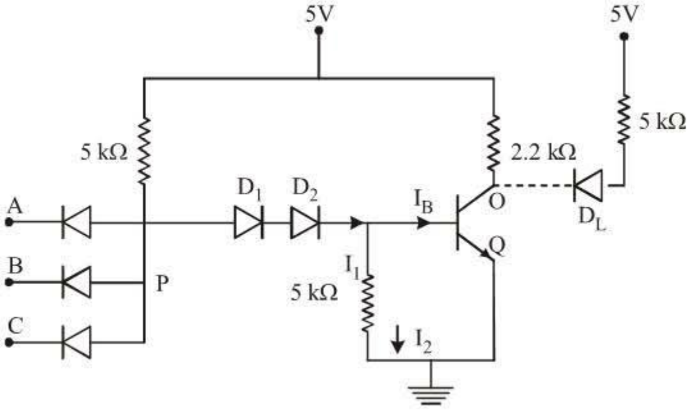
50. A, B, C are at logic 1, output = logic 0 i.e., transistor is in saturation.

Now, $V_p = V_{D_1} + V_{D_2} + V_{BE,sat} = 2.2V$

$I_1 \frac{(V_{CC} - V_p)}{5k\Omega}$

$= \frac{5 - 2.2}{5k\Omega}$

$= 0.56\,mA$



$I_2 = \frac{V_{BE_{sat}}}{5k\Omega} = \frac{0.8}{5k\Omega} = 0.16mA$

$I_B = I_1 - I_2 = 0.56 - 0.16 = 0.40\,mA$

At the output node O, $V = 0.7 + V_{CE(sat)}$

$= 0.7 + 0.2$

$= 0.9$ Volts

So, $I_D = \frac{5 - 0.9}{5k\Omega} = 0.82\,mA$

and, $I_C = \frac{5 - 0.2}{2.2k\Omega} = 2.18\,mA$

If N is the fan-out then,

$I_1' = 0.82\,N + 2.18 = h_{FE} \times I_B$

$0.82N + 2.18 = 30 \times 0.4$

$\Rightarrow$ $N = 12$

51. (d) **Given** $K_m = 50$ rpm/V

To find The range of motor speed.

Solution Speed = $K_m V_m$

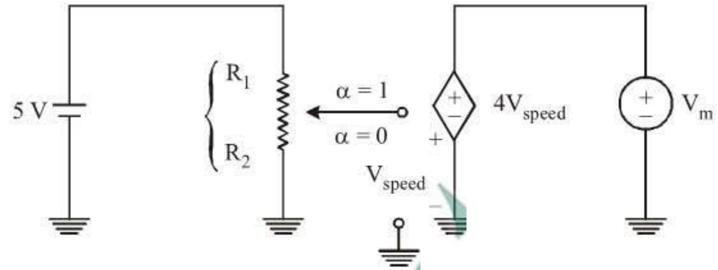
$V_m = 4V_{speed}$

$V_{speed} = 5\frac{R_2}{R_1 + R_2}$

$= 5\left[\frac{R_2}{R_{pot}}\right] = 5\alpha$

$R_2 = d\,R_{pot} = R_1 = (1 - \alpha)\,R_{pot}$

Combining relationships to eliminate V_{speed}, yields a relationship between motor speed and α that is rpm = 20α



Here, K_m = 50 rpm/V

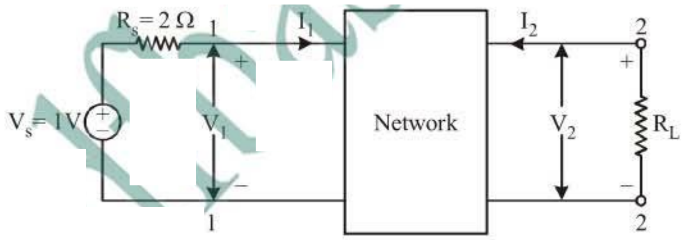
So, speed = $K_m V_m$

Speed = 50 × 20 α

= 1000 α

Ranges = 0 to 1000

52. $V_s = 1$ V, $R_s = 2\,\Omega$, $Y_{11} = 2$, $Y_{22} = 2$ and $Y_{12} = Y_{21} = -1$



For maximum power transferred from the source, R_L should be equal to the equivalent resistance seen from the terminal 2-2′.

The Y parameters are written as

$I_1 = Y_{11} V_1 + Y_{12} Y_2$

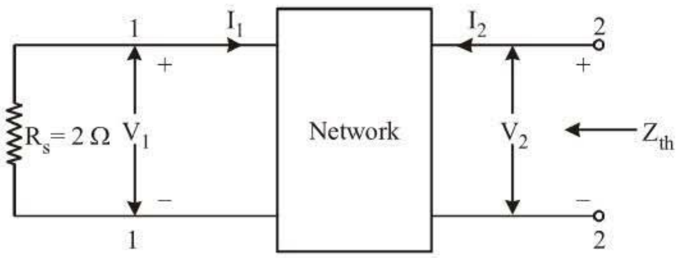
$I_2 = Y_{21} V_1 + Y_{22} Y_2$

Putting the given values of Y parameters in above equations

$I_1 = 2V_1 - V_2$ ..... (i)

$I_2 = -V_1 + 2V_2$ ..... (ii)

Make $V_s = 0$, to determine Z_{Th}



From above network it is clear that

$V_1 = -2I_1$

$\Rightarrow$ $I_1 = \frac{-V_1}{2}$

Putting this value of I in equation (i) we get

$\frac{-V_1}{2} = 2V_1 - V_2$

$\Rightarrow$ $V_1 = \frac{2}{5}V_2$

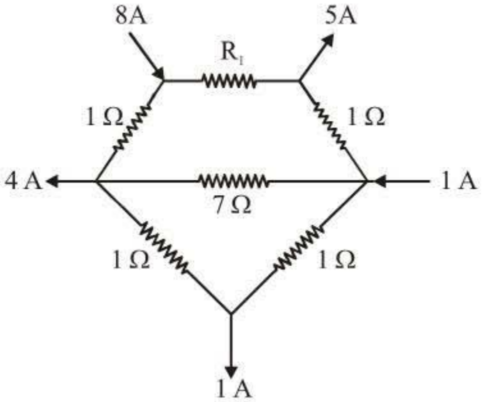
Putting this value of V_1 in equation (ii) we get

$I_2 = \frac{-2}{5}V_2 + 2V_2 = \frac{8}{5}V_2$

$$\Rightarrow \quad \frac{V_2}{I_2} = \frac{5}{8}$$

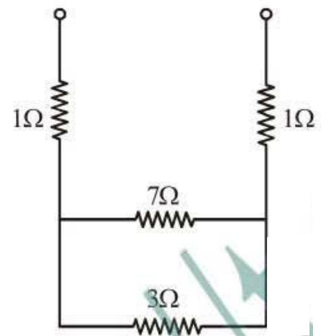
So, $\quad R_L = \frac{5}{8}\Omega = 0.625\Omega$

53. (a) **Given** $I = 2$ A

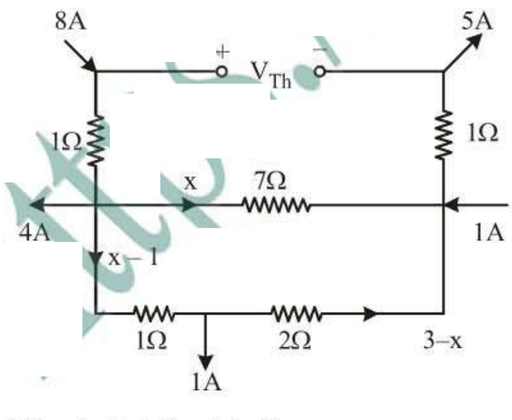


To find Thevenin equivalent circuit about R_1.
Solution Equivalent resistance

$$R_{eq} = 1 + 1 + 7 \,||\, (2+1) = 4.1\Omega$$



Thevenin equivalent voltage, by applying KVL



$2(3-x) - 7x + (4-x)\,1 = 0$

$\Rightarrow \quad x = 1$

$V_{Th} = 8 \times 1 + 1 \times 7 + 5 \times 1$

$V_{Th} = 20$ Volts

54. (a) **Given** $\frac{dV}{dt} = 25\ V/\mu s$

$L = 0.2$ mH $= 0.2 \times 10^{-3}$ H

Vrms = 230 V

To find The value of R and C of the Snubber circuit.

Solution $V_m = 230 \times \sqrt{2} = 325.27$ V

$L = 0.2 \times 10^{-3}$ H

$$\frac{dV}{dt} = 25\frac{V}{\mu s} = 25 \times 10^6\ V/s$$

$\xi = 0.65$

$$C = \frac{1}{2L}\left(\frac{0.564 V_m}{\frac{dV}{dt}}\right)^2$$

$$C = \frac{1}{2 \times 0.2 \times 10^{-3}}\left(\frac{0.564 \times 325.27}{25 \times 10^6}\right)^2$$

$C = 134.62 \times 10^{-9}$ F

$$R = 2\xi\sqrt{\frac{L}{C}}$$

$$R = 2 \times 0.65\left(\frac{0.2 \times 10^{-3}}{134.62 \times 10^{-9}}\right)^2$$

$R = 2.866$ MΩ

55. (d) Given that SRIM (Slip Ring Induction Motor) and syncrhonous machine are coupled. Therefore, SRIM rotates at synchronous speed of the synchronous motor.

∴ Speed of the induction motor (N_r)

$$= \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

Given slip across rotor terminals = Sf = 150 Hz

$f = 50$ Hz

$\Rightarrow$ $S = 3 \Rightarrow S = \pm 3$

$\Rightarrow$ For $S = +3$ and $N_s = 1500$ rpm

$1500 = N_s(1-3) \Rightarrow N_s = 750$ rpm

$$N_s = \frac{120 f}{P}$$

$$\Rightarrow \quad 750 = \frac{120 \times 50}{P}$$

$P = 8$

$\Rightarrow$ For $S = 1$ annd $N_r = 1500$ rpm

$1500 = N_s(1+3) \Rightarrow N_s = 375$ rpm

$$375 = \frac{120 \times 50}{P}$$

$P = 16$

34. (c) **Given** A generator delivers power of 1.0 pu to an infinite bus through a purely reactive network δ_{max} = 110 elec degree.

To find The rotor angle in electrical degree as $t = t_c$.

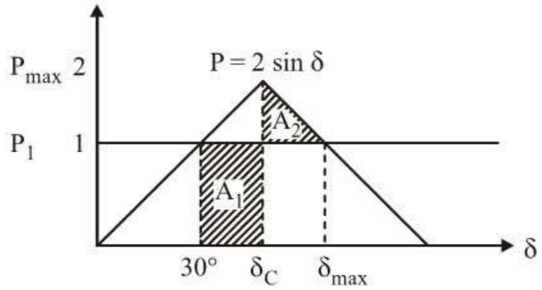
Solution By equal area criterion

$$P_s(\delta_m - \delta_0) = \int_{\delta_e}^{\delta_m} P_{max}\ \sin\delta\, d\delta$$

$$2 \sin\delta_e\ (\delta_m - \delta_0) = P_{max}(\cos\delta - \cos\delta_m)$$

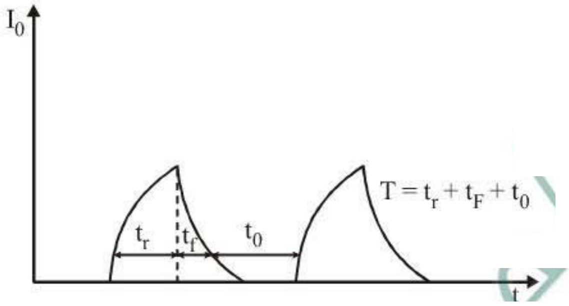
$P_{max} = 2$

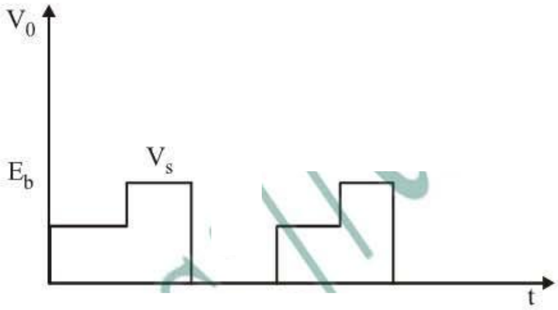
∴ $\quad \delta_0 = 30°$



$$2\times 0.5\frac{(110-30)\pi}{180} = 2(\cos\delta_c - \cos 110)$$
$$\delta_c = 69.138° \cong 69.14°$$

57. (c) A step-down chopper operates from a DC voltage source V_s and feeds a DC motor armature with a back emf E_b.





$$V_0(\text{average}) = \frac{V_s t_r + E_b t_0}{(t_r + t_f + t_0)}$$

58. (a) $X(\omega) = \dfrac{2e^{-j\omega}}{1-0.25e^{-2j\omega}}$

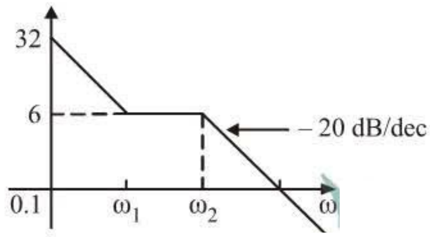
$$X(\omega) = \frac{2e^{-j\omega}}{1-0.25e^{-2j\omega}}$$

$$X(\omega) = \frac{2e^{-j\omega}}{(1+0.5e^{-j\omega})(1-0.5e^{-j\omega})}$$

$$X(\omega) = \frac{-2}{1+0.5e^{-j\omega}} + \frac{2}{1-0.5e^{-j\omega}}$$

$x[n] = -2(-0.5)^n u(n) + 2(0.5)^n u(n)$
$x[n] = 2(0.5)^n u(n) - 2(-0.5)^n u(n)$

59. (c)



$$G(s) = \frac{K(s+2)}{s(s+5)(s+10)}$$

$|G(j\omega)|\,|(j\omega)|$ at $\omega = 0.1 = 20\log K - 20\log\omega$
$32 = 20\log K - 20\log(0.1)$
$32 - 20 = 20\log K$
$12 = 20\log K$
$K = 10^{0.6} = 3.98 \cong 4$

$$\therefore \quad G(s) = \frac{4(s+2)}{s(s+5)(s+10)}$$

60. (b) The open loop transfer function of unity feedback prototype second order system is

$$G(s) = \frac{\omega_n^2}{s(s+2\xi\,\omega_n)}$$

Phase margin $= 180° + \phi_{\omega=\omega_{gc}}$

To get ω_{gc}, $|a(j\omega)|_{\omega=\omega_{gc}} = 1$

$$\omega_{gc} = \sqrt{-2\xi^2\omega_n^2 \pm \omega_n^2\sqrt{4\xi^4+1}}$$

Substitute ω_{gc} in $|G(j\omega)| = 1$

$$\therefore \quad PM = \tan^{-1}\left[\frac{2\xi}{\sqrt{\sqrt{4\xi^4+1}-2\xi^2}}\right]$$

61. $I = \int_0^\infty t^{-3/2}(1-e^{-t})\,dt$

$$I = \int_0^\infty t^{-3/2}(1-e^{-t})\,dt$$

$$I = \left|(1-e^{-t})\frac{t^{-\frac{1}{2}}}{-\frac{1}{2}}\right|_0^\infty - \int_0^\infty e^{-t}\frac{t^{-\frac{1}{2}}}{-\frac{1}{2}}\,dt$$

$$I = 0 + 20 + 1\int_0^\infty e^{-t}t^{-\frac{1}{2}}\,dt$$

$$I = 2\Gamma\frac{1}{2} = 2\sqrt{\pi}$$

$$I = 2\sqrt{\pi} = 3.544$$

62. $\int_c [(1-y)dx + 3xy\,dx]$

$\Rightarrow \quad y_1 = \frac{x^2}{4}, \ x = 0$

$\Rightarrow \quad y_2 = 2\sqrt{x}, \ x = 4$

Green theorem $= \iint_R (3y+1)dy\,dx$

$$I = \int_0^4 \int_{\frac{z^2}{4}}^{2\sqrt{\pi}} (3y+1)dydx$$

$I = 34.13$

63. $f(z) = u(x, y) + iv(x, y)$
$u = x^2 - y^2$
$u = x^2 - y^2$

$$\frac{\partial u}{\partial x} = 2x = \phi_1(x, y)$$

$$\frac{\partial u}{\partial y} = -2y = \phi_2(x, y)$$

Now, by Midne Thompson's method, on replacing x by z and y by 0, we have

$$f(z) = \int [\phi_1(z, 0) - i\phi_2(z, 0)]dz + c$$

$$f(z) = \int [2z - i(0)]dz + c$$

$$f(z) = \int 2zdz + c = z^2 + c$$

64. (d) $\int f(z)dz$ and $f(z) = \frac{\cos z}{z}$

$f(z)\,dz$ and $f(z) = \frac{\cos z}{z}$

$$\Rightarrow \quad \int \frac{\cos z}{z-0} dz \qquad ...(i)$$

$|z| = 1$

We know that, the Cauchy-integral formula

$$\int \frac{f(z)}{z-a} dz = 2\pi i f(a) \qquad ...(ii)$$

On comparing Eqs. (i) and (ii)

$f(z) = \cos z$ and $a = 0$

$f(a) = \cos a$

$\Rightarrow \quad f(0) = \cos 0 = 1$

From Eq. (ii)

$$\int \frac{\cos z}{z-a} dz = 2\pi i f(0) = 2\pi i$$

65. (a) $x^3 + 4x - 9 = 0$

Let $f(x) = x^3 + 4x - 9 = 0$

$f'(x) = 3x^2 + 4 = 0$

Now, Newton-Raphson method

$$x_{K+1} = x_K - \frac{f(x_K)}{f'(x_K)}$$

$$x_{K+1} = x_K - \frac{x_K^3 + 4x_K - 9}{3x_K^2 + 4}$$

$$x_{K+1} = \frac{3x_K^3 + 4x_K - x_K^3 - 4x_K + 9}{3x_K^2 + 4}$$

$$x_{K+1} = \left(\frac{2x_K^3 + 9}{3x_K^2 + 4}\right)$$