DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 4

Section A : Control Systems + Microprocessors and Microcontroller

Section B : Network Theory-1

Section C : Digital Circuits-1

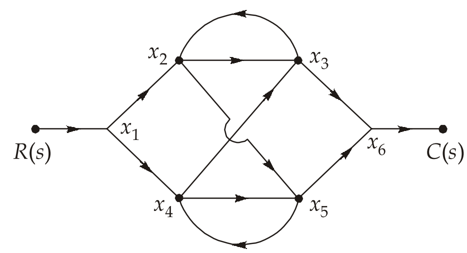
1.	(b)	16.	(d)	31.	(a)	46.	(d)	61.	(a)
2.	(d)	17.	(d)	32.	(b)	47.	(a)	62.	(c)
3.	(c)	18.	(d)	33.	(d)	48.	(c)	63.	(b)
4.	(a)	19.	(a)	34.	(b)	49.	(d)	64.	(d)
5.	(c)	20.	(b)	35.	(d)	50.	(a)	65.	(a)
6.	(c)	21.	(d)	36.	(c)	51.	(d)	66.	(b)
7.	(a)	22.	(b)	37.	(a)	52.	(c)	67.	(a)
8.	(a)	23.	(b)	38.	(d)	53.	(a)	68.	(a)
9.	(c)	24.	(d)	39.	(b)	54.	(c)	69.	(b)
10.	(c)	25.	(c)	40.	(c)	55.	(c)	70.	(a)
11.	(a)	26.	(d)	41.	(a)	56.	(a)	71.	(c)
12.	(a)	27.	(b)	42.	(d)	57.	(b)	72.	(d)
13.	(c)	28.	(d)	43.	(d)	58.	(d)	73.	(a)
14.	(c)	29.	(a)	44.	(c)	59.	(b)	74.	(c)
15.	(b)	30.	(c)	45.	(d)	60.	(d)	75.	(c)

DETAILED EXPLANATIONS

Section A : Control Systems + Microprocessors and Microcontroller

1. (b)

We have,



Forward path:
- $R(s) - x_1 - x_2 - x_3 - x_6 - C(s)$
- $R(s) - x_1 - x_4 - x_5 - x_6 - C(s)$
- $R(s) - x_1 - x_2 - x_5 - x_6 - C(s)$
- $R(s) - x_1 - x_4 - x_3 - x_6 - C(s)$
- $R(s) - x_1 - x_2 - x_5 - x_4 - x_3 - x_6 - C(s)$
- $R(s) - x_1 - x_4 - x_3 - x_2 - x_5 - x_6 - C(s)$

Number of forward path, $M = 6$

Individual Loops:
- $x_2\, x_3\, x_2$
- $x_4\, x_5\, x_4$
- $x_2\, x_5\, x_4\, x_3\, x_2$

Number of loops, $N = 3$

2. (d)

Roots on the imaginary axis represents a marginally stable system, whereas roots in the RHS of the s-plane represent an unstable system. Hence, option (d) is correct.

3. (c)

- Adding a zero leads to decrease the angle of the asymptote, so it pushes the root locus to the left.
- Adding a pole leads to increase the angle of asymptote, so it pushes root locus to the right.
- Complementary root locus refers to root loci with negative K.
- Adding a pole in the forward-path transfer function increases maximum overshoot, while adding a zero reduces maximum overshoot.

4. (a)

The pair AB is controllable implies that the pair $A^T B^T$ is observable.

The pair AC is observable implies that the pair $A^T C^T$ is controllable.

5. (c)

$$G(s) = \frac{sT_1 + 1}{sT_2 + 1}$$

The angle, $\phi = \tan^{-1}(\omega T_1) - \tan^{-1}(\omega T_2)$

For a lead network, $\phi > 0$

So, $\tan^{-1}(\omega T_1) - \tan^{-1}(wT_2) > 0$

$$\tan^{-1}(\omega T_1) > \tan^{-1}(\omega T_2)$$

$$T_1 > T_2$$

Similarly, for a lag network,

$$T_1 < T_2$$

Thus, option (c) is correct.

6. (c)

- Transfer an open-loop transfer function into a constant-time form.
- For the low-frequency asymptote, if there is only the proportion link, one should plot a horizontal line with the amplitude value 20 log K (dB).
- Compensate the asymptote to get the precise frequency characteristics diagram.

7. (a)

- When $|G(j\omega)|$ is equal to 1, the corresponding point on the polar plot lies on a circle of unit radius centered at the origin.
  Hence, statement-1 is correctly defines the gain crossover point in the polar plot.
- The zero dB line represents the locus points where the magnitude is unity.
  Hence, statement-2 is correct.
- For Nichol's chart the gain crossover point is the point where magnitude vs phase plot crosses or intersect the zero dB line.
  Hence, statement-3 is incorrect.

8. (a)

$$-\omega_1 T - \tan^{-1}\left(\frac{-1}{\omega_1}\right) = 0$$

$$\tan(-\omega_1 T) = \frac{-1}{\omega_1}$$

$$\omega_1 = \cot(\omega_1 T)$$

9. (c)

From the given transfer function, we get in the frequency domain,

$$G(j\omega)H(j\omega) = \frac{10e^{-jL\omega}}{j\omega}$$

$$= \frac{10}{\omega}\angle(-L\omega - 90°)$$

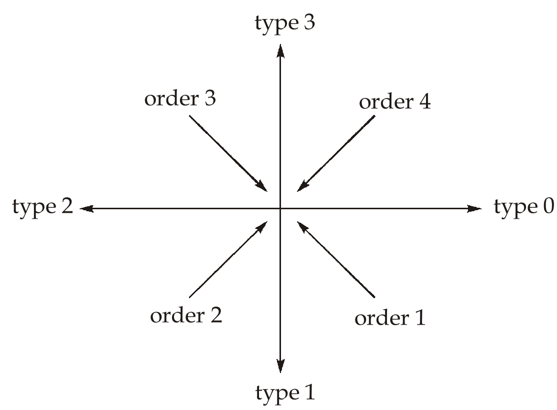
At phase cross-over frequency ω_p;

$$-L\omega_p - 90° = -180°$$

$$L\omega_p = 90° = \frac{\pi}{2}$$

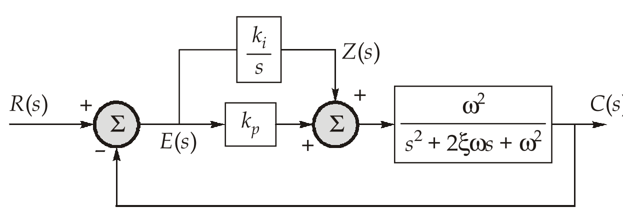
$$L = \frac{\pi}{2\omega_p} = \frac{\pi}{2\times 5} = \frac{\pi}{10}$$

10. (c)



11. (a)

Step input $\Rightarrow$ $R(s) = \frac{1}{s}$



$$G(s) = \left(k_p + \frac{k_i}{s}\right)\left(\frac{\omega^2}{s^2 + 2\xi\omega s + \omega^2}\right)$$

and $H(s) = 1$

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

$$E(s) = R(s) - C(s)$$

$$= R(s)\left[1 - \frac{C(s)}{R(s)}\right]$$

$$= R(s)\left[1 - \frac{G(s)}{1+G(s)}\right] = \frac{R(s)}{1+G(s)}$$

$$Z(s) = \frac{k_i}{s}\cdot E(s) = \frac{k_i}{s}\cdot\frac{R(s)}{1+G(s)}$$

Steady state value of Z

$$Z_{ss} = \lim_{s\to 0} sZ(s)$$

$$= \lim_{s\to 0} \frac{s \cdot \frac{k_i}{s} \cdot \frac{1}{s}}{1 + \left(k_p + \frac{k_i}{s}\right)\left(\frac{\omega^2}{s^2 + 2\xi\omega s + \omega^2}\right)}$$

$$= \frac{k_i}{k_i \cdot \frac{\omega^2}{\omega^2}} = 1$$

12. (a)

- From the given Bode plot, it is evident that there are three poles in the transfer function, out of which there are double poles at a corner frequency near, but less than, ω = 8 rad/sec, and one pole is near but greater than ω = 0.5 rad/sec.
- The initial slope is +20 dB/dec. Therefore, one zero exists at s = 0. So from all the given options, option (a) satisfies all the conditions. Therefore, option (a) is correct.

13. (c)

As there is no encirclement to $-1 + j0$ point, it implies $N = 0$.

Since the problem statement does not provide the open-loop transfer function $G(s)H(s)$.

Hence assuming no open loop in the RHP.

$$P = 0$$

Using the formula

$$Z = N + P$$

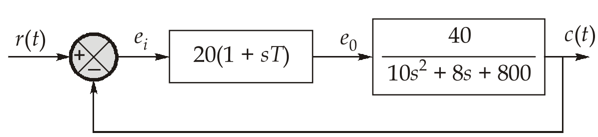
Since $Z = 0$, the closed loop system does not have any poles in the RHP and is therefore stable.

14. (c)

$$e_0 = 20\left(e_i + \frac{Tde_i}{dt}\right)$$

$$e_0(s) = 20e_i(s) + 20sTe_i(s)$$

$$\frac{e_0(s)}{e_i(s)} = 20(1 + sT)$$



$$\text{TF} = \frac{80(1+sT)}{s^2 + (0.8 + 80T)s + 160}$$

$$\omega_n = \sqrt{160} = 12.64 \text{ rad/sec}$$

$$2\xi\omega_n = 0.8 + 80T$$

For critical damping, $\xi = 1$:

$$2 \times 1 \times 12.64 = 0.8 + 80T$$

$$T = 0.306$$

15. (b)

We know the property of the state-transition matrix:

$$\phi(0) = I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

From option (a):

$$\phi(0) = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$$

From option (b):

$$\phi(0) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

From option (c):

$$\phi(0) = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$$

From option (d):

$$\phi(0) = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$$

So, answer is option (b).

16. (d)

$$\text{Resonant frequency, } (\omega_r) = \omega_n\sqrt{1-2\xi^2}$$

$$= 3\sqrt{1-2\times\frac{1}{4}} = 2.1 \text{ rad/sec}$$

$$\text{Resonant peak } (M_r) = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

$$= \frac{1}{2\times\frac{1}{2}\sqrt{1-\frac{1}{4}}} = 1.16$$

17. (d)

Characteristic equation

$$s(s + 4)(s + 5)(s + 6) + K(s + 3) = 0$$

$$\Rightarrow \qquad \text{OLTF} = \frac{K(s+3)}{s(s+4)(s+5)(s+6)}$$

$$\text{Zero} = -3$$

$$\text{Number of zeros, } Z = 1$$

$$\text{Poles} = 0, -4, -5, -6$$

$$\text{Number of poles, } P = 4$$

$$\text{Number of asymptotes} = P - Z = 4 - 1 = 3$$

$$\text{Centroid} = \frac{\Sigma\begin{pmatrix}\text{Real part of open}\\ \text{-loop poles}\end{pmatrix} - \Sigma\begin{pmatrix}\text{Real part of open-}\\ \text{loop zeros}\end{pmatrix}}{P - Z}$$

$$= \frac{(0-4-5-6)-(-3)}{4-1} = -4$$

As centroid always lie on real axis.

Thus, centroid, $C(-4, 0)$.

Hence, the answer is option (d).

18. (d)

The operand store microprogram is:

$$T_1 \ : \ \text{ACC (Data)} \rightarrow \text{MDR}$$
$$T_2 \ : \ \text{IR[Addr]} \rightarrow \text{MAR}$$
$$T_3 \ : \ \text{MDR} \rightarrow \underbrace{M[\text{MAR}]}_{\text{Memory}}$$

19. (a)

- Direct memory access (DMA) is used to transfer large amounts of data from memory to an output device or input device memory.
- Depending on the availability of the microprocessor and the number of devices, the modes are Burst mode, Cycle stealing technique, and interleaved DMA.
- In Burst mode, DMA is given complete access to the bus until the data transfer is completed.
- During this entire period, no other device, including the CPU, can access the data bus. This mode facilitates high-speed data transfer between memory and a peripheral device, or vice-versa.

20. (b)

In ICW_1,

D_1, D_0

D_0: $0 \rightarrow ICW_4$ not needed

$1 \rightarrow ICW_4$ needed

D_1: $0 \rightarrow$ Cascade mode

$1 \rightarrow$ Single mode

For cascade and fully nested mode, set D_0 and D_1 to 1 and 0.

21. (d)

INTR is non-vectored, so it has no specific memory location assigned.

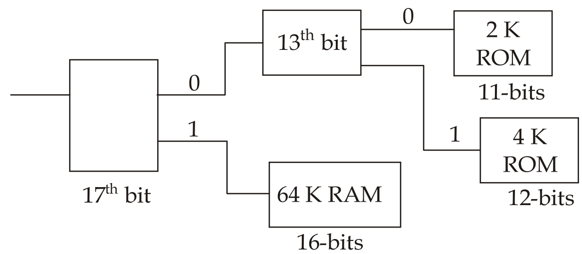
22. (b)

The Auxiliary carry Flag status is used only in DAA DAS instructions. Decimal adjust after additions/substraction.

- The zero Flag is set to 1 when the operands are equal (after addition or subtraction).
- All conditional jumps are short jumps, not long jumps.

23. (b)

2 K ROM $\Rightarrow$ 2^{11} bytes
4 K ROM $\Rightarrow$ 2^{12} bytes
64 K ROM $\Rightarrow$ 2^{16} bytes



Total at least 17-bits needed to access the given memories.

24. (d)

0	0	0	0 H
0000	0000	0000	0000
A_{15} to	A_9	A_8 to	A_0
0000	0001	1111	1111
0	1	F	F H

25. (c)

26. (d)

LXI H, 2500 H	:	Store 2500 H in HL pair
LXI D, 0200 H	:	Store 0200 H in DE pair
DAD D	:	DE + HL $\rightarrow$ HL So, HL pair contain 2700 H
XCHG	:	Exchange contents HL pair and DE pair thus HL pair will contain 0200 H and DE pair will contain 2700 H.
After execution	:	HL pair = 0200 H DE pair = 2700 H

27. (b)

$$\text{One T-state} = \frac{1}{f} = \frac{1}{2\text{ MHz}} = 0.5\,\mu\text{sec}$$

So, Instruction cycle = 10 T-states
= 10 × 0.5 μsec
= 5 μsec

Hence, the instruction cycle time is 5 μs.

28. (d)

PCHL $\rightarrow$ Transfer the contents of HL to the PC.
SPHL $\rightarrow$ Transfer the content of HL to the SP.
XTHL $\rightarrow$ Exchange the top of the stack with HL.
XCHG $\rightarrow$ Exchange the contents of HL with those of the DE pair.

29. (a)

$$\begin{array}{r l}
8\ 0 & \longleftarrow \text{Accumulator} \\
8\ F & \longleftarrow \text{Register B} \\
\hline
\underbrace{1}_{\text{Carry}}\ \underbrace{0\ F}_{\text{Stored in Accumulator}} &
\end{array}$$

30. (c)

NV-RAM (Non-volatile RAM) combines the advantages of RAM and ROM; the read and write capability of RAM plus the non-volatility of ROM. To retain its contents, every NV-RAM chip internally includes the following components:

1. Extremely power efficient SRAM cells built out of CMOS.
2. An internal lithium battery as a backup energy source.
3. Intelligent control circuitry. The main function of this control circuitry is to monitor the V_{CC} pin constantly to detect any loss of the external power supply. If the power to the V_{CC} pin fails the control circuitry switches automatically to its internal power source (the lithium battery). This internal lithium power source is used to retain the NV-RAM contents only when the external power source is off. Hence, statement-2 is not correct.

31. (a)

The internal RAM stack allows only direct-addressing mode.

32. (b)

$$\text{Execution time} = 4T + 3T \qquad (\because \text{ Three wait states are inserted})$$
$$= 7T$$
$$\Rightarrow \qquad T = \frac{1}{10}\,\mu\text{sec}$$
$$\text{Execution time} = 0.7\ \mu\text{sec}$$

33. (d)

$\overline{BHE}$	A_0	Status
0	0	One 16-bit word
0	1	One byte from/to even address
1	0	One byte from/to odd address
1	1	NOP

34. (b)

The 8254 is a programmable interval/timer counter

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
SC_1	SC_0	RW_1	RW_0	M_2	M_1	M_0	BCD

Control word register.

The 8254 can operate in six different modes:

M_2	M_1	M_0			
0	0	0	Mode 0	:	Interrupt on terminal count
0	0	1	Mode 1	:	Hardware-triggerable one-shot
X	1	0	Mode 2	:	Rate generator
X	1	1	Mode 3	:	Square wave generator
1	0	0	Mode 4	:	Software-triggered strobe
1	0	1	Mode 5	:	Hardware-triggered strobe

35. (d)

Statement-II is correct because INTR requires external hardware for implementation. Statement-I is incorrect because the SIM instruction is used to implement RST7.5, RST6.5, RST5.5, not INTR.

36. (c)

D – Direction flag is used to set the direction in string manipulation instructions.

$D \rightarrow 0$; Auto-increment mode.

$D \rightarrow 1$; Auto-decrement mode.

37. (a)

Since a lead compensation increases the margin of stability, we use lead compensation in type-II or higher order systems.

38. (d)

- A Bode plot gives frequency response. It does not directly give the closed-loop poles (roots) of the characteristics equation. We can only infer relative stability (gain margin, phase margin) not exact pole locations.
  Therefore statement (I) is incorrect.
- Nyquist plot shows the frequency response in the complex plane. It helps determine stability but does not directly give corner frequencies (break frequencies). Corner frequencies are usually identified from Bode plots, not Nyquist plots.
  Therefore statement (iI) is correct.

Section B : Network Theory-1

39. (b)

- Superposition theorem → Valid only for linear systems.
- Thevenin's theorem → Equivalent voltage source in series with resistance R.
- Norton's theorem → Equivalent current source in parallel with resistance R.
- Reciprocity theorem → Applicable in bilateral linear networks.

40. (c)

- The inductor current depends on the initial condition — it is not always zero.
- The capacitor voltage is continuous, thus the initial voltage across a capacitor cannot change abruptly.
- The inductor resists a sudden change in current.

41. (a)

We know that,
$$\tau = \frac{L}{R} = \frac{5}{5} = 1\,\text{sec}$$
and
$$i(t) = I_{max}[1 - e^{-t/\tau}]$$
where
$$I_{max} = \frac{10}{5} = 2\text{A}$$
$$i(t) = 2[1 - e^{-t/1}]$$
At t = 1 sec:
$$i(t) = 2[1 - e^{-1}] = 2[1 - 0.368]$$
$$i(t) = 1.26 \text{ A}$$

42. (d)

Case I: When only the voltage source is activated.

Power dissipated, $P_{diss} = 4$ W
$$I_1^2 R = 4$$
$$I_1 = \sqrt{\frac{4}{R}} \text{ Amp.}$$

Case-II: When only the current source is activated.

Power dissipated, $P_{diss} = 9$ W
$$I_2^2 R = 9$$
$$I_2 = \sqrt{\frac{9}{R}} = \frac{3}{\sqrt{R}} \text{ Amp}$$

Case-III: When both sources are activated using superposition, the total current across R is $I = I_1 + I_2$
$$I = \left[\frac{2}{\sqrt{R}} + \frac{3}{\sqrt{R}}\right]\text{A}$$

Power dissipated, $P_{diss} = I^2 R$
$$= \left[\frac{2}{\sqrt{R}} + \frac{3}{\sqrt{R}}\right]^2 R$$
$$P_{diss} = \left[\frac{4}{R} + \frac{9}{R} + \frac{12}{R}\right] R$$
$$= 25 \text{ W}$$

Alternate:

We can directly use

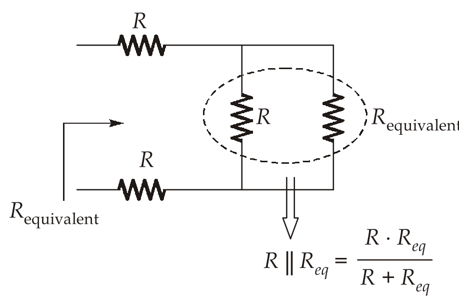
$$P_{\text{diss}} = \left[\sqrt{P_1} + \sqrt{P_2}\right]^2$$

$$= \left[\sqrt{4} + \sqrt{9}\right]^2$$

$$= 25 \text{ W}$$

43. (d)

We can redraw the circuit as follows:



$$R_{eq} = R + R + \frac{R \cdot R_{eq}}{R + R_{eq}}$$

$$R_{eq} = 2R + \frac{R \cdot R_{eq}}{R + R_{eq}}$$

On multiplying both sides by $(R + R_{eq})$, we get

$$R_{eq}(R + R_{eq}) = 2R(R + R_{eq}) + R \cdot R_{eq}$$

$$R \cdot R_{eq} + R_{eq}^2 = 2R^2 + 3R \cdot R_{eq}$$

$$R_{eq}^2 - 2R \cdot R_{eq} - 2R^2 = 0$$

Solving the quadratic equation:

$$R_{eq} = \frac{2R \pm \sqrt{4R^2 + 8R^2}}{2}$$

$$R_{eq} = R \pm \sqrt{3R^2}$$

$$R_{eq} = R \pm \sqrt{3}R$$

$$R_{eq} = \left[1 + \sqrt{3}\right]R; \left[1 - \sqrt{3}\right]R$$

Since 'R' is a finite positive resistance value,

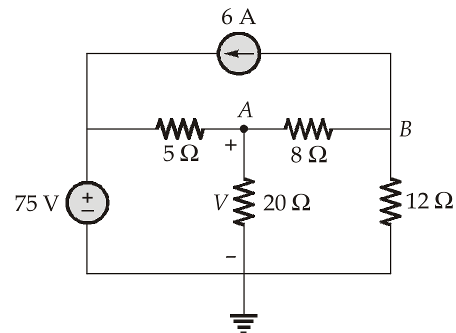
$$R_{eq} = \left[1 - \sqrt{3}\right]R \text{ is discarded.}$$

Hence, $$R_{eq} = \left(1 + \sqrt{3}\right)R$$

Thus, $$\frac{R_{eq}}{R} = \left[1 + \sqrt{3}\right]$$

44. **(c)**

We have,



On applying nodal analysis at node A, we get:

$$\frac{V_A - 75}{5} + \frac{V_A}{20} + \frac{V_A - V_B}{8} = 0$$

Simplifying, $$\frac{3V_A}{8} - \frac{V_B}{8} = 15 \quad \text{...(i)}$$

Similarly,

using KCL at node B, we get

$$\frac{V_B}{12} + \frac{V_B - V_A}{8} + 6 = 0$$

Simplifying, $$\frac{-V_A}{8} + \frac{5V_B}{24} = -6 \quad \text{...(ii)}$$

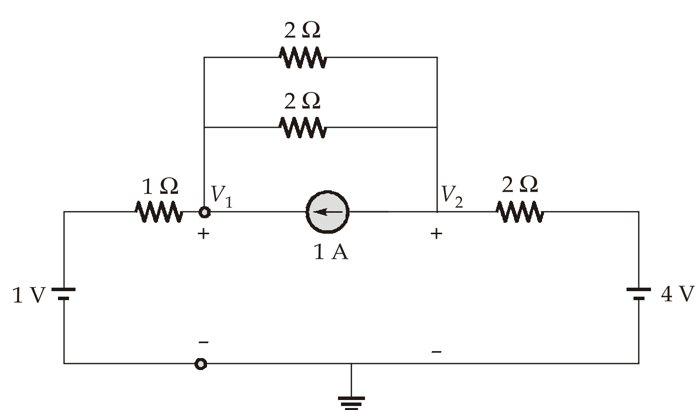
Using equations (i) and (ii), we get:

$$V_A = 38 \text{ V}; V_B = -6 \text{ V}$$

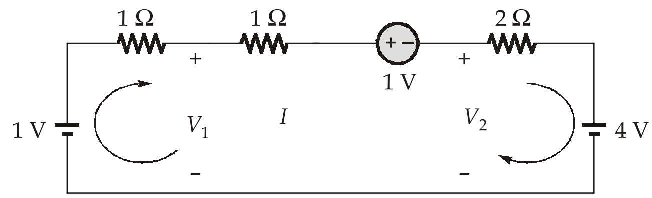
Hence, $$V_A = V = 38 \text{ volt}$$

45. **(d)**

On applying source transformation, we get:



Again after performing the source transformation, we get



On applying KVL, we get

$$-1 + 1 + 4 + 4I = 0$$

$$I = \frac{-4}{4}$$

$$I = -1 \text{ A}$$

Now,
$$-1 + I + V_1 = 0$$
$$V_1 = 1 - I$$
$$V_1 = 1 + 1 = 2 \text{ volt}$$

Similarly,
$$-V_2 + 2I + 4 = 0$$
$$V_2 = -2 + 4$$
$$V_2 = 2 \text{ volt}$$

46. (d)

We know that,
$$E = \int P(t)dt$$

For $0 < t < 2$ sec

$$E_1 = \int_0^2 (5t)dt \Rightarrow \frac{5t^2}{2}\bigg|_0^2 = \frac{5}{2}\times 4 = 10 \text{ Joule}$$

For $2 < t < 4$ sec

$$E_2 = \int_2^4 10dt = 10t\bigg|_2^4 = 10[4-2] = 20 \text{ Joule}$$

For $4 < t < 5$ sec

$$E_3 = \int_4^5 -\left(\frac{10}{4}t\right)dt$$

$$E_3 = -\frac{10}{4}\left[\frac{t^2}{2}\bigg|_4^5\right]$$

$$E_3 = -\frac{10}{4}\left[\frac{25}{2}-\frac{16}{2}\right]$$

$$E_3 = \frac{-10}{4}\times\frac{9}{2}$$

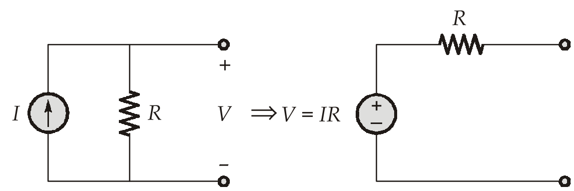
$$E_3 = -\frac{90}{8} \text{ Joule}$$

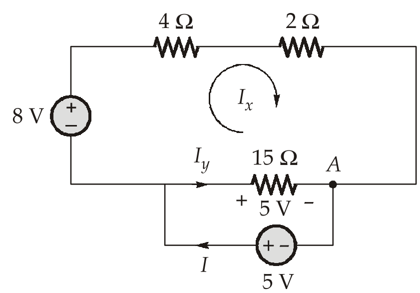
$$E_T = E_1 + E_2 + E_3$$

$$= 10 + 20 - \frac{90}{8} = 18.75 \text{ Joule}$$

47. (a)

From the source transformation theorem,





$$I_x = \frac{8+5}{6} = \frac{13}{6} \text{ A}$$

$$I_y = \frac{5}{15} = \frac{1}{3} \text{ A}$$

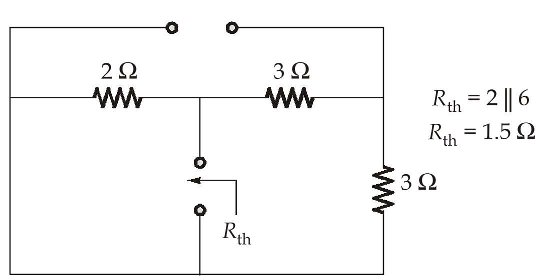
KCL at node A: $\quad I_x + I_y = I$

$$\frac{13}{6} + \frac{1}{3} = I$$

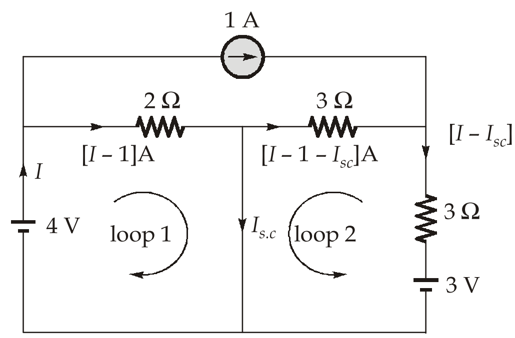
$$I = \frac{13+2}{6} = \frac{15}{6} = \frac{5}{2} = 2.5 \text{ Amp}$$

48. (c)

Step-I : Norton equivalent across 1 Ω.



Step-II: $I_{s.c}$ (Short-circuit current)



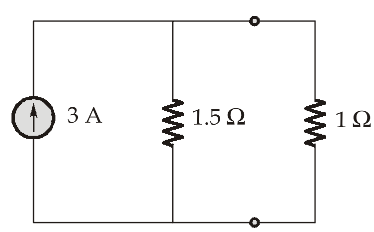
On applying KVL in loop 1, we get

$$-4 + 2(I - 1) = 0$$
$$2I - 2 = 4$$
$$I = 3 \text{ A}$$

Similarly, on applying KVL in loop 2,

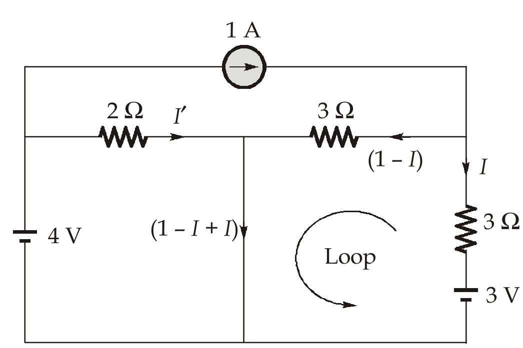
$$-3 - 3(I - I_{sc}) - 3(I - 1 - I_{sc}) = 0$$
$$-3 - 3I + 3I_{sc} - 3I + 3 + 3I_{sc}) = 0$$
$$6I_{sc} = 6I$$
$$I_{sc} = I$$
$$I_{sc} = 3A$$

Step-II: Norton equivalent circuit



49. (d)

We have,



Applying KVL in loop 1, we get

$$-3 - 3I + 3(1 - I) = 0$$
$$-3 - 3I + 3 - 3I = 0$$
$$I = 0$$

50. (a)

We have,

$$V_2 = |V_R| = 100 \text{ V} \qquad ...(i)$$

$$V_3 = |V_{R_L} + jV_L| = 120 \text{ V} \qquad ...(ii)$$

$$|V_3| = \sqrt{V_{R_L}^2 + V_L^2} = 120$$

$$V_{R_L}^2 + V_L^2 = (120)^2 \qquad ...(iii)$$

From using KVL we get

$$V = V_R + V_{R_L} + jV_L = V_1$$

$$|V| = \sqrt{(V_R + V_{R_L})^2 + V_L^2} = 220$$

$$\left(V_R + V_{R_L}\right)^2 + V_L^2 = (220)^2$$

$$V_R^2 + V_{R_L}^2 + V_L^2 + 2V_R V_{R_L} = (220)^2$$

Using equation (i) and (iii) we get

$$(100)^2 + (120)^2 + 2 \times 100 V_{R_L} = (220)^2$$

$$V_{R_L} = \frac{(220)^2 - (100)^2 - (120)^2}{200} = 120 \text{ volt}$$

51. (d)

We know that,

$$i_1(t) + i_2(t) + i_3(t) = 0$$

$$i_3(t) = -(i_1(t) + i_2(t))$$

$$i_3(t) = -(\cos \omega t - \sin \omega t) \text{ mA}$$

$$i_3(t) = -\sqrt{2}\cos(\omega t + 45°)\text{mA}$$

52. (c)

As, power dissipated in 5 Ω is P_5 = 10 W

or $$10 = I_{rms}^2 \times 5$$

$\therefore$ $$I_{rms}^2 = \frac{10}{5} = 2$$

$$I_{\text{rms}} = \sqrt{2} \text{ A}$$

Total real power (for both resistors 5 + 10 = 15 Ω)

$$P_{\text{real}} = I_{\text{rms}}^2(15) = (\sqrt{2})^2 \times 15 = 30 \text{ W}$$

$$\text{Apparent power: } S = V_{rms} I_{rms} = \frac{50}{\sqrt{2}} \times \sqrt{2} = 50 \text{ VA}$$

$$\text{Power factor, PF} = \frac{P_{real}}{S} = \frac{30}{50} = 0.6$$

Since circuit contains an inductor, it implies that the circuit is lagging.

53. (a)

The power dissipated in 10 Ω resistor is 250 W i.e.

$$P = I_{rms}^2 \times 10 = 250$$

$$I_{rms} = 5 \text{ A}$$

Now,
$$\sqrt{A^2 + \left(\frac{4}{\sqrt{2}}\right)^2 + \left(\frac{4}{\sqrt{2}}\right)^2} = 5$$

$$A = 3 \text{ A}$$

54. (c)

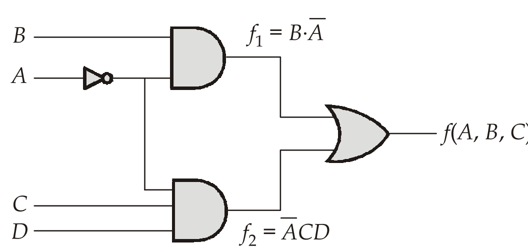
55. (c)

- The Maximum Power Theorem guarantees the transfer of maximum power, not maximum efficiency.
- At maximum power transfer, the efficiency of the circuit is atmost 50%.

Section C : Digital Circuits-1

56. (a)

We have,



$$f(A, B, C, D) = f_1 + f_2$$

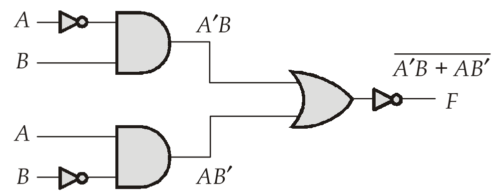
$$f(A, B, C, D) = \bar{A}B + \bar{A}CD$$

CD \ AB	00	01	11	10
00		1		
01		1		
11	1	1		
10		1		

Therefore, option (a) is correct.

57. **(b)**

From option (b), we get



58. **(d)**

The given function of $F(A,B,C,D) = A \odot B \odot C \odot D$ is a four-variable EX-NOR function and acts as an even function. The truth table is shown below:

	A	B	C	D	F
0	0	0	0	0	1
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	1
6	0	1	1	0	1
7	0	1	1	1	0
8	1	0	0	0	0
9	1	0	0	1	1
10	1	0	1	0	1
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	0
14	1	1	1	0	0
15	1	1	1	1	1

Therefore, in minterm form, $f(A, B, C, D) = \Sigma m(0, 3, 5, 6, 9, 10, 12, 15)$

59. **(b)**

$$(93)_{16} = (147)_{10}$$
$$(357)_8 = (239)_{10}$$
$$(147)_{10} + (239)_{10} = (386)_{10}$$

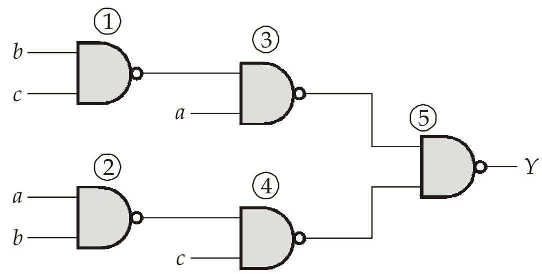
5	386	
5	77	1
5	15	2
	3	0

$$(386)_{10} = (3021)_5$$

60. (d)

We have,

$$Y = (a+c)(\overline{a}+\overline{b}+\overline{c})$$
$$Y = a\overline{a}+a\overline{b}+a\overline{c}+\overline{a}c+\overline{b}c+\overline{c}c$$
$$Y = a\overline{bc}+\overline{ab}c$$



Hence, the implementation requires five two-input NAND gates.

61. (a)

Fan-in is the maximum number of inputs a logic gate can accept, while fan-out is the maximum number of other gates an output can drive.

62. (c)

63. (b)

64. (d)

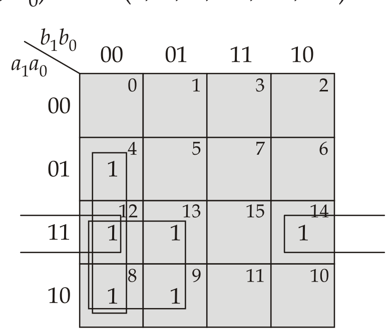
From the given circuit,

We have,
$$Z = \overline{A}\overline{B}C+\overline{A}B+A\overline{B}+AB$$
$$= \overline{A}(\overline{B}C+B)+A(\overline{B}+B)$$
$$= \overline{A}(\overline{B}C+B)+A$$
$$= (\overline{A}+A)(A+B+\overline{B}C)$$
$$= A+(B+\overline{B})(B+C)$$
$$= A+B+C$$

65. (a)

66. (b)

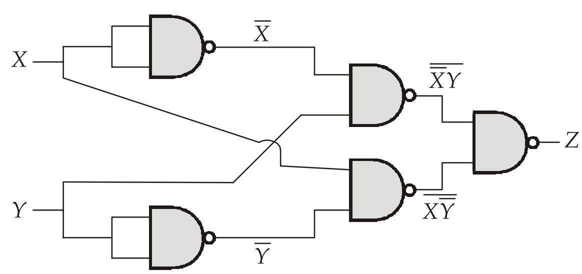
$$F(a_1, a_0, b_1, b_0) = \Sigma m(4, 8, 9, 12, 13, 14)$$



Minimized form of F:

$$F = a_1 a_0 \overline{b_0} + a_1 \overline{b_1} + a_0 \overline{b_1}\,\overline{b_0}$$

67. (a)



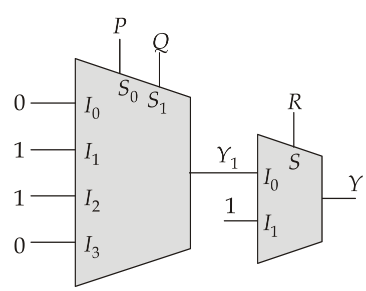
$$Z = \overline{(\overline{\overline{X}Y})(\overline{X\overline{Y}})}$$

$$= \overline{\overline{(\overline{X}Y)}} + \overline{\overline{(X\overline{Y})}}$$

$$= \overline{X}Y + X\overline{Y} = X \oplus Y$$

Hence, the circuit realize the XOR function.

68. (a)



For the 4 × 1 MUX,

$$Y_1 = \overline{S_1}\,\overline{S_0}\, I_0 + \overline{S_1} S_0 I_1 + S_1 \overline{S_0}\, I_2 + S_1 S_0 I_3$$

Here, $S_0 = P$, $S_1 = Q$, $I_0 = 0$, $I_1 = 1$, $I_2 = 1$ and $I_3 = 0$

Thus, $$Y_1 = \overline{Q}\,\overline{P}(0) + \overline{Q}P(1) + Q\overline{P}(1) + QP(0)$$

$$Y_1 = \overline{Q}P + Q\overline{P}$$

$$Y_1 = P \oplus Q$$

For the 2 × 1 MUX

$$Y(P, Q, R) = \overline{S}I_0 + SI_1$$

$$= \overline{R}Y_1 + R(1)$$

$$= R + \overline{R}Y_1$$

$$= (R + \overline{R})(R + Y_1)$$

$$= R + Y_1$$

$$= R + (P \oplus Q)$$

69. (b)

Number of Address lines $(n) = 10$

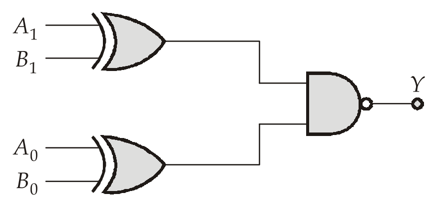
Total memory words $= 2^{10}$

Number of Data output lines $(m) = 8$

Total storage capacity $= 2^{10} \times 8$ bits

70. (a)

We have,



We have,

$$Y_1 = A_1\overline{B_1} + \overline{A_1}B_1 ; Y_2 = A_0\overline{B_0} + \overline{A_0}B_0$$

$$Y = [\overline{Y_1 \cdot Y_2}]$$

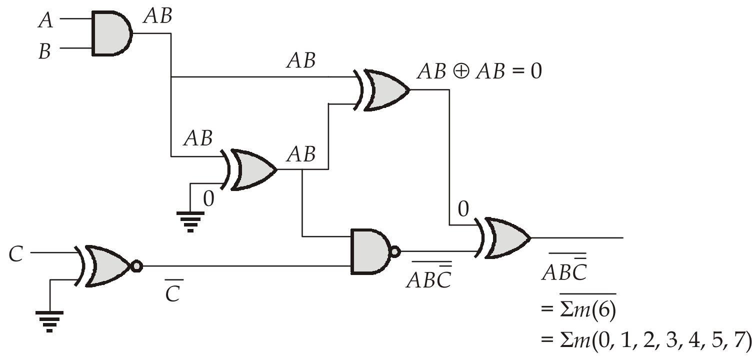
$$Y = \overline{\left[A_1\overline{B_1} + \overline{A_1}B_1\right]\left[A_0\overline{B_0} + \overline{A_0}B_0\right]}$$

$$Y = (A_1 \odot B_1) + (A_0 \odot B_0)$$

A_1	B_1	A_0	B_0	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

The logic circuit for detecting equality of two numbers is shown below:
The Output, $Y = 1$ only when both the inputs are same. Otherwise Y will be zero
Therefore, option (a) is correct.

71. (c)



72. (d)

$$Z = x \odot y \oplus (x \odot \overline{x}) \oplus 1 \oplus y$$

$$x \odot \overline{x} = x\overline{x} + \overline{x}\,\overline{\overline{x}} = 0$$

$$Z = x \odot y \oplus (0 \oplus 1) \oplus y$$

$$Z = x \odot y \oplus (1 \oplus y)$$

$$Z = x \odot y \oplus \overline{y}$$

$$Z = x \odot 1$$

$$Z = x(1) + \overline{x} \cdot \overline{1}$$

$$Z = x$$

73. (a)

$$f(A, B, C, D) = \Sigma m(1, 2, 3, 7, 10, 11, 15) + \Sigma d(5, 6, 14)$$
$$f(A, B, C, D) = \Pi M(0, 4, 8, 9, 12, 13) + \Sigma d(5, 6, 14)$$

	$C+D$	$C+\overline{D}$	$\overline{C}+\overline{D}$	$\overline{C}+D$
$A+B$	0			
$A+\overline{B}$	0	X		X
$\overline{A}+\overline{B}$	0	0		X
$\overline{A}+B$	0	0		

$$f(A, B, C, D) = (C+D)(\overline{A}+C)$$

74. (c)

$$Y = \overline{S}_1 S_0 I_1 + S_1 \overline{S}_0 I_2$$

Carry output of half adder = $I_1 = AB$

Difference output of half subtractor = $I_2 = A \oplus B$

Select input, S_1 = Sum output of half adder

$S_1 = A \oplus B$

$$S_0 = \overline{A \oplus B} = A \odot B$$

$$Y = \bar{S}_1 S_0 I_1 + S_1 \bar{S}_0 I_2$$

$$Y = \overline{A \oplus B}\,(A \odot B)AB + A \oplus B(\overline{\overline{A \oplus B}})\,(A \oplus B)$$

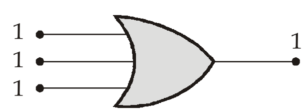
$$= (A \odot B)AB + A \oplus B \;=\; (AB + \bar{A}\bar{B})AB + A\bar{B} + \bar{A}B$$

$$Y = AB + \bar{A}B + A\bar{B}$$

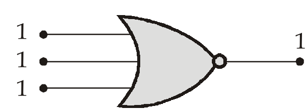
$$Y = A(B + \bar{B}) + B(A + \bar{A})$$

$$Y = A + B$$

75. (c)



Odd number of 1's detector



Odd number of 1's detector

❍❍❍❍