DETAILED SOLUTIONS

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ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

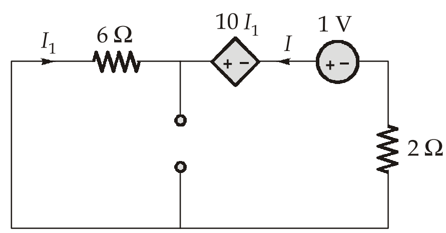
1.	(d)	**26.**	(b)	**51.**	(d)	**76.**	(b)	**101.**	(a)	**126.**	(d)
2.	(c)	**27.**	(b)	**52.**	(c)	**77.**	(b)	**102.**	(a)	**127.**	(c)
3.	(b)	**28.**	(a)	**53.**	(c)	**78.**	(b)	**103.**	(d)	**128.**	(b)
4.	(d)	**29.**	(d)	**54.**	(b)	**79.**	(b)	**104.**	(d)	**129.**	(a)
5.	(d)	**30.**	(*)	**55.**	(c)	**80.**	(d)	**105.**	(b)	**130.**	(a)
6.	(c)	**31.**	(a)	**56.**	(c)	**81.**	(d)	**106.**	(d)	**131.**	(a)
7.	(a)	**32.**	(c)	**57.**	(c)	**82.**	(d)	**107.**	(a)	**132.**	(a)
8.	(a)	**33.**	(c)	**58.**	(d)	**83.**	(d)	**108.**	(d)	**133.**	(c)
9.	(b)	**34.**	(a)	**59.**	(c)	**84.**	(a)	**109.**	(d)	**134.**	(a)
10.	(b)	**35.**	(c)	**60.**	(a)	**85.**	(a)	**110.**	(b)	**135.**	(a)
11.	(b)	**36.**	(a)	**61.**	(d)	**86.**	(c)	**111.**	(d)	**136.**	(b)
12.	(d)	**37.**	(c)	**62.**	(b)	**87.**	(d)	**112.**	(c)	**137.**	(d)
13.	(d)	**38.**	(c)	**63.**	(c)	**88.**	(a)	**113.**	(d)	**138.**	(a)
14.	(b)	**39.**	(c)	**64.**	(b)	**89.**	(c)	**114.**	(b)	**139.**	(b)
15.	(d)	**40.**	(b)	**65.**	(b)	**90.**	(a)	**115.**	(c)	**140.**	(b)
16.	(b)	**41.**	(d)	**66.**	(a)	**91.**	(c)	**116.**	(d)	**141.**	(d)
17.	(c)	**42.**	(c)	**67.**	(a)	**92.**	(c)	**117.**	(b)	**142.**	(a)
18.	(b)	**43.**	(c)	**68.**	(b)	**93.**	(d)	**118.**	(a)	**143.**	(a)
19.	(b)	**44.**	(a)	**69.**	(b)	**94.**	(c)	**119.**	(b)	**144.**	(b)
20.	(b)	**45.**	(d)	**70.**	(a)	**95.**	(b)	**120.**	(b)	**145.**	(d)
21.	(a)	**46.**	(c)	**71.**	(d)	**96.**	(d)	**121.**	(d)	**146.**	(c)
22.	(b)	**47.**	(d)	**72.**	(d)	**97.**	(c)	**122.**	(c)	**147.**	(c)
23.	(b)	**48.**	(d)	**73.**	(c)	**98.**	(b)	**123.**	(b)	**148.**	(a)
24.	(d)	**49.**	(d)	**74.**	(d)	**99.**	(c)	**124.**	(d)	**149.**	(b)
25.	(a)	**50.**	(b)	**75.**	(b)	**100.**	(c)	**125.**	(c)	**150.**	(c)

Note: In Q. no. 30 ('*' indicates) mark to all.

DETAILED EXPLANATIONS

1. (d)

Finding R_{Th}, we get,



Here, $$R_{Th} = \frac{1}{I}$$

By applying KVL, we get,

$$2I + 6I - 10I_1 - 1 = 0$$
$$8I - 1 - 10I_1 = 0$$
$\because$ $$I_1 = -I$$
$\therefore$ $$8I - 1 + 10I = 0$$
$\Rightarrow$ $$18I = 1$$
$\Rightarrow$ $$R_{Th} = 18\ \Omega$$

2. (c)

From h-parameter model,

$$V_1 = h_{11}I_1 + h_{12}V_2 \quad \text{...(i)}$$
$$I_2 = h_{21}I_1 + h_{22}V_2 \quad \text{...(ii)}$$
$\therefore$ $$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0}$$

From $ABCD$ parameter,

$$V_1 = AV_2 - BI_2 \quad \text{... (iii)}$$
$$I_1 = CV_2 - DI_2 \quad \text{... (iv)}$$

By keeping $V_2 = 0$ in equation (iv), we have

$$I_1 = -DI_2$$
or $$\frac{I_2}{I_1} = -\frac{1}{D} = h_{21}$$

3. (b)

The equivalent resistance across the terminals of inductor,

$$R_{eq} = 50 + 20 + 10 = 80\ \Omega$$

Time constant, $$T = \frac{L}{R_{eq}} = \frac{0.5}{80} = \frac{1}{160}\text{sec}$$

The current through the inductor at $t = 0^+$,

$$i_L(0^+) = i_L(0^-) = \frac{150}{50} = 3\text{ A}$$

The current through the inductor,

$$i_L(t) = i_L(0^+)e^{\frac{-R_{eq}}{L}t} = 3e^{-160t}\text{ A}, \; t > 0$$

4. (d)

An ideal voltage source produces a specific potential difference across its terminals regardless of what is connectd to it. An ideal current source produces a specific current through its terminals regardless of what is connected to it.

5. (d)

- An open circuit is a circuit elment with resistance approaching infinity.
- A short circuit is a circuit element with resistance approaching zero.
- The power dissipated in a resistor is a non-linear function of either current or voltage.

6. (c)

By KVL for the second mesh

$$-3V_R + 5I + 4 + V_R = 0$$

$$-2V_R + 5I + 4 = 0$$

$$V_R = 2 \times (I - 2)$$

$$-2 \times 2(I - 2) + 5I + 4 = 0$$

$$-4I + 8 + 5I + 4 = 0$$

$$I = -12\text{ A}$$

8. (a)

The applications of resonant effects can be summarized as follows:

- The most common application of resonance is tuning, i.e. as an oscillator circuit.
- A series resonant circuit is used as a voltage amplifier.
- A parallel resonant circuit is used as a current amplifier.

9. (b)

The node voltage method will be used and the matrix form of equation are

Voltage at node 1 = V_1

Voltage of node 2 = V_2

Applying KCL at node 1,

$$\frac{V_1}{20} + \frac{V_1}{7} + \frac{V_1}{4} - \frac{V_2}{4} = \frac{V_s}{20}$$

$$\frac{31}{70}V_1 - \frac{V_2}{4} = \frac{V_s}{20} \quad \text{...(i)}$$

Applying KCL at node 2,

$$-\frac{V_1}{4}+\frac{V_2}{4}+\frac{V_2}{6}+\frac{V_2}{6} = 0$$

$$\frac{7}{3}V_2 = V_1 \quad \text{...(ii)}$$

From equation (i),

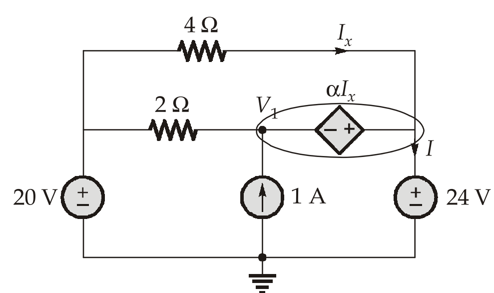
$$\frac{31}{70}\times\frac{7}{3}V_2-\frac{V_2}{4} = \frac{V_s}{20}$$

$$V_2 = 0.0638\ V_s$$

From circuit, $I_0 = 7.5 \times 10^{-3} = \frac{V_2}{6} = \frac{0.0638\ V_s}{6}$

$$V_s = 0.705\ \text{V}$$

11. (b)



and $I_x = \frac{20-24}{4} = -1\ \text{A}.$

thus, $\alpha I_x = 24 - V_1$

$\alpha I_x = 24 - 28 = -4$

$\left(\because\ V_1 = \frac{28\ \text{W}}{1\ \text{A}} = 28\ \text{V}\right.$, and since the absorbed power is negative, thus the source will dissipate the power).

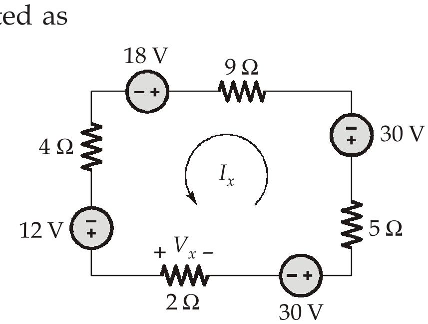
$$\alpha(-1) = -4$$

$$\alpha = 4$$

12. (d)

The above circuit can be solved by using source transformation.

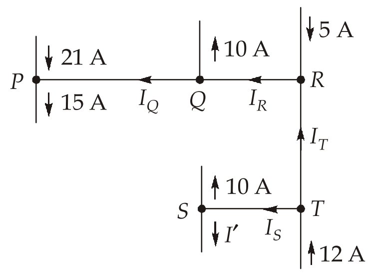
The circuit will be represented as



$$I_x = \frac{12+30-30-18}{9+5+4+2}\text{ A} = -\frac{6}{20}\text{ A}$$

$$V_x = I_x \times 2\ \text{W} = -\frac{6}{10}\text{ V} = -0.6\text{ V}$$

13. (d)



By current division rule,

$$12\text{ A} = I_S + I_T$$

At point R, $\quad 5\text{ A} + I_T = I_R$

At point Q, $\quad I_R = 10\text{ A} + I_Q$

At point P, $\quad I_Q = 15\text{ A} - 21\text{ A} = -6\text{ A}$

$$I_R = 10\text{ A} - 6\text{ A} = 4\text{ A}$$

$\therefore \quad I_T = 4\text{ A} - 5\text{ A} = -1\text{ A}$

and $\quad I_S = 12\text{ A} - I_T = 13\text{ A}$

14. (b)

$$\text{Average load} = \frac{\text{Actual energy consumed}}{\text{time duration}} = \frac{80\times60\times5+2\times1000\times3}{24} = 350\text{ W}$$

$$\text{Load factor} = \frac{\text{average load}}{\text{maximum demand}} = \frac{350}{1500} = 0.2333$$

15. (d)

It may be noted that the condition

$$I_a + I_b + I_c = 0 \text{ is not satisfied}$$

(i) Power frequency L-G (line-to ground fault) currents, where

$$I_a + I_b + I_c = 3I_0$$

(ii) Third and multiple of third harmonic currents under healthy condition, where

$$I_a(3) + I_b(3) + I_c(3) = 3I(3)$$

16. (b)

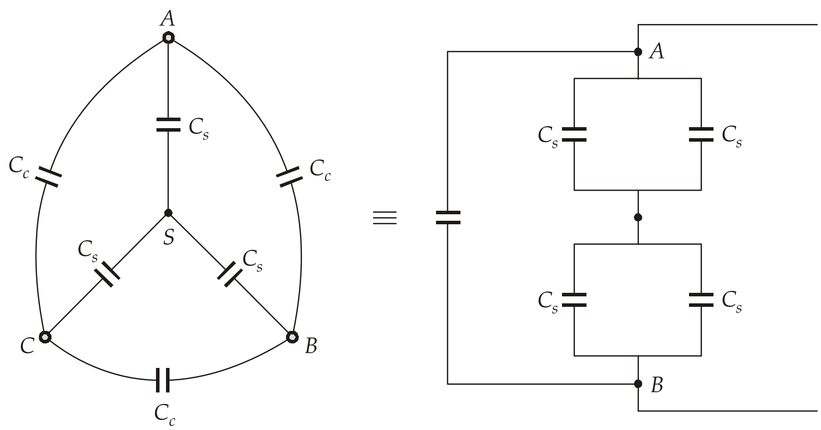
When AC is flowing through a conductor the current is non-uniformly distributed over the cross-section in a manner that the current density is higher at the surface of the conductor compared to the current density at the centre.

17. (c)

$$\text{Diversity factor} = \frac{\Sigma \text{ Individual maximum demand of consumers}}{\text{Maximum load on the system}}$$

18. (b)

Total capacitance measured between the cases A and B is



$$C_1 = C_s + \frac{C_c + C_s}{2} = \frac{1}{2}(3C_c + C_s) = \frac{1}{2}C_{ph}$$

$$C_{ph} = 2C_1$$

$$C_{ph} = 0.6\ \mu\text{F/km}$$

19. (b)

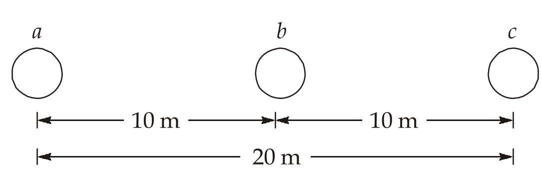
Capacitance of the p^{th} link from the top

$$C_p = \frac{p.c}{n-p} = \frac{5\times 2}{7-5} = 5\ \mu\text{F}$$

20. (b)

- When corona is present the effective capacitance of the conductor is increased because the effective dia of the conductor is increased.
- Corona reduces the magnitude of high voltage steep fronted waves due to lighting or switching.

21. (a)



$$\text{Mutual GMD} = \sqrt[3]{D_{ab}D_{bc}D_{ca}}$$

$$= \sqrt[3]{10\times 10\times 20} = 12.6\text{ m}$$

22. (b)

P_A is the power in MW supplied to load by the generator A.

$P_B = (300 - P_A)$ be the power in MW supplied by the generator B.

Given % drop = 10

% Drop in speed of generator A

$$= \frac{10}{1.25} \times P_A = \frac{10P_A}{125}$$

% drop in speed of generator B

$$= \frac{10}{250}(300 - P_A)$$

since the two machines are working in parallel, the percentage drop in frequency from both the machines due to different loadings must be same.

$$\frac{10 \times P_A}{125} = \frac{10}{250}(300 - P_A)$$

$$300 - P_A = \frac{250}{125}P_A$$

$$3P_A = 300$$

$$P_A = 100 \text{ MW}$$

Power shared by generator $A = P_A = 100$ MW

Power shared by generator $B = P_B = 300 - P_A = 200$ MW

23. (b)

In practical power cables the loading is less than surge impedance loading.

24. (d)

Total number of buses, $n = 50$

Number of PV buses, $m = 10$

Slack bus = 1

The size of Jacobian matrix,

$$[J] = (2n - m - 2) \times (2n - m - 2)$$

$$= [(2 \times 50) - 10 - 2] \times [(2 \times 50) - 10 - 2] = 88 \times 88$$

25. (a)

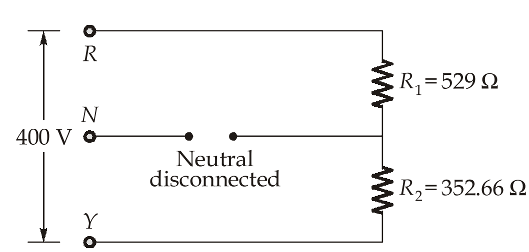
Resistance of lamp 1, $R_1 = \frac{230^2}{100} = 529\ \Omega$

Resistance of lamp 2, $R_2 = \frac{230^2}{150} = 352.66\ \Omega$

Current through lamps, $I = \frac{V_{L-L}}{R_1 + R_2} = \frac{400}{529 + 352.67}$

$I = 0.454$ A

Voltage across lamp 1 = 0.454 × 529 = 240 V



26. **(b)**

For a fault at F_1, the voltage drop from A to F_1

$$= (500 \times 30) + (500 + 200)75 = 67500 \text{ V}$$

The impedance seen by the relay at A

$$= \frac{67500}{500} = 135\ \Omega$$

27. **(b)**

The transmission line without reflection of voltage and current is called infinite line.

28. **(a)**

$$G_e(s) = G_1(s) + G_2(s) + G_3(s)$$

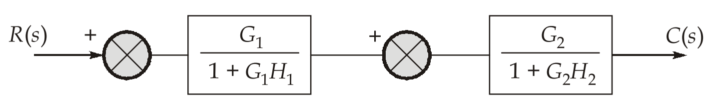
$$= \frac{1}{(s+1)} + \frac{1}{(s+4)} + \frac{(s+3)}{(s+5)}$$

$$= \frac{s^2+9s+20+s^2+6s+5+s^3+5s^2+4s+3s^2+15s+12}{(s+1)(s+4)(s+5)}$$

$$= \frac{s^3+10s^2+34s+27}{(s+1)(s+4)(s+5)}$$

29. **(d)**

Reducing the blocks by applying feedback formula



$$\frac{G(s)}{R(s)} = \frac{G_1G_2}{(1+G_1H_1)(1+G_2H_2)}$$

$$= \frac{G_1G_2}{1+G_1H_1+G_2H_2+G_1G_2H_1H_2}$$

30. **(*)**

Characteristic equation:

$$s(1 + sT_1)(1 + sT_2) + K = 0$$

$$s(1 + sT_1 + sT_2 + s^2T_1T_2) + K = 0$$

$$s^3T_1T_2 + s^2(T_1 + T_2) + s + K = 0$$

Routh table:

s^3	T_1T_2	1
s^2	(T_1+T_2)	K
s^1	$\frac{(T_1+T_2)-T_1T_2K}{T_1+T_2}$	
s^0	K	

For stable system:

$$K > 0$$

and $$(T_1 + T_2) - T_1 T_2 K > 0$$

$$K < \left(\frac{1}{T_1} + \frac{1}{T_2}\right)$$

Range of K : $$0 < K < \left(\frac{1}{T_1} + \frac{1}{T_2}\right)$$

31. (a)

Characteristic equation $1 + G(s)H(s) = 0$

$$s^6 + s^5 - 6s^4 + s^2 + s - 6 - 8 = 0$$

$$s^6 + s^5 - 6s^4 + s^2 + s - 14 = 0$$

$$s^6 + s^5 - 6s^4 + 0s^3 + s^2 + s - 14 = 0$$

Routh table:

s^6	1	–6	1	–14
s^5	1	0	1	0
s^4	–6	0	–14	
s^3	$0 \to \varepsilon$	$-\frac{4}{3}$		
s^2	$\frac{-24}{3\varepsilon}$	–14		
s^1	$\frac{126\varepsilon^2 - 96}{-72}$	0		
s^0	–14			

$(\varepsilon > 0)$

In the first column, there are three sign change

so, 3 poles $\to$ RHP

3 poles $\to$ LHP

0 poles $\to$ imaginary axis

32. (c)

The system is type 2 system. Thus for step and ramp inputs steady state error will be zero.

33. (c)

Given $\to$ settling time (t_s) = 7 sec

$$\frac{4}{\xi\omega_n} = 7$$

$$\xi\omega_n = 0.571$$

and time for first undershoot:

$$\frac{2\pi}{\omega_n\sqrt{1-\xi^2}} = 3 \text{ sec}$$

$$\omega_n\sqrt{1-\xi^2} = \frac{2\pi}{3}$$

$$\omega_n\sqrt{1-\xi^2} = 2.094$$

location of poles,

$$s = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2}$$

$$\text{poles} = -0.571 \pm j2.094$$

34. (a)

For ω_2 value

We know 20 dB/decade = 6 dB/octave

from ω_2 to 10 rad/sec → change in magnitude = 6 dB

so $$\omega_2 = \frac{10}{2^1} = 5\text{ rad/sec}$$

Transfer function:

$$T(s) = \frac{K\left(1+\frac{s}{\omega_1}\right)}{s\left(1+\frac{s}{\omega_2}\right)\left(1+\frac{s}{10}\right)}$$

Bode plot → Poles at origin (initial slope = 20 dB/dec)

zero at $\omega = \omega_1$ = 2 rad/sec (slope changes from –20 dB/dec to 0)

pole at $\omega = \omega_2$ = 5 rad/sec (slope changes from 0 dB/dec to –20 dB/dec)

pole at ω = 10 rad/sec (slope changes from –20 dB/dec to –40 dB/dec)

$$T(s) = \frac{K\left(1+\frac{s}{2}\right)}{s\left(1+\frac{s}{5}\right)\left(1+\frac{s}{10}\right)}$$

$$T(s) = \frac{25K(s+2)}{s(s+5)(s+10)}$$

35. (c)

Gain margin:

$$20\log\frac{1}{|G(j\omega)H(j\omega)|} = 20$$

$$\frac{1}{|G(j\omega)H(j\omega)|} = 10$$

$$|G(j\omega)H(j\omega)| = 0.1$$

system will cross at $s = -0.1$

36. (a)

Given:

$$G(s) = \frac{K}{s(s+1)(2s+1)(3s+1)}$$

$$G(j\omega) = \frac{K}{j\omega(j\omega+1)(1+2j\omega)(1+3j\omega)}$$

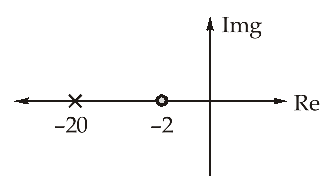
$$\angle G(j\omega) = -90° - \tan^{-1}(\omega) - \tan^{-1}(2\omega) - \tan^{-1}(3\omega)$$

$$\angle G(j\omega)\big|_{\omega\to 0} = -90°$$

$$\angle G(j\omega)\big|_{\omega\to \infty} = -360°$$

37. (c)

Pole-zero diagram:



$$G(s) = \frac{10(s+2)}{(s+20)}$$

zero is more dominant then pole hence it is lead compensator.

$$\text{standard form} = \frac{(1+0.5s)}{(1+0.05s)}$$

$$\text{Comparing with standard form} = \frac{(1+Ts)}{(1+\alpha Ts)}$$

$$T = 0.5,\ \alpha T = 0.05$$

$$\alpha = \frac{0.05}{0.5} = 0.1$$

maximum phase lead occurs at:

$$\omega_m = \frac{1}{T\sqrt{\alpha}} = \frac{1}{0.5\sqrt{0.1}} = 6.32 \text{ rad/sec}$$

$$f_m = 1 \text{ Hz}$$

maximum phase lead:

$$\phi_m = \sin^{-1}\left(\frac{1-\alpha}{1+\alpha}\right) = \sin^{-1}\left(\frac{1-0.1}{1+0.1}\right) = \sin^{-1}\left(\frac{0.9}{1.1}\right)$$

$$\phi_m = \sin^{-1}\left(\frac{9}{11}\right) = \sin^{-1}(0.81) \approx 54.9° \quad \{\sin 53.13° = 0.8\}$$

39. (c)

The transition temperature of a superconductor can be reduced by the application of an external magnetic field.

40. (b)

Loss tangent, $\tan\delta = \dfrac{\varepsilon_r''}{\varepsilon_r'}$

Complex permittivity, $\varepsilon_r{*} = \varepsilon_r' - j\varepsilon_r''$

$$\varepsilon_r'' = 2 \times 0.004 = 0.008$$

$$\varepsilon_r{*} = 2 - j\,0.008$$

41. (d)

Both the statements are correct.

42. (c)

Ionic bonds are non-directional in nature.

43. (c)

Conductivity of a metal is given by,

$$\sigma = ne\mu$$

$$\Rightarrow \quad \sigma \propto n\mu$$

44. (a)

Fermi level is that energy level at which the probability of finding an electron is 50%.

45. (d)

- The maximum value of residual flux density is known as retentivity.
- The maximum value which a coercive field can attain is known as coercivity.

46. (c)

The properties of carbon nanotubes:

- High stiffness
- High strength
- Low densities
- Very high conductivity
- Ductile

47. (d)

$$T_{avg} = H_C T_C + (1 - H_C)(T_M + T_C)$$

$$= (0.8 \times 50) + (1 - 0.8)(800 + 50)$$

$$= 40 + 170 = 210 \text{ ns}$$

48. (d)

← 32 bit →

Opcode	Reg	Mem	Immediate
7 bit	$\log_2 64$	$\log_2 1K$	9 bit
	↓ 6 bit	↓ 10 bit	

$$\text{Unsigned constant} = (2^{9-1} - 1) = 255$$

49. (d)

PC-Relative mode is use for programme reallocation at run time.

50. (b)

$$\text{Min 'M'} = \text{All 0's in M} = 0$$

$$\therefore \quad \text{Normal 'M'} = 1.\text{M} = 1.0 = 1$$

$$\text{Max 'M'} = \text{All 1's in M} = 1111 \ldots (20)\ 1\text{'s}$$

$$\text{Normal 'M'} = 1.\text{M} = 1.1111 \ldots (20)\ 1\text{'s} = (2 - 2^{-20})$$

$$\text{Mantissa range} = \{1 \text{ to } (2 - 2^{-20})\}$$

51. (d)

Default micro programmed control unit is vertical encoded form of CS

$$\text{Number of bits/CS} = \log_2 200 = 7.64 \approx 8 \text{ bit (FC)}$$

Micro instruction with 6 CS's

← Control Field → (FC1 to FC6)

BC	Flags	FC1	FC2	FC3	FC4	FC5	FC6	CM addr
		8	8	8	8	8	8	

$$\text{Size of control field} = 8 \times 6 = 48 \text{ bits}$$

52. (c)

$$\text{EMT} = (P \times S) + (1 - P)\,T_m$$

$$= (0.85 \times 800) + (1 - 0.85)\,200$$

$$= 680 + 30 = 710 \text{ ns}$$

53. (c)

Number of lines in cache memory, (N) = 128

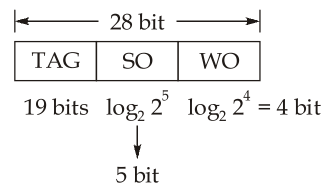
Number of lines in the set (P) = 4

$$\text{Number of Set (S)} = \frac{N}{\text{P – way}} = \frac{128}{4} = 2^5$$

$$\text{Main memory size} = 2^{24} \text{ block} \times 2^4 \text{ bytes/block}$$

$$= 2^{28} \text{ bytes}$$

Physical Address = 28 bit



54. (b)

$$\text{Disk capacity} = (64 \times 2) \times 256 \times 512 \times 1024 \text{ B}$$

$$= 128 \times 256 \times 512 \times 1024 \text{ B}$$

$$= 2^7 \times 2^8 \times 2^9 \times 2^{10} \text{ B}$$

$$= 2^{34} \text{ B} = 16 \text{ GB}$$

$$\text{Number of address} = 2^7 \times 2^8 \times 2^9 = 2^{24}$$

So, 24 address bits are required.

55. (c)

Primary voltage

$$E = \sqrt{2}\pi f \cdot \phi_m \cdot N_1$$

$$E = 4.44 \times f \times \phi_m \times N_1$$

$$\phi_m = \frac{2000}{4.44 \times 50 \times 100}$$

$$\phi_m = 0.09 \text{ Wb}$$

56. (c)

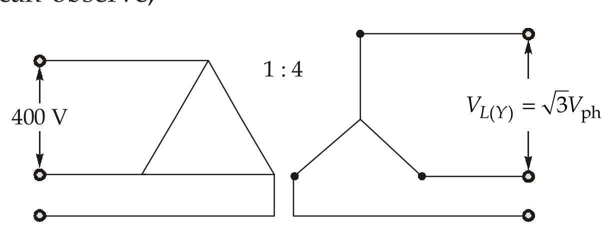
Regulation at 0.8 pf loading

$$= R_{e2} \cos \phi_2 - X_{e2} \sin \phi_2$$

$$= 1 \times 0.8 - 5 \times 0.6 = -2.2\%$$

57. (c)

From figure below, we can observe,



$$\frac{V_{ph\Delta}}{V_{phY}} = \frac{1}{4}$$

For delta side, $V_{ph\Delta} = V_{L\Delta} = 400$ V

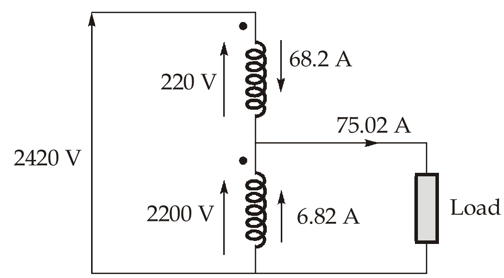
$V_{phY} = 4\, V_{ph\Delta}$

$= 4 \times 400 = 1600$ V

Now $V_{LY} = \sqrt{3}V_{phY} = 1600\sqrt{3}$

$= 2771.28$ V

59. (c)



output kVA = 72.02 × 2200 = 165 kVA

60. (a)

Power converted, $P = \left(\frac{ZP}{2\pi}\right)\phi\omega_m I_a$

Torque developed, $T = \left(\frac{ZP}{2\pi}\right)\phi I_a$

These quantities depend on number of conductors and permissible conductor current.

61. (d)

All the above methods are the remedies of the cross magnetizing effect of the armature reaction.

62. (b)

Given, $P_A + P_B = 50$ MW ...(i)

No load frequency, $f_0 = 50$ Hz

For alternator A:

For a load of 50 MW, the drop in frequency,

$$= 3\% \text{ of } f_0 = \frac{3}{100} \times 50 = 1.5 \text{ Hz}$$

For a load of P_A MW, the drop in frequency,

$$= \frac{1.5}{50}P_A$$

Operating frequency of alternator,

$$A = 50 - \frac{1.5}{50} P_A \quad \text{...(ii)}$$

For alternator B:

Similarly, the operating frequency of alternator B,

$$= 50 - \frac{3.5}{50} P_B \quad \text{...(iii)}$$

Since for parallel operation both generators must operate at the same frequency,

$$50 - \frac{1.5}{50} P_A = 50 - \frac{3.5}{50} P_B$$

or, $$3 P_A = 7 P_B \quad \text{...(iv)}$$

From equation (i) and (ii), we get

$$\frac{7}{3} P_B + P_B = 50$$

$$P_B = 15 \text{ MW}$$

and $$P_A = 35 \text{ MW}$$

63. (c)

Given, $$P_{in} = 100 \text{ kW}$$

$$\text{Stator loss} = 3 \text{ kW}$$

$$\text{Rotor input, } P_g = 100 - 3 = 97 \text{ kW}$$

$$\text{Rotor Cu loss, } P_{cu} = s \times \text{rotor input}$$

$$= 0.04 \times 97 = 3.88 \text{ kW}$$

$$\text{Mechanical power developed} = P_g - P_{cu}$$

$$= 97 - 3.88 = 93.12 \text{ kW}$$

64. (b)

Given, Starting current, $I_{sc} = 5\, I_{fl}$

Full load slip, $s_{fl} = 5\% = 0.05$

We know that, $$\frac{T_{st}}{T_{fl}} = x^2 \left(\frac{I_{sc}}{I_{fl}}\right)^2 \times s_{fl}$$

$$1 = x^2 \left(\frac{5 I_{fl}}{I_{fl}}\right)^2 \times 0.05$$

$$x^2 = \frac{1}{25 \times 0.05} = \frac{1}{1.25} = 0.8$$

$$x = 89.44\%$$

65. (b)

each transformer rating = 40 kVA

3-ϕ transformer rating if connected in delta-delta connection

$$(S_{\Delta\text{-}\Delta}) = 3 \times 40 = 120 \text{ kVA}$$

Open delta rating $$S_{V\text{-}V} = \frac{1}{\sqrt{3}}(S_{\Delta-\Delta}) = \frac{120}{\sqrt{3}}$$

$$S_{V\text{-}V} = 69.28 \text{ kVA}$$

66. (a)

Losses in two-winding transformer and auto transformer remains same.

For 2 winding transformer:

$$\eta = \frac{\text{output}}{\text{output + losses}}$$

$$0.95 = \frac{25 \times 0.8}{25 \times 0.8 - \text{losses}}$$

$$\text{losses} = \left(\frac{20}{0.95} - 20\right)$$

$$\text{losses} = 1.052 \text{ kW}$$

= losses of auto-transformer of 2-winding transformer

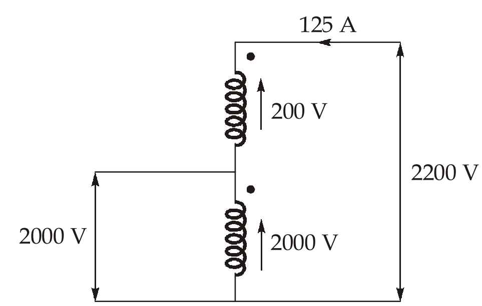
Output kVA of auto-transformer

= 2200 × 125

= 275 kVA

$$(\eta)_{auto} = \frac{\text{output}}{\text{output + losses}}$$

$$= \frac{275}{275 + 1.052} = 99.61\%$$



67. (a)

Double squirrel cage induction motor:

1. It provides high starting torque with a low starting current.
2. It's outer cage contain a high resistance and low leakage reactance winding.
3. It's inner cage contain a low resistance and high leakage reactance winding.
4. The inner winding provides the running torque.
5. The outer winding provides the accelerating torque.

So, statement 1 and 2 are true.

68. (b)

Short circuit ratio of a synchronous machine is defined as the ratio of field current required to produce rated voltage on open circuit and field current required to produce rated armature current on short circuit.

69. (b)

Due to excitation increase only power factor will get change as real power remains constant. The power factor becomes more lagging in nature.

70. (a)

$$\text{Inductive kick} = \frac{L.\dfrac{2I_a}{A}}{T_c}$$

Where, Number of parallel paths,

$$A = P = 6$$

and T_c = Commutation time

$$\text{Inductive kick} = \frac{(2\times10^{-3}).\dfrac{2\times6}{6}}{2\times10^{-3}} = 2\text{ V}$$

71. (d)

Let, V_1 = Output of buck converter = Input of boost converter

$$V_1 = 10\,D_1$$

$$\text{Output of boost converter} = 30\text{ V} = \frac{V_1}{1-D_2}$$

$$30 = \frac{10D_1}{1-D_2}$$

or $3 - 3\,D_2 = D_1$

or $D_1 + 3\,D_2 = 3$

72. (d)

In armature voltage control speed control method in DC machine we reduce the voltage, we cannot increase the voltage due to insulation of windings. So for this purpose we can't use boost converter.

73. (c)

For proper turn on $I_A \geq I_L$

$$I_A = \frac{1}{L}\int V\,dt + \frac{V}{R}$$

$$I_A = \frac{V}{L}t + \frac{V}{R}$$

or $\frac{V}{L}t + \frac{V}{R} \geq 5\times10^{-3}$

or $\frac{50}{L}\times5\times10^{-6} + \frac{50}{50\times10^{3}} \geq 5\times10^{-3}$

or $$\frac{250\times10^{-6}}{L} \geq 4 \times 10^{-3}$$

or $$L \leq \frac{250\times10^{-6}}{4\times10^{-3}}$$

or $$L \leq 0.0625 \text{ H}$$

$$L = 0.0625 \text{ H}$$

74. (d)

In voltage source inverter the shape of output voltage is independent from load parameter. The output voltage shape will be square wave (or) rectangular depended upon switching.

75. (b)

$$\alpha = 120°$$

$$\text{Input power factor} = \frac{2\sqrt{2}}{\sqrt{\pi(\pi-\alpha)}}\cos^2\frac{\alpha}{2}$$

$$= \frac{2\sqrt{2}}{\sqrt{\pi\left(\pi-\frac{2\pi}{3}\right)}}\cos^2 60° = \frac{2\sqrt{2}}{\pi}\times\sqrt{3}\times\frac{1}{4}$$

$$= 0.9\times\sqrt{3}\times\frac{1}{4} = 0.389$$

76. (b)

For proper commutation the circuit should be under damped.

$$\frac{1}{LC}-\left(\frac{R}{2L}\right)^2 > 0$$

or $$R < \sqrt{\frac{4L}{C}}$$

$$R < \sqrt{\frac{4\times20\times10^{-6}}{50\times10^{-6}}}$$

$$R < 1.26\ \Omega$$

Option (b) is the only value which is less than 1.26 Ω

∴ $$R_L = 1\ \Omega$$

77. (b)

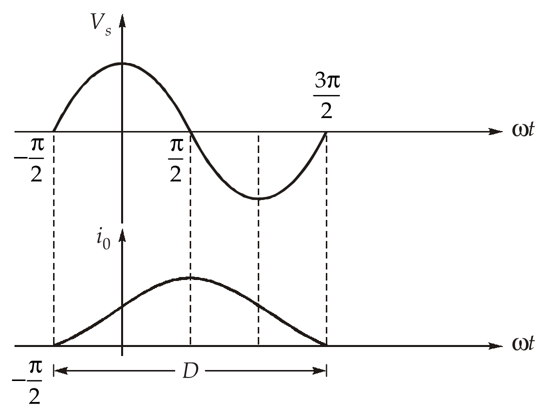
Let, I_0 = ripple free load current

Rms current through free wheeling diode = $I_0\sqrt{1-D}$

Rms current through switch = $I_0\sqrt{1-D}$

$$\text{Required Ratio} = \frac{I_0\sqrt{1-D}}{I_0\sqrt{D}} = \frac{\sqrt{1-0.75}}{\sqrt{0.75}} = 0.57$$

78. (b)



Initiall condition:

At $\omega t = -\frac{\pi}{2}, i = 0$

KVL : D → ON:

$$V_m \cos \omega t = L \cdot \frac{di}{dt}$$

$$\int di = \int \frac{V_m \cdot \cos \omega t}{L} \cdot dt$$

$$i = \frac{V_m}{\omega L} \cdot \sin \omega t + K$$

Use initial condition and find the value of K

$$0 = \frac{V_m}{\omega L} \sin\left(\frac{-\pi}{2}\right) + K$$

$$K = \frac{V_m}{\omega L}$$

$$i = \frac{V_m}{\omega L} \cdot \sin \omega t + \frac{V_m}{\omega L}$$

$$i_{peak} \text{ at } \omega t = \frac{\pi}{2} = \frac{2V_m}{\omega L} = 20 \text{ A}$$

79. (b)

When conduction angle of thyristor increases, form factor decreases.

$$I_{T(avg)} = \frac{I_{rms}\,(\text{rating})}{F.F}$$

If form factor decreases then $I_{T(avg)}$ increases.

80. (d)

Magnetic field due to a square loop current is given by,

$$h = \frac{\mu_0}{4\pi}\frac{I}{r}(\sin\phi_1 + \sin\phi_2)$$

Now magnetic field produced at the loop centre,

$$H_A = \frac{\mu_0}{4\pi}\frac{I}{\left(\frac{d}{2}\right)}[\sin 45° + \sin 45°] = \frac{\mu_0}{4\pi}\frac{I}{d}\left(2\sqrt{2}\right)$$

$$H_B = \frac{\mu_0}{4\pi}\frac{I}{d}(\sin 45° + \sin 45°) = \frac{\mu_0}{4\pi}\frac{I}{d}\left(\sqrt{2}\right)$$

Hence, $H_A : H_B = 2 : 1$

81. (d)

The magnetic field intensity at the centre of a circular coil is equal to $\frac{I}{(2a)}$ where I is current and 'a' is the radius of the circular coil. Here I = 2 A and $a = \frac{1}{2}$ m.

The magnetic field intensity, $H = \frac{I}{2a} = \frac{2}{2\left(\frac{1}{2}\right)} = 2$ A/m

82. (d)

Electric field density in dielectric, $\vec{D} = \epsilon_o \vec{E} + \vec{P}$

$\vec{P} = \epsilon_o \chi_e \vec{E}$

where, $\vec{P}$ = Polarizability, χ_e = Susceptibility

$1 + \chi_e = \epsilon_r$

$\chi_e = \epsilon_r - 1 = 2$

$\vec{P} = \epsilon_o (2 \times 6)\hat{a}_x = 12 \epsilon_o \hat{a}_x$

83. (d)

Energy stored between two charge particles,

$$E = QV = Q \times \frac{Q}{4\pi \epsilon_0 d} = -2 \times 10^{-6} \times \frac{-2 \times 10^{-6}}{4\pi \times \frac{10^{-9}}{36\pi} \times 9}$$

$$= 4 \times 10^{-12} \times 10^{9} = 4 \times 10^{-3} \text{ J} = 4 \text{ mJ}$$

84. (a)

$$I_C = \frac{I_{\text{reff}}}{\left(1 + \frac{N}{\beta}\right)} \;; \quad \text{Here } N = 4$$

$$= \frac{21\times10^{-3}}{1+\left(\frac{4}{100}\right)} = \frac{25}{26}\times 21\text{ mA} = 20.19\text{ mA}$$

86. (c)

$$A_v = \frac{-R_2/R_1}{1+\frac{(1+R_2/R_1)}{A_{OL}}} = \frac{-8/2}{1+\frac{(1+8/2)}{100}}$$

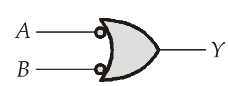
$$= \frac{-4}{1+\frac{5}{100}} = \frac{-4}{1.05} = -3.8095 \approx -3.81$$

87. (d)

By replacing the emiiter resistance with a current mirror circuit the common mode gain decreases as well as CMRR also.

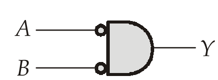
88. (a)

OR gate with inverted input,



$$Y = \bar{A}+\bar{B} = \overline{AB} = \text{NAND gate}$$

AND gate with inverted input,



$$Y = \bar{A}\cdot\bar{B} = \overline{A+B} = \text{NOR gate.}$$

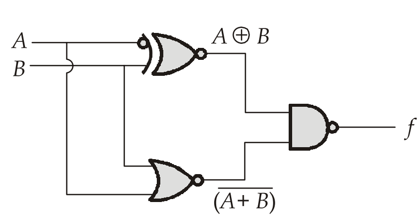
89. (c)

$$S_1 = \bar{C}B + C\bar{B} = B\oplus C$$

$$F = \overline{(B\oplus C)}A + (B\oplus C)\cdot 1$$

Let $(B\oplus C) = Z$, $F = A\bar{Z}+Z = A+Z = A+(B\oplus C)$

90. (a)

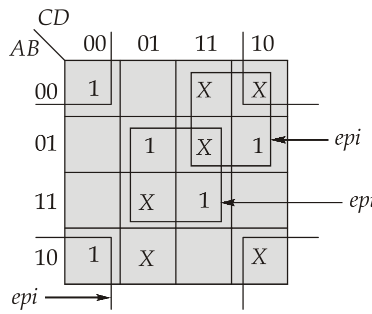


$$f = \overline{(A\oplus B)\,\overline{(A+B)}} = \overline{(A\oplus B)} + \overline{\overline{(A+B)}}$$

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

$$= 1$$

91. (c)



$$f = BD + \bar{A}C + \bar{B}\bar{D}$$

92. (c)

$\because \quad f(A,B,C) = \overline{\Sigma m(1,2,4,6)} = \Sigma m(0, 3, 5, 7)$

93. (d)

I_1: LDA 2018H requires 4 machine cycles: one opcode fetch + 2 memory reads to read 2018H + 1 memory read to read data from 2018H location.

I_2: LDI H, 2018H requires 3 machine cycles: one opcode fetch + 2 memory reads to read the data 2018H.

94. (c)

The noise figure of any multistage circuit is mainly controlled by its first stage. RF amplifier is at the first stage in a superheterodyne receiver.

96. (d)

LXI H, XX 65H

Flag resister value unknown

MVI M, FFH

INR M

Value of M is 00H

$\Rightarrow \quad Z = 1$

INR does not affect the carry flag.

97. (c)

Memory size = 512 TB

$= 2^9 \times 2^{40} \times 8$ bit

$= 2^{49} \times 8$ bit

$= 2^n \times$ m bit $\quad$ ($n \rightarrow$ no. of address lines)

$n = 49$

98. (b)

Given Am signal,

$$S_{AM}(t) = 40 \cos 400\,\pi t + 4 \cos 360\pi t + 4 \cos 440\pi t$$

Comparing with standard *AM* signal

$$S_{AM}(t) = A_c \cos 2\pi f_c t + \frac{\mu A_c}{2}\cos 2\pi(f_c + f_m)t + \frac{\mu A_c}{2}\cos 2\pi(f_c - f_m)t$$

$$A_c = 40$$

$$\frac{\mu A_c}{2} = 4$$

$$\Rightarrow \quad \frac{\mu \times 40}{2} = 4$$

$$\mu = 0.2$$

$$\text{Modulation efficiency } (\eta) = \frac{\mu^2}{2+\mu^2} = \frac{0.04}{2+0.04} = \frac{4}{204} = \frac{1}{51} \approx 0.02 = 2\%$$

99. (c)

Johnson's formula, $P_n = KTB$

Where, P_n = Average noise power

K = Boltzmann constant = 1.38×10^{-23} J/k

T = Temperature = 500 K

B = Bandwidth = 10 kHz

So, $P_n = 1.38 \times 10^{-23} \times 500 \times 10 \times 10^3$ W

$= (1.38 \times 5) \times 10^{-17}$ W

$= 6.9 \times 10^{-17}$ W

100. (c)

When $m(t)$ is applied as message signal:

$$\Delta f_{max} = \frac{k_p}{2\pi}\left|\frac{dm(t)}{dt}\right|_{max}$$

$$\frac{k_p}{2\pi}\left|\frac{dm(t)}{dt}\right|_{max} = 10 \text{ kHz}$$

When $x(t) = m(2t)$ is applied as message signal:

$$\frac{dx(t)}{dt} = \frac{dm(2t)}{dt}$$

Let, $\tau = 2t \Rightarrow d\tau = 2dt$

So, $$\frac{dx(t)}{dt} = \frac{dm(\tau)}{d\tau} \times \frac{d\tau}{dt} = 2\frac{dm(\tau)}{d\tau}$$

$$\left|\frac{dx(t)}{dt}\right|_{\max} = 2\left|\frac{dm(\tau)}{d\tau}\right|_{\max} = 2\left|\frac{dm(t)}{dt}\right|_{\max}$$

So, $$\Delta f_{\max} = \frac{k_p}{2\pi}\left|\frac{dx(t)}{dt}\right|_{\max} = 2\left[\frac{k_p}{2\pi}\left|\frac{dm(t)}{dt}\right|_{\max}\right] = 20\text{ kHz}$$

101. (a)

Capture range of a PLL is much narrower than the lock range.

102. (a)

$$\text{sinc}(1000t) \xleftrightarrow{\text{CTFT}} \frac{1}{1000}\text{rect}\left(\frac{f}{1000}\right) \Rightarrow f_{\max} = 500\text{ Hz}$$

$$x_1(t) = \text{sinc}^2(1000t) \xleftrightarrow{\text{CTFT}} \frac{1}{10^6}\left[\text{rect}\left(\frac{f}{1000}\right) * \text{rect}\left(\frac{f}{1000}\right)\right] \Rightarrow f_{\max} = 1000\text{ Hz}$$

$$x_2(t) = \text{sinc}^3(2000t) \xleftrightarrow{\text{CTFT}} \frac{1}{(2000)^3}\left[\text{rect}\left(\frac{f}{2000}\right) * \text{rect}\left(\frac{f}{2000}\right) * \text{rect}\left(\frac{f}{2000}\right)\right] \Rightarrow f_{\max} = 3000\text{ Hz}$$

$$x(t) = x_1(t) * x_2(t) \xleftrightarrow{\text{CTFT}} X_1(f)X_2(f) \Rightarrow f_{\max} = \min\{1000\text{ Hz}, 3000\text{ Hz}\} = 1000\text{ Hz}$$

So, $$f_{s\,(\min)} = 2f_{\max} = 2000\text{ Hz} = 2\text{ kHz}$$

103. (d)

Thermal run-away will take place if $V_{CE} > \frac{1}{2}V_{CC}$.

Hence option (a), (b) and (c) will satisfy the condition.

104. (d)

The Thevenin equivalent is shown below:

$$V_T = \frac{R_2}{R_1 + R_2}V_{CC} = \frac{6}{12+6}\times 18 = 6\text{ V}$$

Since β is large,

$$I_C = I_E,$$
$$I_B \approx 0$$

and $$I_E = \frac{V_T - V_{BE}}{R_E} = \frac{6-0.7}{0.530\text{ k}\Omega} = \frac{5.3}{0.530\text{ k}\Omega} = 10\text{ mA}$$

105. (b)

$$\theta_L = 180° + 45° = 225°$$
$$\theta_h = 180° - 45° = 135°$$

106. (d)

In current shunt,
$$R_{if} = \frac{R_i}{1 + A\beta}$$
$$R_{of} = R_0(1 + A\beta)$$

107. (a)

The PIV rating of full-wave rectifier with centre tap is $2V_m = 2 \times 100 = 200$ V.

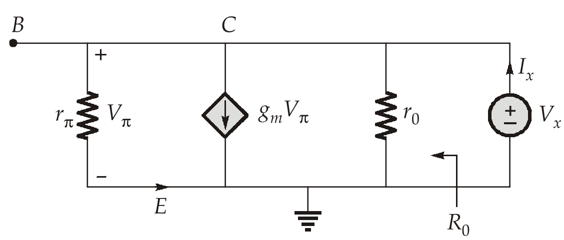
108. (d)

For full bridge diode rectifier

- Average current $I_{dc} = \dfrac{2I_m}{\pi}$.
- DC output voltage $(V_{dc})_{NL} = \dfrac{2V_m}{\pi}$.
- Rms load current $I_{rms} = \dfrac{I_m}{\sqrt{2}}$.

109. (d)

Small signal model



As B and C are connected,

$\therefore$ $$V_x = V_\pi$$

and output resistance between C and E is

$$R_0 = \frac{V_x}{I_x}$$

Applying KCL at collector

$$g_m V_\pi + \frac{V_x}{r_0} + \frac{V_\pi}{r_\pi} = I_x$$
$$V_x\left[g_m + \frac{1}{r_0} + \frac{1}{r_\pi}\right] = I_x$$
$$\frac{V_x}{I_x} = R_0 = \frac{1}{\frac{1}{r_0} + \frac{1}{r_\pi} + g_m}$$

$\therefore$ $$R_0 = \frac{1}{g_m} \| r_\pi \| r_0$$

110. (b)

Type of feedback		R_i	R_0
Series Shunt	Voltage Series	Increases	Decreases
Shunt-Shunt	Voltage Shunt	Decreases	Decreases
Shunt-Series	Current Shunt	Decreases	Increases
Series-Series	Current Series	Increases	Increases

111. (d)

Resistance R and R_E constitute the feedback network. R is directly connected to input node, hence shunt mixing and not directly connected to output node, hence current sampling.

Hence, the feedback is current shunt feedback.

112. (c)

Total energy consumption = 220 × 6 × 1 × 8

$$E = (VI\cos\phi) \times t$$

$$\text{Energy meter constant} = \frac{\text{Total no. of revolution}}{\text{Total energy consumption}}$$

$$= \frac{3300 \times 1000}{220 \times 48 \times 1} = 312.5 \text{ rev/kWhr}$$

113. (d)

Using the virtual short concept,

$$V_- = V_+ = 0 \text{ V}$$

Applying KCL at input side

$$\frac{2-0}{1} = \frac{0-V_0}{4} + \frac{0-V_0}{4}$$

$$2 \times 4 = -2\,V_0$$

$$V_0 = -4 \text{ Volt}$$

Applying KCL at output side

$$\frac{V_0}{2} + \frac{V_0-0}{4} + \frac{V_0-0}{4} = I$$

$$\frac{-4}{2} + \frac{(-4)}{4} + \frac{(-4)}{4} = I$$

$$I = -2 - 1 - 1$$

$$I = -4 \text{ mA}$$

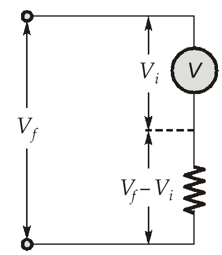
114. (b)

Full scale deflection voltage,

$$V_i = 20 \text{ mV} = 0.02 \text{ V}$$

New full scale deflection voltage,

$$V_f = 400 \text{ V}$$



To measure higher voltage we connect a resistance in series with instrument,

$$R = \frac{V_f - V_i}{I_m} = \frac{400 - 0.02}{0.02}$$

$$= \frac{399.98}{0.02} = \frac{39998}{2} = 19999$$

$$= 19.99 \text{ k}\Omega \approx 20 \text{ k}\Omega$$

115. (c)

$$\frac{f_y}{f_x} = \frac{\text{No. of horizontal tangencies}}{\text{No. of vertical tangencies}}$$

$$\frac{f_y}{50} = \frac{3}{2}$$

$$f_y = \frac{3}{2} \times 50 = 75 \text{ Hz}$$

116. (d)

Given,current in current coil = 10 A

As rectifier is half wave rectifier it conducts for half cycle only

Reading of wattmeter = average power over a cycle

$$= \frac{1}{2\pi}\int_0^{2\pi} VI\, d(\omega t)$$

$$= \frac{1}{2\pi}\int_0^{\pi} 200\sin\omega t \times 10\, d(\omega t) = \frac{2000}{2\pi}[-\cos\omega t]_0^{\pi}$$

$$= \frac{2000}{2\pi}[1 - (-1)] = \frac{2000}{\pi}\text{W}$$

117. (b)

Under balance condition,

$$\left(R_1 \parallel \frac{1}{j\omega C_1}\right)(R_4 + j\omega L_4) = R_2R_3$$

$$\frac{R_1}{j\omega R_1 C_1 + 1}(R_4 + j\omega L_4) = R_2R_3$$

$$R_1R_4 + j\omega R_1L_4 = R_2R_3 + j\omega R_1\, C_1\, R_2R_3$$

Comparing real and imaginary terms

$$R_1R_4 = R_2R_3$$

and $$R_1L_4 = R_1C_1R_2R_3$$

$$L_4 = C_1R_2R_3$$

So, $$L_4 = L$$

$$L = C_1R_2R_3$$

$$= 0.4 \times 10^{-6} \times 100 \times 200$$

$$= 8 \text{ mH}$$

118. (a)

We know,

$$\frac{\partial A}{A} \times 100 = \%\in_r$$

$$\frac{\partial A}{300} \times 100 = \pm 1.5$$

$$\partial A = \pm 4.5 \text{ V}$$

∴ Range of readings = (40 – 4.5)V to (40 + 4.5)V

= 35.5 V to 44.5 V

119. (b)

Only statetment-3 is correct.

120. (b)

$$P = I^2R$$

$$R = \frac{P}{I^2}$$

$$\%\frac{\partial R}{R} = \pm\left[\frac{\partial P}{P} + 2\frac{\partial I}{I}\right] \times 100$$

$$\%\frac{\partial R}{R} = \pm[6 + 2 \times 4]$$

$$\%\frac{\partial R}{R} = \pm 14\%$$

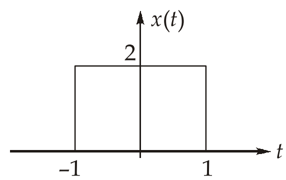
121. (d)

$$y(t) = \int_0^{10} 4x(t-2) * \delta(t-4)dt$$

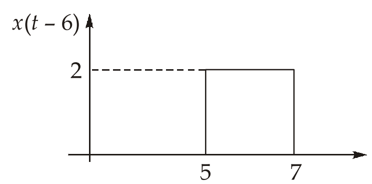
$$= \int_0^{10} 4x(t-6)dt \; ; \qquad f(t) * \delta(t - t_0) = f(t - t_0)$$

$$= 4\int_0^{10} x(t-6)dt$$

$x(t)$ is defined as



For $x(t - 6)$, shifting towards right by 6 unit,



$$y(t) = 4\int_5^7 2 \cdot dt = 4 \times 2 \times [7-5] = 16$$

122. (c)

We know,

$$y[n] = x[n] * h[n]$$

x[n] \ h[n]	–1	↓ 3	0	3	2
1	–1	3	0	3	2
1	–1	3	0	3	2
→ 0	0	0	0	0	0
–1	1	–3	0	–3	–2

$$y[n] = \{-1, 2, 3, \underset{\uparrow}{4}, 2, 2, -3, -2\}$$

$$y[2] = 2$$

123. (b)

FFT alogorithm to solve N-point DFT will require

$$\text{Number of additions} = N\log_2 N$$

$$\text{Number of multiplications} = \frac{N}{2}\log_2 N$$

$$\text{For 8-point DFT} - N = 8$$

$$\text{Number of multiplications} = \frac{N}{2}\log_2 N$$

$$= \frac{8}{2}\log_2 8 = 4\log_2 8 = 12$$

124. (d)

The digital frequency (Ω) is related to the analog frequency (f) through the sampling frequency (f_s) as-

$$\Omega = \frac{2\pi f}{f_s} = \omega T_s$$

125. (c)

$$x(t) = \underbrace{2\cos\left(\frac{2\pi}{6}t\right)}_{T_1=6} + \underbrace{\sin(2\pi t)}_{T_2=1}$$

Fundamental time period, $\quad$ "T" $= \text{LCM}[T_1, T_2]$

$= \text{LCM}[6, 1] = 6$

Fundamental frequency of the signal,

$$\omega_0 = \frac{2\pi}{6} = \frac{\pi}{3}\text{ rad/sec}$$

126. (d)

$x(t)$	TFS coefficients
Even signal	$b_n = 0, a_n \neq 0$
Odd signal	$b_n \neq 0, a_n = 0$
Even + HWS	$b_n = 0, a_n \neq 0$, ... for odd values of n
Odd + HWS	$b_n \neq 0$,....for odd values of n; $a_n = 0$
HWS	$a_n \neq 0$ and $b_n \neq 0$ for odd values of n

127. (c)

Properties of FIR filter:

- It is a non-recursive system because there is no feedback path present in the FIR filter.
- There are always be designed as linear phase.

128. (b)

$$H(z) = \frac{5z^2}{z^2 - z - 6}$$

$$\frac{H(z)}{z} = \frac{5z}{z^2 - z - 6} = \frac{5z}{(z-3)(z+2)}$$

$$= 5\left[\frac{3}{5(z-3)} + \frac{2}{5(z+2)}\right]$$

$$\frac{H(z)}{z} = \frac{3}{(z-3)} + \frac{2}{(z+2)}$$

$$H(z) = \frac{3}{1-3z^{-1}} + \frac{2}{1+2z^{-1}}$$

Since $h[n]$ is causal so ROC is $|z| > 3$

$$h[n] = 3(3)^n\, u(n) + 2(-2)^n\, u(n)$$

$$= \left[3^{n+1} + 2(-2)^n\right]u(n)$$

129. (a)

$$\cos t\, u(t) \xleftrightarrow{\text{L.T.}} \frac{s}{s^2+1}$$

$$e^{-t}\cos t\, u(t) \xleftrightarrow{\text{L.T.}} \frac{(s+1)}{(s+1)^2+1}$$

$$\frac{d}{dt}\left[e^{-t}\cos t\, u(t)\right] \xleftrightarrow{\text{L.T.}} \frac{s(s+1)}{(s+1)^2+1} \qquad \left\{\begin{matrix} x(t) \longleftrightarrow X(s) \\ \frac{d}{dt}x(t) \longleftrightarrow sX(s) \end{matrix}\right\}$$

$$t \cdot \frac{d}{dt}\left[e^{-t}\cos t\, u(t)\right] \xleftrightarrow{L.T.} \frac{-d}{ds}\left[\frac{s^2+s}{s^2+1+2s+1}\right]$$

$$\frac{-d}{ds}\left[\frac{s^2+s}{s^2+2s+2}\right]$$

$$= -\left[\frac{(s^2+2s+2)(2s+1)-(s^2+s)(2s+2)}{(s^2+2s+2)^2}\right]$$

$$= -\left[\frac{2s^3+4s^2+4s+s^2+2s+2-2s^3-2s^2-2s^2-2s}{(s^2+2s+2)^2}\right]$$

$$= -\frac{(s^2+4s+2)}{(s^2+2s+2)^2}$$

130. (a)

1. $$a^n \cos\Omega_0 n\, u[n] \xleftrightarrow{Z} \frac{1 - az^{-1}\cos\Omega_0}{1 - 2az^{-1}\cos\Omega + a^2 z^{-2}} \quad \text{...(i)}$$

2. $$a^n \sin\Omega_0 n\, u[n] \xleftrightarrow{Z} \frac{az^{-1}\sin\Omega_0}{1 - 2az^{-1}\cos\Omega + a^2 z^{-2}} \quad \text{...(ii)}$$

Here, $a = 0.5$, $\Omega_0 = \pi$

From equation (i),

$$X(z) = \frac{1 - 0.5z^{-1}\cos\pi}{1 - 2(0.5)z^{-1}\cos\pi + (0.5)^2 z^{-2}} = \frac{1 + 0.5z^{-1}}{1 + z^{-1} + 0.25z^{-2}}$$

$$X(z) = \frac{z^2 + 0.5z}{z^2 + z + 0.25} = \frac{z(z+0.5)}{(z+0.5)^2}$$

$$X(z) = \frac{z}{z+0.5} \;;\; |z| > 0.5$$

131. (a)

$$f(x) = 3x - \cos x - 1$$

$$f'(x) = 3 + \sin x$$

∴ Newton's iteration formula gives

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$$= x_n - \frac{3x_n - \cos x_n - 1}{3 + \sin x_n}$$

$$= \frac{3x_n + x_n \sin x_n - 3x_n + \cos x_n + 1}{3 + \sin x_n}$$

$$= \frac{x_n \sin x_n + \cos x_n + 1}{3 + \sin x_n}$$

132. (a)

Two cards are drawn by placing one again, then the probability of first card to be drawn

$$= \frac{^4C_1}{^{52}C_1}$$

Probability of second card $= \dfrac{^4C_1}{^{52}C_1}$

Probability of two cards drawn

$$= \frac{^4C_1}{^{52}C_1} \times \frac{^4C_1}{^{52}C_1} = \frac{1}{169}$$

133. (c)

$f(z) = e^z$ is analytic within the circle $|z| = 2$

Point, $p = 1$ lies inside the circle C

$p = 3$ lies outside the circle C

Residue at $p = 1$ can be calculated as,

$$\lim_{z\to 1}(z-1)\cdot\frac{e^z}{(z-1)(z-3)} = \frac{e^1}{(-2)} = -\frac{1}{2}e^1$$

From Cauchy's integral formula

$$\int_C f(z) = 2\pi i \text{ (sum of residue)}$$

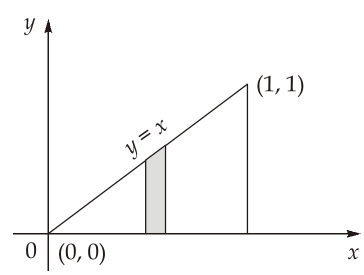
$$= 2\pi i\left(-\frac{1}{2}e^1\right) = -\pi ie$$

134. (a)

By Green's Theorem,

$$\int_C (\phi dx + \psi dy) = \iint_R \left(\frac{\partial\psi}{\partial x} - \frac{\partial\phi}{\partial y}\right) dxdy$$

$$\phi = x^2y \text{ and } \psi = x^2$$



$$\int_C \left(x^2ydx + x^2dy\right) = \iint_R \left(2x - x^2\right)dx\,dy$$

$$= \int_0^1\int_0^x (2x - x^2)dx\,dy$$

$$= \int_0^1 (2x - x^2)dx\int_0^x dy = \int_0^1 (2x - x^2)dx[y]_0^x$$

$$= \int_0^1 (2x^2 - x^3)dx = \left(\frac{2x^3}{3} - \frac{x^4}{4}\right)_0^1 = \frac{2}{3} - \frac{1}{4} = \frac{5}{12}$$

135. (a)

$$\int_0^1 [3x]dx = \int_0^{1/3}[3x]dx + \int_{1/3}^{2/3}[3x]dx + \int_{2/3}^{1}[3x]dx$$

$$= \int_0^{1/3} 0\,dx + \int_{1/3}^{2/3} 1\,dx + \int_{2/3}^{1} 2\,dx$$

$$= [x]_{1/3}^{2/3} + 2[x]_{2/3}^{1}$$

$$= \frac{1}{3} + \frac{2}{3} = 1$$

136. (b)

$$n(E_3) = \text{Number of ways of selecting 1 red ball out of 8 and 2 black balls out of 5}$$

$$P\ (\textit{getting}\ 1 \text{ red and 2 black balls}) = \frac{n(E_3)}{n(s)}$$

$$n(E_3) = {}^8C_1 \cdot {}^5C_2 = \frac{8!}{7!\,1!} \times \frac{5!}{3!\,2!}$$

$$= \frac{8}{1} \times \frac{5 \times 4}{2} = 80$$

$$n(s) = {}^{13}C_3 = \frac{13!}{10!\,3!} = \frac{13 \times 12 \times 11}{1 \times 2 \times 3}$$

$$= 13 \times 22 = 286$$

$\therefore$ P(getting 1 red and 2 black balls)

$$= \frac{80}{286} = \frac{40}{143}$$

137. (d)

$$\frac{dy}{dx} = \sec(x + y)$$

On putting, $x + y = z$

So that, $$1 + \frac{dy}{dx} = \frac{dz}{dx}$$

$$\Rightarrow \frac{dy}{dx} = \frac{dz}{dx} - 1$$

$$\Rightarrow \frac{dz}{dx} - 1 = \sec z$$

$$\Rightarrow \frac{dz}{1 + \sec z} = dx$$

$$\Rightarrow \frac{\cos z\, dz}{1 + \cos z} = dx$$

On Integrating,

$$\int \frac{\cos z\, dz}{1 + \cos z} = \int dx$$

$$\Rightarrow \int \left[1 - \frac{1}{\cos z + 1}\right] dz = x + C$$

$$\Rightarrow \int \left[1 - \frac{1}{2\cos^2\left(\frac{z}{2}\right) - 1 + 1}\right] dz = x + C$$

$$\Rightarrow \int \left[1 - \frac{1}{2}\sec^2\left(\frac{z}{2}\right)\right] dz = x + C$$

$$\Rightarrow \qquad z - \tan\left(\frac{z}{2}\right) = x + C$$

$$\Rightarrow \qquad x + y - \tan\left(\frac{x+y}{2}\right) = x + C$$

$$\Rightarrow \qquad y = \tan\left(\frac{x+y}{2}\right) + C$$

138. (a)

For matrices to be additive inverse : $[A] + [B] = 0$

Sum of two matrices will be zero.

139. (b)

Let, $$y = \lim_{x\to 0}\left(\frac{\tan x}{x}\right)^{1/x}$$

$$\log y = \lim_{x\to 0}\frac{1}{x}\log\left(\frac{\tan x}{x}\right) \qquad \left(\text{form} : \frac{0}{0}\right)$$

$$= \lim_{x\to 0}\frac{\frac{x}{\tan x}\left(\frac{x\sec^2 x - \tan x}{x^2}\right)}{1}$$

$$= \lim_{x\to 0}\frac{x\sec^2 x - \tan x}{x\tan x} \qquad \left(\text{form} : \frac{0}{0}\right)$$

$$= \lim_{x\to 0}\frac{\sec^2 x + 2x\sec^2 x\tan x - \sec^2 x}{\tan x + x\sec^2 x}$$

$$= \lim_{x\to 0}\frac{2x\sec^2 x\tan x}{\tan x + x\sec^2 x} \qquad \left(\text{form} : \frac{0}{0}\right)$$

$$= \lim_{x\to 0}\frac{2\sec^2 x\tan x + 2x(\sec^4 x + 2\sec^2 x\tan^2 x)}{2\sec^2 x + x\,2\sec^2 x\tan x}$$

$$= \frac{0}{2} = 0$$

$$\log y = 0$$

$$y = 1$$

140. (b)

$$|A - \lambda I| = \begin{vmatrix} 2-\lambda & 1 & 1 \\ 1 & 2-\lambda & 1 \\ 1 & 1 & 2-\lambda \end{vmatrix} = 0$$

$$R_1 \rightarrow R_1 + R_2 + R_3 \begin{vmatrix} 4-\lambda & 4-\lambda & 4-\lambda \\ 1 & 2-\lambda & 1 \\ 1 & 1 & 2-\lambda \end{vmatrix} = 0$$

$$(4-\lambda)\begin{vmatrix} 1 & 1 & 1 \\ 1 & 2-\lambda & 1 \\ 1 & 1 & 2-\lambda \end{vmatrix} = 0$$

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

$$(4-\lambda)\begin{vmatrix} 1 & 1 & 1 \\ 0 & 1-\lambda & 0 \\ 0 & 0 & 1-\lambda \end{vmatrix} = 0$$

$$(4 - \lambda)\,(1 - \lambda)^2 = 0$$

$$\lambda = 1, 1, 4$$

141. (d)

$$f(x) = x^3 - 9x^2 + 24x + 12$$

$$f'(x) = 3x^2 - 18x + 24$$

For minima/maxima

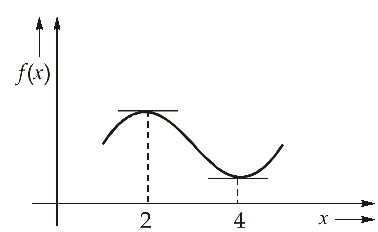
$$f'(x) = 3x^2 - 18x + 24 = 0$$

From here, $x = 2, 4$

$$f''(x) = 6x - 18$$

$$f''(2) = 12 - 18 = -6 < 0 \Rightarrow \text{maxima}$$

$$f''(4) = 24 - 18 = 6 > 0 \Rightarrow \text{minima}$$



The nature of function is increasing, decreasing and then increasing.

142. (a)

$$\text{Cofactor of } A = \begin{bmatrix} \cos x & \sin x & 0 \\ -\sin x & \cos x & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\text{Adj } A = \begin{bmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$|A| = \cos^2 x + \sin^2 x = 1$$

$$A^{-1} = \frac{AdjA}{|A|} = \begin{bmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= f(-x)$$

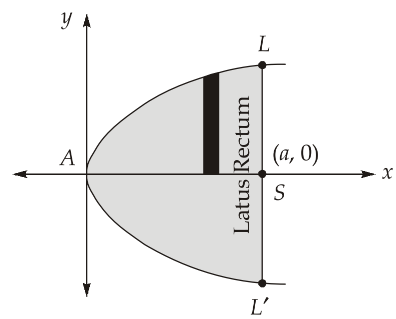
143. (a)

Required area = 2 (Area (ASL))

$$= 2\int_0^a \int_0^{2\sqrt{ax}} dy\,dx$$

$$= 2\int_0^a [y]_0^{2\sqrt{ax}} dx$$

$$= 2\int_0^a 2\sqrt{ax}\,dx = \frac{8a^2}{3}$$



144. (b)

$r > 1$ is not possible.

So our choice of regression line should be such that r is less than 1.

The regression line of x on y is $x - 2y + 1 = 0$

The regression line of y on x is $2x - 9y + 6 = 0$

$$x - 2y + 1 = 0$$

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

$$\Rightarrow \quad b_{xy} = 2$$

$$2x - 9y + 6 = 0$$

$$\Rightarrow \quad y = \frac{2}{9}x + \frac{2}{3}$$

$$\rightarrow \quad b_{yx} = \frac{2}{9}$$

$$r = \sqrt{b_{xy}\,b_{yx}}$$

$$= \sqrt{2 \times \frac{2}{9}} = \frac{2}{3}$$

145. (d)

For series RLC circuit at resonance.

Imaginary part of input impedance = 0

$\therefore \quad Z_{min} = R$

and hence, $\quad I = \frac{V}{R} = I_{maximum}$

146. (c)

Statement-I is true but statement-II is not true. The resistance start induction motor has a lesser efficiency than that of a permanent capacitor motor.

147. (c)

Only two NAND gates are not sufficient to accomplish any of the basic gate.

148. (a)

When thyristor is open circuited in half bridge inverter the PIV is V_S.

149. (b)

Both statements are correct but statement-II is not the correct explanation of statement-I.

150. (c)

Deflection type instruments are more suitable under dynamic conditions than null type of instruments as the intrinsic response of the null type instruments are slower than deflection type instruments.

■■■■