DETAILED SOLUTIONS

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ESE 2022 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

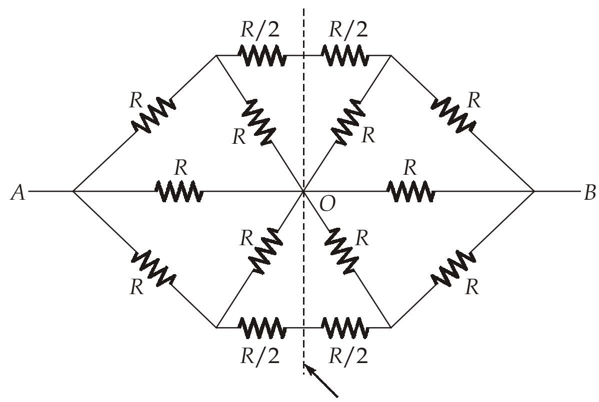
1.	(b)	**26.**	(b)	**51.**	(d)	**76.**	(c)	**101.**	(b)	**126.**	(d)
2.	(a)	**27.**	(b)	**52.**	(a)	**77.**	(b)	**102.**	(b)	**127.**	(d)
3.	(b)	**28.**	(d)	**53.**	(d)	**78.**	(b)	**103.**	(b)	**128.**	(d)
4.	(d)	**29.**	(c)	**54.**	(b)	**79.**	(d)	**104.**	(c)	**129.**	(c)
5.	(c)	**30.**	(d)	**55.**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

Q.22 : Marks to all. **Q.24 :** Answer key has been updated.

DETAILED EXPLANATIONS

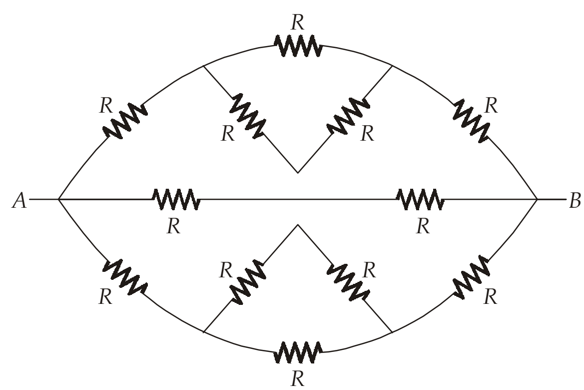
1. (b)

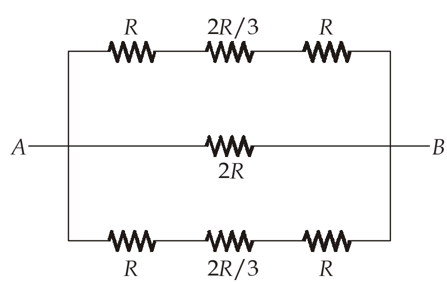
Using perpendicular symmetry

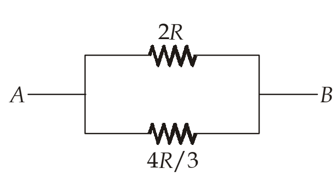


Perpendicular Symmetry

Here, O is equipotential point. Along the perpendicular (dotted line) point O is separated because no current flows at point O.



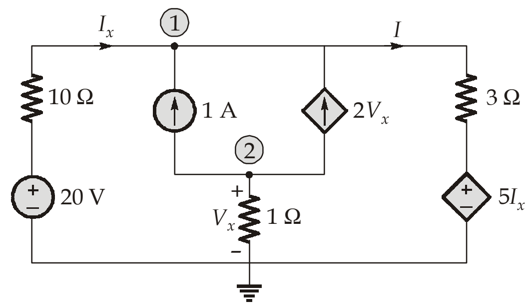




$$\therefore \qquad R_{AB} = \frac{4R}{5}$$

2. (a)

The given circuit is



KCL at node-1 $\quad I = I_x + 2V_x + 1 \quad$ ...(1)

Applying KVL, we get

$$-20 + 10Ix + 3I + 5I_x = 0$$

$$-20 + 15I_x + 3(I_x + 2V_x + 1) = 0$$

$$-20 + 18I_x + 6V_x + 3 = 0$$

$$18I_x + 6V_x = 17 \quad \text{...(2)}$$

$$V_x = -1 \times (2V_x + 1)$$

KCL at node-2, $\quad V_x = -2V_x - 1$

$$3V_x = -1$$

$$V_x = -\frac{1}{3}V \quad \text{...(3)}$$

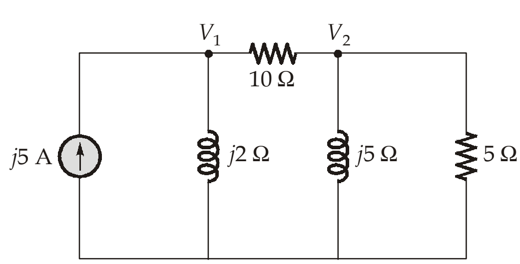
Putting equation (3) in (2), we get

$$18I_x + 6\left(-\frac{1}{3}\right) = 17$$

$$18I_x - 2 = 17$$

$$I_x = \frac{19}{18}\text{A} = 1.056 \text{ A}$$

3. (b)



Applying KCL at node V_1, we get

$$\frac{V_1}{j2} + \frac{V_1 - V_2}{10} - j5 = 0$$

$$\frac{5V_1 + jV_1 - jV_2 + 50}{j10} = 0$$

$$(5 + j)V_1 - jV_2 = -50 \qquad ...(1)$$

Applying KCL at node V_2, we get

$$\frac{V_2 - V_1}{10} + \frac{V_2}{j5} + \frac{V_2}{5} = 0$$

$$\frac{jV_2 - jV_1 + 2V_2 + j2V_2}{j10} = 0$$

$$(2 + 3j)V_2 - jV_1 = 0$$

$$V_2 = \frac{jV_1}{2 + 3j} \qquad ...(2)$$

Putting (2) in (1), we get

$$(5 + j)V_1 - j\left(\frac{jV_1}{2 + 3j}\right) = -50$$

$$(5 + j)V_1 + \frac{V_1}{2 + 3j} = -50$$

$$(5 + j)(2 + 3j)V_1 + V_1 = -50(2 + 3j)$$

$$(10 + 15j + 2j - 3)V_1 + V_1 = -100 - 150j$$

$$V_1(8 + j17) = -100 - 150j$$

$$V_1 = \frac{-100 - 150j}{8 + j17} = 9.59\angle 188.49° \text{ V}$$

Alternate Solution:

$$5 \,||\, j5 = \frac{5}{\sqrt{2}}\angle 45° \,\Omega$$

$$\text{Now, } (2j) \,||\left(10 + \frac{5}{\sqrt{2}}\angle 45°\right) \approx 2j \;\Omega$$

$$\left(\text{Becasue}\left(10 + \frac{5}{\sqrt{2}}\angle 45°\right) >> 2j\right)$$

So,

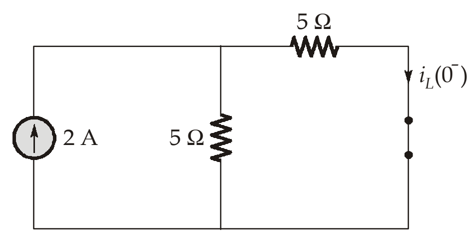
$$V_1 = 2j \times 5\angle 90°$$

$$V_1 = -10 \text{ V}$$

So nearly option (b) is matching.

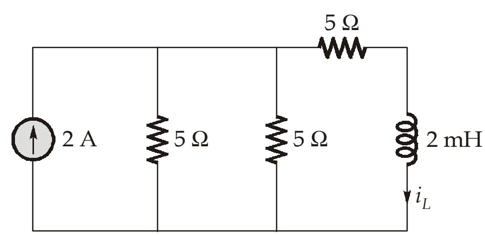
4. (d)

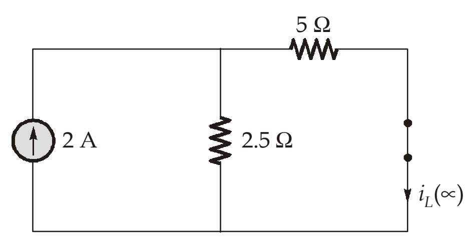
For $t < 0$:



$$i_L(0^-) = \frac{5}{5+5} \times 2 = 1 \text{ A}$$

For $t > 0$:





$$i_L(\infty) = \frac{2.5}{2.5+5} \times 2 = \frac{1 \times 2}{3} = \frac{2}{3} \text{ A}$$

∴ $$i_L(t) = i_L(\infty) + [i_L(0^+) - i_L(\infty)]e^{-t/\tau} \text{ A}$$

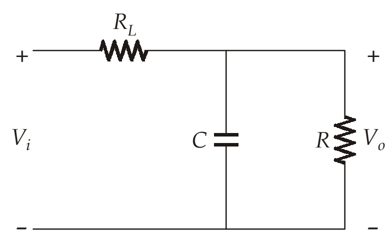
Time constant, $$\tau = \frac{L}{R_{eq}} = \frac{2 \times 10^{-3}}{7.5} = \frac{20 \times 10^{-3}}{75} = \frac{1}{3750} \text{sec}$$

$$i_L(t) = \frac{2}{3} + \left[1 - \frac{2}{3}\right] e^{-3750t} \text{ A}$$

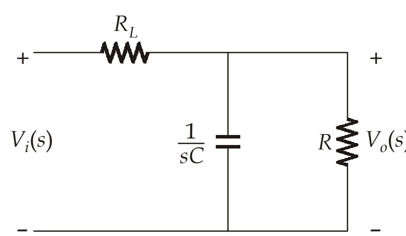
$$= \frac{1}{3}[2 + e^{-3750t}] \text{ A}$$

5. (c)

Given circuit is :



Taking Laplace of the above circuit,



$$Z_1(s) = R \parallel \frac{1}{sC} = \frac{\frac{R}{sC}}{R + \frac{1}{sC}} = \frac{R}{sCR + 1}$$

$$V_o(s) = V_i(s) \times \frac{Z_1(s)}{Z_1(s) + R_L} \quad \text{(from voltage divider)}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{\frac{R}{sCR+1}}{\frac{R}{sCR+1} + R_L}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{R}{R + sCR\,R_L + R_L} \quad \text{...(1)}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{4}{5 + sCR} \text{ (given)} \quad \text{...(2)}$$

Equating eqn. (1) and (2), we get

$$\frac{R}{R + R_L + sCR\,R_L} = \frac{4}{5 + sCR}$$

$$5R + sCR^2 = 4R + 4R_L + 4sCR\,R_L$$

$$R - 4R_L + sCR^2 - 4sCR\,R_L = 0$$

$$R + sCR^2 = 4R_L(1 + sCR)$$

$$R(1 + sCR) = 4R_L(1 + sCR)$$

$$4R_L = R$$

$$R_L = \frac{R}{4}$$

7. **(c)**

The capacitor should be replaced by a voltage source whose value is the same as the initial condition on the capacitor.

8. **(b)**

Two networks are said to be dual of each other when the mesh equations of one are the same as the node equations of the other.

9. **(c)**

For ideal coupling leakage flux equal to zero therefore coefficient of coupling is unity

$$e = -L\frac{di}{dt}$$

$$e \propto L$$

10. **(d)**

Applying KCL at node X

$$\frac{V_{XY}}{10} + \frac{V_{XY} - 10}{10} = 2$$

$$2V_{XY} = 30$$

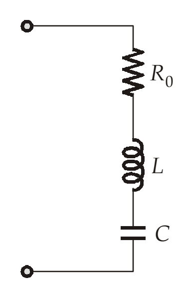
$$\therefore \quad V_{XY} = 15 \text{ V}$$

For R_{in}, deactivate all other independent voltage and current source

$$R_{TH} = \frac{10 \times 10}{10 + 10} = 5\ \Omega$$

11. **(b)**

For a critically damped series RLC circuit,



$$R_0 = \sqrt{\frac{4L}{C}}$$

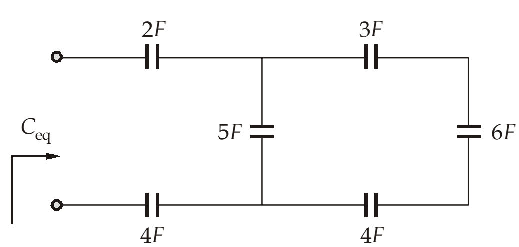
$$= \sqrt{\frac{4 \times 4}{10 \times 10^{-3}}} = 40\ \Omega$$

$$R_0 = R \,||\, 120 = 40\ \Omega$$

$$R = 60\ \Omega$$

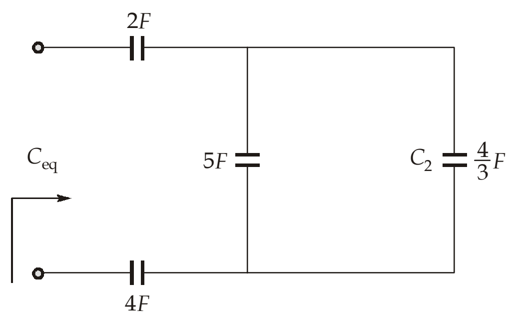
12. **(d)**

The given circuit is

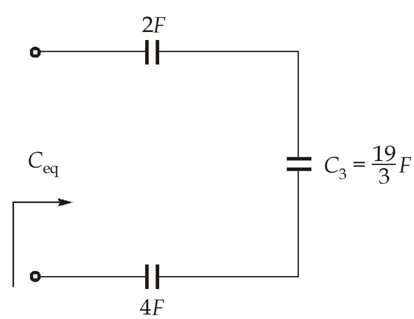


$$C_1 = \frac{3F \times 6F}{3F + 6F} = \frac{18}{9}F = 2F$$

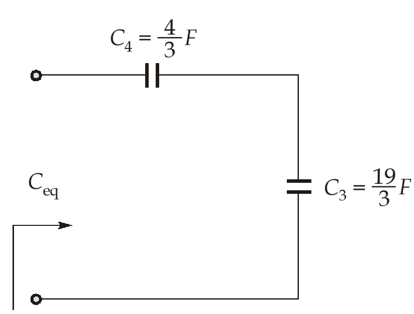
$$C_2 = \frac{2F \times 4F}{2F + 4F} = \frac{8}{6}F = \frac{4}{3}F$$



$$C_3 = 5F + \frac{4}{3}F = \frac{19}{3}F$$



$$C_4 = \frac{2F \times 4F}{2F + 4F} = \frac{8}{6}F = \frac{4}{3}F$$



So equivalent capacitance,

$$C_{eq} = \frac{\frac{4}{3} \times \frac{19}{3}}{\frac{4}{3} + \frac{19}{3}} = \frac{76}{3 \times 23}F \; = 1.101F$$

13. (a)

Rank of incidence matrix = $N - 1$

Rank of cut set matrix = $N - 1$

Rank of tie set matrix = $[b - (N - 1)]$

14. (d)

All given reasons are true reasons regarding superiority of HVDC system over HV-AC transmission system.

15. (c)

Given :

Radius of conductor, $r = \frac{1}{2}$ cm = 0.5 cm

Spacing of conductors, d = 150 cm

Let dielectric strength of air is g_o.

Also line voltage at which corona occurs,

$$V_{do} = g_o r \log_e \frac{d}{r} = 60 \text{ kV}$$

So,
$$g_o = \frac{V_{do}}{r \log_e \frac{d}{r}}$$

$$g_o = \frac{60}{0.5 \times \log_e \frac{150}{0.5}} = \frac{60}{0.5 \times 5.704}$$

$$= 21.038 \text{ kV/cm}$$

16. (d)

All above given statements are correct.

17. (b)

For frequency of transient oscillation

$$L = 0.009 \text{ H}$$

$$C = 0.064 \times 10^{-6} \text{ F}$$

$$f_n = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{9 \times 10^{-3} \times 64 \times 10^{-9}}}$$

$$= \frac{1}{2\pi(3 \times 8) \times 10^{-6}} = \frac{10^6}{48\pi} \text{ Hz}$$

18. (a)

The characteristic of reactance relay on R-X diagram is straight line parallel to R axis.

19. (d)

The primary current in both relay is 16000 A

$$\text{C.T. ratio} = \frac{800}{5} = 160$$

$$\text{Secondary current} = \frac{\text{Primary Current}}{\text{C.T. Ratio}} = \frac{16000}{160} = 100 \text{ A}$$

For relay B,

$$\text{Current setting} = 125\% \text{ of } SA = 1.25 \times 5 = 6.25 \text{ A}$$

Plug setting multiplier,

$$\text{PSM} = \frac{\text{Secondary Current}}{\text{Relay Current Setting}} = \frac{100}{6.25} = 16$$

20. (d)

All given statements are correct regarding principal purpose of grounding.

21. (c)

Charging current, $$I_c = \frac{V_n}{-jX_c}$$

Here, $$X_c = \frac{1}{\omega C_n}$$

So, $$I_c = \frac{V_n}{-j/\omega C_n} = V_n(j\omega C_n)$$

22. (*)

23. (b)

Correct representations are phase currents :

$$I_a = I_{a1} + I_{a2} + I_{a0}$$
$$I_b = a^2 I_{a1} + aI_{a2} + I_{a0}$$
$$I_c = aI_{a1} + a^2 I_{a2} + I_{a0}$$

Correct representation of symmetrical components :

$$I_{a1} = \frac{1}{3}(I_a + aI_b + a^2 I_c)$$

$$I_{a2} = \frac{1}{3}(I_a + a^2 I_b + aI_c)$$

$$I_{a0} = \frac{1}{3}(I_a + I_b + I_c)$$

24. (a)

Dead short-circuit fault = 3-ϕ fault (LLLG fault)

$$I_{f\text{LLLG}} = \frac{E_a}{X_1} = \frac{1}{0.3} = \frac{10}{3}$$

25. (a)

We know, $$P_{out} = \frac{EV}{Z}\cos(\delta - \theta_s) - \frac{V^2}{Z}\cos\theta_s$$

P_{out} is maximum when $\delta = \theta_s$

$$P_{max} = \frac{EV}{Z}\cos 0° - \frac{V^2}{Z}\cos\theta_s$$

$$= \frac{100 \times 100}{10} - \frac{100 \times 100}{10}\cos 36.86°$$

$$= 1000 - 1000 \times 0.8$$

$$= 200 \text{ MW}$$

26. (b)

Given : Base voltage, $kV_B = 400$ V

Base kVA, $kVA_B = 2.5$ kVA

∴ Base impedance at *lv* side

$$Z_{B(lv)} = \frac{(kV_B)^2 \times 1000}{kVA} = \frac{(0.4)^2 \times 1000}{2.5}$$

$$= 64\ \Omega$$

Leakage reactance in per unit,

$$Z_{p.u.} = \frac{\text{Actual reactance}}{\text{Base impedance}} = \frac{0.96}{64} = 0.015 \text{ p.u.}$$

27. (b)

Under excited synchronous motor acts at lagging power factor, behaving like inductor.

28. (d)

For given graph,

Forward paths gains : $P_1 = abcd$

$P_2 = ag$

Individual loop gain : $L_1 = f$

$L_2 = ce$

$L_3 = dh$

Non-touching loops $L_1L_2 = fce$

$L_2L_3 = fdh$

So, graph determinant, $\Delta = 1 - (L_1 + L_2 + L_3) + (L_1L_2 + L_1L_3)$

$= 1 - (f + ce + dh) + (fce + fdh)$

29. (c)

The damped frequency of oscillation of second order control system is given

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

30. (d)

Characteristic equation,

$$1 + G(s) = 0$$

$$1+\frac{K}{s(s+3)(s^2+s+1)} = 0$$

$$s(s + 3)(s^2 + s + 1) + K = 0$$

$$(s^2 + 3s)(s^2 + s + 1) + K = 0$$

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

Routh array :

s^4	1	4	K
s^3	4	3	
s^2	$\frac{13}{4}$	K	
s^1	$\frac{\frac{39}{4}-4K}{13/4}$		
s^0	K		

Condition on value of K

$$K > 0 \text{ and } \frac{39}{4}-4K > 0 \quad \Rightarrow \quad K < \frac{39}{16}$$

31. (d)

$$\phi(s) = [sI - A]^{-1} = \frac{\text{Adj}[sI-A]}{|sI-A|}$$

on comparing $\text{Adj }[sI - A] = \begin{bmatrix} s+6 & 1 \\ -5 & s \end{bmatrix}$

$$|sI-A| = s^2 + 6s + 5$$

$$[sI - A] = \begin{bmatrix} s & -1 \\ 5 & s+6 \end{bmatrix}$$

$$[A] = [sI] - [sI - A]$$

$$= \begin{bmatrix} s-s & +1 \\ -5 & s-s-6 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -5 & -6 \end{bmatrix}$$

32. (a)

For second order system,

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$= \frac{16}{s^2 + 3s + 16}$$

By comparing,

$$\omega_n^2 = 16$$

$$\omega_n = 4$$

$$2\xi\omega_n = 3$$

$$\xi = \frac{3}{2\times 4} = \frac{3}{8}$$

Since $\xi < 1$, the system is an underdamped system.

33. (b)

$$G(j\omega) = \frac{1}{(j\omega)(1+j\omega)(1+4j\omega)} = \frac{1}{(j\omega - \omega^2)(1+4j\omega)}$$

$$= \frac{1}{j\omega - 4\omega^2 - \omega^2 - 4j\omega^3} = \frac{1}{-5\omega^2 + j\omega(1-4\omega^2)}$$

At phase crossover frequency ω_p, imaginary part of $G(j\omega_p)$ is zero.

Using above equation,

$$\omega_p(1 - 4\omega_p^2) = 0$$

$$\omega_p = \frac{1}{2} \text{ rad/sec}$$

Alternate solution :

At phase crossover frequency

$$\angle\omega_{pc} = -180°$$

$$= \frac{1}{(j\omega_p)(1+j\omega_p)(1+4j\omega_p)}$$

$$-90° - \tan^{-1}\omega_p - \tan^{-1}4\omega_p = -180°$$

$$\tan^{-1}\omega_p + \tan^{-1}4\omega_p = 90°$$

$$\tan^{-1}\left(\frac{\omega_p + 4\omega_p}{1-4\omega_p^2}\right) = 90°$$

$$1 - 4\omega_{pc}^2 = 0$$

$$\omega_{pc} = \frac{1}{2} \text{ rad/sec}$$

34. (c)

Bandwidth increases with negative feedback provided to system.

35. (d)

All given statements are correct.

36. (b)

We know,

$$\text{Phase margin (P.M.)} = 180° + G(j\omega_1)H(j\omega_1)$$

where, ω_1 = Gain crossover frequency

$$45° = 180° + \angle G(j\omega_1)H(j\omega_1)$$

$$\angle G(j\omega_1)H(j\omega_1) = -135°$$

$$G(j\omega_1)H(j\omega_1) = \frac{K}{(j\omega_1)(5-\omega_1^2 + j2\omega_1)}$$

$$\angle G(j\omega_1)H(j\omega_1) = -90° - \tan^{-1}\frac{2\omega_1}{5-\omega_1^2} = -135°$$

$$45° = \tan^{-1}\frac{2\omega_1}{5-\omega_1^2}$$

$$1 = \frac{2\omega_1}{5-\omega_1^2}$$

$$5 - \omega_1^2 = 2\omega_1$$

$$\omega_1^2 + 2\omega_1 - 5 = 0$$

$$\omega_1 = \frac{-2 \pm \sqrt{4-4(1)(-5)}}{2(1)} = \frac{-2 \pm \sqrt{24}}{2} = -1 \pm \sqrt{6}$$

$$\omega_1 = \sqrt{6} - 1 = 1.44 \text{ rad/sec}$$

37. (b)

Given : $G(s) = \frac{1}{s(s+1)(s+10)}$; $H(s) = s + 2$

The velocity error constant,

$$K_v = \lim_{s\to 0} sG(s)H(s)$$

$$= \lim_{s\to 0} s \cdot \frac{(s+2)}{s\cdot(s+1)(s+10)}$$

$$= \frac{2}{10} = 0.2$$

38. (a)

Area under BH curve = Hysteresis loss in a cycle

$= 320 \times 8 \times 10^3$

$= 2560 \times 10^3 = 25.6 \times 10^5 \text{ J/m}^3$

39. (a)

- For anisotropic materials : properties are direction dependent.
- For isotropic materials : properties are independent of direction.

40. (a)

In HCP, there are 12 atoms at 12 corners of the top and bottom hexagon.

Two atoms at the centre of top and bottom hexagon.

Three atoms are inside the hexagonal.

$$\text{Number of atom/unit cell} = 12 \times \frac{1}{6} + 2 \times \frac{1}{2} + 3$$

$$= 2 + 1 + 3 = 6$$

41. (b)

Given : $\chi_e = 0.12$, $D = 1.6 \text{ nC/m}^2$

$\chi_e = \in_r - 1$ or $\in_r = \chi_e + 1 = 1 + 0.12 = 1.12$

$$E = \frac{D}{\in} = \frac{D}{\in_o \in_r}$$

$$= \frac{10 \times 10^{-9}}{7 \in_o} \text{ N/C}$$

42. (c)

- Entropy of material at superconducting state is minimum.
- Perfect diamagnetism and zero resistivity are two independent properties of super conducting state, and Meissner effect is not due to zero resistance state in superconductor.

44. (b)

Thomson coefficient is not uniform but varies with temperature.

45. (b)

Given : $T_c = 0 \text{ K}$, $H_c(T) = 4 \times 10^5 \text{ A/m}$

At critical temperature, $T_c = 8 \text{ K}$

$$H_c(T) = H_c(0)\left[1 - \left(\frac{T}{T_c}\right)^2\right] = 4,00,000\left[1 - \left(\frac{6}{8}\right)^2\right]$$

$$= 4,00,000\left[1 - \frac{9}{16}\right]$$

$$= 4,00,000\left[\frac{16-9}{16}\right] = \frac{7}{16}\times 4\times 10^5$$

$$= 1.75 \times 10^5 \text{ A/m}$$

46. (b)

$$\text{Conductivity} = \frac{1}{\text{Resistivity } (\rho)} = \frac{1}{5\times 10^{-3}} = 200/\text{ohm-m}$$

As $\sigma = n_e e\mu_e + n_h e\mu_h$

$$200 = n_e e(\mu_e + \mu_h) = n \times 1.6 \times 10^{-19}(0.3 + 0.2)$$

$$n = \frac{200}{1.6\times 10^{-19}\times 0.5} = \frac{400}{1.6\times 10^{-19}} = 2.5 \times 10^{21}/\text{m}^3$$

47. (d)

Total number of blocks in cache

$$= \frac{\text{Size of cache memory}}{\text{Size of each block}} = \frac{16 \text{ KB}}{8\times 4 \text{ B}} = \frac{2^{14}}{2^5} = 2^9$$

Memory is 4-way set associative, means 4 blocks are represented as 1 set.

So, Total number of sets $= \frac{2^9}{4} = 2^7$

7 bits needed for set field.

Each block contains 8 words and each word is 32 bits or 4 bytes.

Size of each block $= 8 \times 4 = 2^5$ bytes

Number of bits required for each block size is 5 bytes.

Physical Address $= 4$ GB $= 2^{23}$ bytes

No. of bits in physical address = 32 bits

← 32 bits →

Tag	Set	Block
20	7	5

48. (d)

All given statements depicting similarities between the model are correct.

49. (a)

Next instruction reference is not necessary element of machine instruction.

50. (b)

In full duplex type of communication the capacity of the channel is divided between the two direction.

51. (d)

All of the given points are attribute of file.

52. (a)

$$\text{Transmission time } (t_x) = \frac{\text{Packet Size}}{\text{Data Transfer Rate}} = \frac{1000 \text{ bytes}}{1 \text{ MBPS}}$$

$$t_x = 1 \text{ msec}$$

$$\text{Propagation delay} = \frac{\text{Distance}}{\text{Speed}} = \frac{2000 \text{ km}}{2\times10^8 \text{ m/sec}} = 10 \text{ msec}$$

$$\text{RTT} = t_x + 2t_p = 1 + 2 \times 10 = 21 \text{ msec}$$

54. (b)

Consider datawidth of the system bus to be in byte. DMA will run every cycle for every bite.

$$1 \text{ sec} = 2 \times 10^6 \text{ bits}$$

$$1 \text{ bit} = \frac{1}{2\times10^6} \text{ sec}$$

$$4800 \text{ bit} = \frac{4800}{2\times10^6} \text{ sec} = 2.4 \text{ msec}$$

55. (d)

As torque is constant, both armature current and flux remains constant,

$$V = E_b + I_aR_a$$

$$240 = E_b + 40 \times 0.3$$

$$E_b = 228 \text{ V}$$

$$E_{b2} = \frac{N_2}{N_1}E_{b1} \quad (\text{As } \phi = \text{constant})$$

$$= \frac{1000}{1500} \times 228 = 152 \text{ V}$$

Now,

$$240 = 152 + 40\,(0.3 + R_{ext})$$

$$R_{ext} = 1.9\ \Omega$$

56. (b)

$$\text{Armature conductors} = (\text{No. of turns}) \times (\text{No. of coils}) \times 2$$

$$= 4 \times 30 \times 2 = 240$$

$$\text{No. of conductors per slot} = \frac{240}{48} = 5$$

57. (b)

Given : Transformer turn ratio

$$\frac{N_1}{N_2} = \frac{250}{2500}$$

Equivalent impedance of load referred to primary

$$Z' = \left(\frac{N_1}{N_2}\right)^2 \times Z$$

$$Z' = \left(\frac{250}{2500}\right)^2 \times (200 + j400)$$

$$= \frac{1}{100} \times (200 + j400) = 2 + j4\ \Omega$$

58. (a)

In ideal transformer, magnetizing current needed is zero.

59. (a)

- Eddy current losses are minimized by using thin laminated core better than solid core.
- Iron losses are fixed losses.

60. (c)

Given efficiency are equal to 90% at half load and full load.

At full load, $0.9 = \dfrac{1}{1 + P_i + P_{Cu}} \Rightarrow P_i + P_{Cu} = \dfrac{1}{9}$ ...(i)

At half load, $0.9 = \dfrac{0.5}{0.5 + P_i + 0.25P_{Cu}}$

$$P_i + 0.25P_{Cu} = \frac{0.5}{0.9} - 0.5 = \frac{1}{18} \quad \text{...(ii)}$$

Solving (i) and (ii), $P_i = 0.037$ p.u.

61. (c)

Ratio of full load torque to maximum torque

$$\frac{T_{fl}}{T_m} = \frac{2}{\dfrac{s_m}{s} + \dfrac{s}{s_m}}$$

Slip at maximum torque,

$$s_m = \frac{R_2}{X_2} = \frac{0.02}{0.4} = 0.05$$

Slip at full load torque,

$$s = \frac{1500 - 1440}{1500} = 0.04$$

$$\frac{T_{fl}}{T_m} = \frac{2}{\dfrac{0.05}{0.04} + \dfrac{0.04}{0.05}} = \frac{2}{\dfrac{5}{4} + \dfrac{4}{5}} = 0.976$$

or $\dfrac{T_m}{T_{fl}} = 1.02$

62. (b)

We know, Torque, $T = \frac{3}{\omega_s} \times \frac{V^2}{R_2'} s$ (for low slip)

or $T \propto V^2 s$

$$s_2 = \left(\frac{V_1}{V_2}\right)^2 s_1 \text{ or } s_2 = \left(\frac{V_1}{\frac{3}{4}V_1}\right)^2 s$$

$$s_2 = \frac{16}{9} s$$

Also current, $I_2'^2 \propto s$ or $I_2' \propto \sqrt{s}$

$$\frac{I_2'}{I_1'} = \sqrt{\frac{s_2}{s_1}} = \sqrt{\frac{16}{9}} = \frac{4}{3}$$

63. (a)

As airgap increases, leakage reactance increases and s_m also reduces,

$$s_m = \frac{R}{X\uparrow} \Rightarrow S_m \downarrow \qquad \left[\text{and } T_m \propto \frac{1}{X}\right]$$

which reduces T_m and T_{st}.

64. (b)

For same air gap flux, $\frac{V}{f}$ ratio should be constant.

Flux, $\phi = \frac{V}{f}$ = Constant

$$\frac{V_2}{f_2} = \frac{V_1}{f_1}$$

$$V_2 = \frac{400}{50} \times 40 = 320 \text{ V}$$

Synchronous speed of motor for 50 Hz source

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

$$\text{Slip, } s = \frac{1500 - 1460}{1500} = \frac{40}{1500}$$

At small value of slip, $T \propto \frac{V^2}{f} \cdot s$

Since, $\frac{V}{f}$ = constant

$\Rightarrow \quad T \propto Vs$

So, $\quad s_1V_1 = s_2V_2$

$$\frac{40}{1500} \times 400 = s_2(320)$$

$$s_2 = \frac{1}{30} = 0.0333$$

65. (b)

The reluctance of airgap in salient pole synchronous machine is not uniform.

66. (d)

We know, $\quad f = \frac{PN}{120} = \frac{6 \times 1000}{120} = 50 \text{ Hz}$

Total number of stator conductors

= Conductors per slot × Number of slots

= 8 × 90 = 720

Stator conductors per phase,

$$Z_p = \frac{720}{3} = 240$$

Winding factor, $\quad K_w = 1$

$$E_p = 2.22 \times K_w f \times \phi \times Z_p$$

$$= 2.22 \times 1 \times 50 \times 0.05 \times 240 = 1332 \text{ V}$$

67. (d)

All given statements are correct.

68. (c)

Synchronous motor always runs at synchronous speed independent of load connected to it.

69. (a)

R and *RC* firing scheme can not be used for feedback control systems.

70. (d)

All given statements are correct regarding power diodes.

71. (c)

MOSFET is free from secondary breakdown voltage problem.

72. (b)

We know for 3-ϕ halfwave diode rectifier

$$V_o = \frac{1}{2\pi/3}\int_{\pi/6}^{5\pi/6} V_{mp}\sin\omega t d(\omega t) = \frac{3\sqrt{3}}{2\pi}V_{mp}$$

where, V_{mp} = Maximum value of phase voltage

73. (c)

In 3-ϕ diode bridge rectifiered each diode conducts for 120° for one cycle

$$I_{D\text{ rms}} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi/3} I_0^2 d\omega t} = I_0\sqrt{\frac{2\pi}{2\pi\times 3}} = \frac{I_0}{\sqrt{3}}$$

$$= \frac{120}{\sqrt{3}} = 40\sqrt{3}\text{ A} = 69.28 \text{ A}$$

74. (b)

For a single phase full converter,

Average output voltage, $V_o = \frac{2V_m}{\pi}\cos\alpha$

$$= \frac{2\times\sqrt{2}\times 230}{\pi}\times\cos 30°$$

$$= \frac{230\sqrt{6}}{\pi}\text{V}$$

75. (c)

Average value of thyristor current

$$I_{T,A} = I_o\frac{\pi}{2\pi} = \frac{I_o}{2}$$

76. (c)

For step up chopper, $V_o = \frac{V_s}{1-\alpha}$

$$660 = 220\times\frac{1}{1-\alpha}$$

$$1 - \alpha = \frac{1}{3}$$

$$\alpha = \frac{2}{3} = \frac{T_{\text{on}}}{T}$$

Given : T_{on} = 100 μsec

So, $T = \frac{3}{2}T_{\text{on}} = \frac{3}{2}\times 100 = 150$ μsec

77. (b)

We know for dc boost converter

$$V_0 = \frac{V_s}{1-\alpha}$$

$$\Rightarrow \quad 40 = \frac{15}{1-\alpha}$$

$$1 - \alpha = \frac{15}{40}$$

$$\text{or} \quad \alpha = \frac{25}{40} = \frac{5}{8}$$

$$I_0 = \frac{V_0}{R} = \frac{V_s}{(1-\alpha)R} = \frac{40}{40} = 1\text{ A}$$

Also $\quad V_0 I_0 = V_s I_s$

Average inductor current,

$$I_L = I_S = \frac{I_0}{1-\alpha} = \frac{1}{3/8} = 2.66\text{ A}$$

78. (b)

DC transmission voltage = 200 + 200 = 400 kV

Direct current in transmission line

$$I_d = \frac{2000\times 10^3}{400} = 5000\text{ A}$$

We know for 3 phase full converter each thyristor conducts for 120° for a periodicity of 360°.

RMS current rating of thyristor

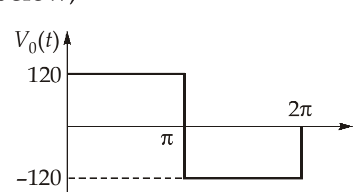
$$= I_D\sqrt{\frac{120^\circ}{360^\circ}} = \frac{5000}{\sqrt{3}}\text{A}$$

79. (d)

In inverter mode operation of line commutated converter active power is delivered to source and it absorbs reactive power from source.

80. (b)

Output voltage can be drawn as below,



Fundamental rms component,

$$V_{01} = \frac{4V_s}{\sqrt{2}\pi} = \frac{4 \times 120}{\sqrt{2}\pi} = 108.037 \text{ V}$$

81. (a)

$$C = \frac{\varepsilon A}{d} = \frac{10\varepsilon_o A}{0.02} = 500\varepsilon_o A \text{ F}$$

82. (c)

If the vector field, $\vec{A}$ is conservative,

$$\nabla \times \vec{A} = 0$$

$$\begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ -3ax^2yz & x^3z & bx^3y - 2az \end{vmatrix} = 0$$

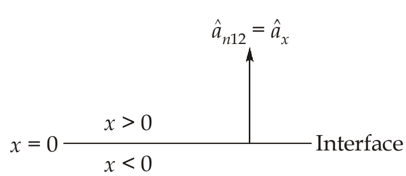
$$= \hat{a}_x(bx^3 - x^3) - \hat{a}_y(3bx^2y + 3ax^2y) + \hat{a}_z(3x^2z + 3ax^2z) = 0$$

$$bx^3 - x^3 = 0 \qquad 3x^2z + 3ax^2z = 0$$

$$b = 1 \qquad (1 + a) = 0$$

$$a = -1$$

83. (b)



Given : $\vec{K} = 10\hat{a}_z$ A/m

$$\vec{H}_1 = 12\hat{a}_y \text{ A/m}$$

As the interface is $x = 0$ or yz-plane, hence y, z are tangential components and x is normal component.

$$\vec{H}_{t1} - \vec{H}_{t2} = \hat{a}_{n12} \times \vec{K}$$

$$12\hat{a}_y - \vec{H}_{t2} = \hat{a}_x \times 10\hat{a}_z = -10\hat{a}_y$$

$$\vec{H}_{t2} = 22\hat{a}_y \text{ A/m}$$

84. (d)

All given statements are correct.

85. (b)

$$(\text{CMRR})_{\text{dB}} = (A_d - A_c)\ \text{dB}$$
$$= 48 - 2 = 46\ \text{dB}$$

86. (b)

Given op-amp configuration is non-inverting constant gain multiplier.

$$A = 1 + \frac{R_f}{R_1}$$

$$R_f = 240\ \text{k}\Omega \parallel 240\ \text{k}\Omega = 120\ \text{k}\Omega$$

$$A = 1 + \frac{120 \times 10^3}{2.4 \times 10^3} = 1 + 50 = 51$$

∴ Output voltage, $V_o = AV_i = 51(100\ \mu\text{V})$

$$= 5.1\ \text{mV}$$

87. (d)

Cutoff frequency, $f_{OH} = \dfrac{1}{2\pi R_1 C_1} = \dfrac{1}{2\pi \times 2 \times 10^3 \times 0.02 \times 10^{-6}}$

$$= 3978.87\ \text{Hz or } 3.97\ \text{kHz}$$

88. (a)

$$f_{\text{samp}} = \frac{1}{T_{\text{conv}}}$$

$$f_{\text{samp}} \geq 2f_{\text{max-analog}}$$

$$\Rightarrow \quad \frac{1}{T_{\text{conv}}} \geq 2f_{\text{max-analog}}$$

$$f_{\text{max-analog}} \leq \frac{1}{2T_{\text{conv}}}$$

$$f_{\text{max}} = \frac{1}{2T_{\text{conv}}} = \frac{10^6}{2 \times 50} = 10\ \text{kHz}$$

89. (b)

An extra hardware logic circuit is needed to implement n variable function by using $n \times 2^n$ size decoder.

90. (c)

$$00010000 \rightarrow (16)_{10}$$

$$V_o = K \times (\text{decimal equivalent of binary})$$

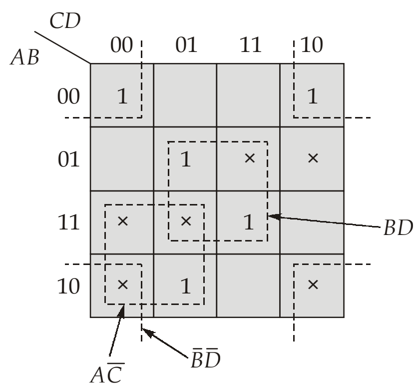
$$4 = K \times 16$$

$$K = \frac{1}{4}$$

$$(V_o)_{full} = \left[(11111111)_2 \text{ decimal equivalent}\right] \times \frac{1}{4}$$

$$(V_o)_{full} = 63.75 \text{ V}$$

91. (b)



So, essential prime implicants: $BD, \bar{B}\bar{D}, A\bar{C}$.

92. (b)

CLK	Q_3	Q_2	Q_1	Q_0
–	1	0	1	0
1	1	1	0	1
2	1	1	1	0
3	1	1	1	1

93. (c)

(AD0–AD7) are tri-state multiplexed address/data buses. They enter high impedance state during hold and halt modes.

95. (b)

Interrupts are disabled and enabled using DI and EI signal respectively.

96. (b)

Serial communication interface gets a single byte of data from the microprocessor and sends it bit by bit to other system serially and vice-versa.

97. (c)

Fetching and execution cannot take place simultaneously everytime because during execution of some of the instruction data has to be fetched from memory for execution. At this time BIU uses buses for fetching data from memory while EU waits.

98. (b)

Given : $M_x = 4, \sigma_x^2 = 6$

Mean square value, $E[x^2] = \sigma_x^2 + [E[x]]^2$

$$= (6) + (4)^2$$

$$E[x^2] = 22$$

99. (b)

Entropy, $H(x) = -\sum_{i=1}^{5} P(x_i)\log_2 P(x_i)$

$$= -\left[\frac{1}{2}\log_2\left(\frac{1}{2}\right) + \frac{1}{4}\log_2\left(\frac{1}{4}\right) + \frac{1}{8}\log_2\left(\frac{1}{8}\right) + \frac{2}{16}\log_2\left(\frac{1}{16}\right)\right]$$

$$= \frac{1}{2} + \frac{1}{4}\times 2 + \frac{1}{8}\times 3 + \frac{1}{8}\times 4$$

$$= \frac{15}{8} = 1.875$$

$$H(x) = 1.875 \text{ bits/symbol}$$

100. (b)

Given : $B = \text{B.W.} = 1 \text{ MHz}, C = 10 \text{ Mbps}$

$$C = B\log_2\left(1 + \frac{S}{N}\right)$$

$$10 \times 10^6 = 10^6 \log_2\left(1 + \frac{S}{N}\right)$$

$$10 = \log_2\left(1 + \frac{S}{N}\right)$$

$$1 + \frac{S}{N} = 2^{10}$$

$$\frac{S}{N} = 1023$$

$$\frac{S}{N} = \frac{S}{\eta B} = 1023$$ (η = noise power spectral density)

$$\frac{S}{\eta} = 1023 \times 10^6$$

When bandwidth approaches to infinite, then capacity

$$C = 1.44\frac{S}{\eta} = 1.44 \times 1023 \times 10^6 = 1.473 \times 10^9$$

$$C = 1.5 \text{ Gbps}$$

101. (b)

Hilbert transform provides a phase shift of –90° to the applied signal.

102. (b)

From the given equation,

$$A_c = 40$$

$$\frac{\mu A_c}{2} = 10$$

$$\mu(40) = 20$$

Modulation index, $\mu = 0.50$

103. (b)

Zener breakdown has negative temperature coefficient means if temperature increases then breakdown voltage decreases and opposite in avalanche breakdown.

104. (c)

In unbiased *p-n* junction diode electric field is maximum at the junction and decreases on either side of junction.

The only element left in the depletion region are ionized donor or acceptor impurities.

Depletion width is inversely proportional to $\sqrt{\text{doping concentration}}$.

Due to the positive space-charge region on the *n*-side of the junction and negative space charge region on the *p*-side of the junction, an electric field directed from positive charge to negative charge develops. So, direction of electric field is from *n*-side to *p*-side.

105. (a)

$$\alpha = 0.99$$

$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.99}{1-0.99} = 99$$

The current gain in common collector mode = $\beta + 1 = 100$.

106. (c)

Schottky diode have no depletion layer due to metal-semiconductor junction hence due to electrons in metals very low cut in voltage.

Operating speed is high.

Tunnel diodes generally used to make oscillators due to negative resistance region.

107. (b)

Pinch off voltage (V_p) is defined as the minimum drain to source voltage where the drain current enters into saturation. In other words, it is also defined as the minimum gate to source voltage where I_D is reduced to zero.

108. (d)

Transistor works as current source and when both sources are connected in parallel, then

$$(g_m)_{\text{effective}} = g_{m1} + g_{m2}$$
$$= 3 + 1$$
$$g_{m,eff} = 4 \text{ mA/V}$$

and Amplification factor $= \dfrac{\mu_1 r_{d2} + \mu_2 r_{d1}}{\mu_1 + \mu_2}$

$\because$ $\mu = g_m r_d$

$\therefore$ $\mu_1 = g_{m1} r_{d1} = 3 \times 2$

$$\mu_1 = 6$$
$$\mu_2 = g_{m2} r_{d2} = 1 \times 5$$
$$\mu_2 = 5$$
$$\mu_{\text{effective}} = \frac{6\times5+5\times2}{6+5} = \frac{40}{11} = 3.63$$

109. (d)

For a standard Darlington amplifier

$$Z_{\text{in(1)}} = \beta_1 \beta_2 R_E$$
$$= 50 \times 70 \times 10 \text{ k}\Omega$$
$$Z_{\text{in(1)}} = 35 \text{ M}\Omega$$
$$Z_{\text{in(2)}} \simeq \beta_2 R_E \approx 70 \times 10 \text{ K}\Omega$$
$$Z_{\text{in(2)}} = 0.7 \text{ M}\Omega$$

110. (d)

Since mobility decreases as temperature increases. So, in drain current I_{ds} decreases with rise in temperature. As temperature increases, the leakage current I_{co} increases, so the current I_c increases in BJT.

The current equation for BJT is :

$$I_c = \beta I_b + (1 + \beta) I_{co}$$

111. (d)

Due to cascading voltage gain

$$A_V = A_{V1}.A_{V2}$$

$$A_{V1} = \text{Voltage gain of 1st stage}$$

$$A_{V2} = \text{Voltage gain of 2nd stage}$$

So, it increases. While upper cut off frequency $f_H^* = \left[\sqrt{2^{1/n} - 1}\right] f_H$ decreases.

112. (d)

$$M = -8 \cos(\theta + 45°)\text{mH}$$

The deflecting torque in electrodynamometer type ammeter is given as

$$T = I^2 \frac{dM}{d\theta}$$

$$= (10 \times 10^{-3})^2 \frac{d}{d\theta}(-8\cos(\theta + 45°)) \times 10^{-3}$$

$$= 10^{-4} \times (-8 \times (-\sin(\theta + 45°))) \times 10^{-3}$$

$$= 10^{-7} \times 8 \sin(45° + 45°)$$

$$= 0.8\ \mu\text{N-m}$$

∴ option (d) is correct.

113. (d)

Introduction of any element in a system results, invariably, in extraction of energy from the system thereby distorting the original signal. This distortion may take the form of attenuation (reduction in magnitude), waveform distortion, phase shift and many a time all these undesirable features put together.

114. (b)

Systematic errors are divided into three categories :

1. Instrumental Errors : These errors arise due to three main reasons :
   (i) Due to inherent shortcomings in the instrument.
   (ii) Due to misuse of the instruments, and
   (iii) Due to loading effects of instruments.
2. Environmental Errors
3. Observational Errors

115. (d)

Line voltage, $|V_L| = 200$ V

Line current, $|I_L| = 115.5$ A

1st wattmeter reading, $W_1 = 20$ kW $= 20{,}000$ W

2nd wattmeter reading, $W_2 = 0$

Now, $$W_1 + W_2 = \sqrt{3}|V_L||I_L|\cos\theta$$

where cos θ is the power factor, i.e.,

$$\cos\theta = \frac{W_1 + W_2}{\sqrt{3}V_L I_L} = \frac{20000 + 0}{\sqrt{3} \times 200 \times 115.5}$$

$$= 0.5 \text{ lagging}$$

116. (c)

Gauge factor is defined as,

$$G = \frac{\Delta R / R}{\text{Strain}}$$

$$\Delta R = G \times R \times \text{Strain}$$

$$= 4 \times 120 \times 10^{-5}$$

$$= 4.8 \times 10^{-3}\ \Omega$$

117. (a)

$$\text{Meter constant} = \frac{\text{No. of revolutions}}{\text{Energy supplied}}$$

$$= \frac{2070}{230 \times 40 \times 1 \times 3 \times 10^{-3}}$$

$$= 75 \text{ rev/kWh}$$

118. (a)

$$\frac{f_x}{f_y} = \frac{\text{No. of intersections of the vertical line with the curve}}{\text{No. of intersections of the horizontal line with the curve}}$$

$$= \frac{2}{5}$$

119. (a)

At balance,

$$\left(R - \frac{j}{\omega C}\right)\left(\frac{R\left(\frac{-j}{\omega C}\right)}{R - \frac{j}{\omega C}}\right) = ZR$$

Let $$Z = X + jY$$

Comparing the real and imaginary parts, we get

$$RX = 0$$

$$X = 0$$

and $$R\left(-\frac{j}{\omega C}\right) = RjY$$

$$Y = \frac{-1}{\omega C}$$

$\therefore$ Z is purely capacitive.

120. (c)

The transformation ratio decreases as the power factor of secondary burden increases.

121. (b)

$e^{-2t}u(t)$ is an energy signal with an energy of $\frac{1}{4}$.

122. (c)

Given : $$X(z) = \frac{1}{1-z^{-3}}$$

By definition of z-transform

$$X(z) = \sum_{n=-\infty}^{\infty} x(n)z^{-n}$$

Simplifying $X(z)$ by division

$$\begin{array}{r|l} 1 - z^{-3} & 1 \quad (1 + z^{-3} \\ & \underline{1 - z^{-3}} \\ & z^{-3} \\ & \underline{z^{-3} - z^{-6}} \\ & z^{-6} \end{array}$$

$\therefore$ $$X[z] = x[0] + x[1]z^{-1} + x[2]z^{-2} + x[3]z^{-3} \;.....$$
$$= 1 + [0]z^{-1} + [0]z^{-2} + [1]z^{-3} \;.....$$

On comparing, $x[0] = 1, x[3] = 1$

123. (a)

$$e^{-at^2} \leftrightarrow \sqrt{\frac{\pi}{a}}e^{-\omega^2/4a}$$

Let $a = \frac{1}{2}$

$$e^{-t^2/2} \leftrightarrow \sqrt{2\pi}e^{-\omega^2/2}$$

124. (c)

Fundamental frequency,

$$\omega_o = \text{GCD}[2, 3, 5] = 1$$

$$T = \frac{2\pi}{\omega_o} = \frac{2\pi}{1} = 2\pi$$

125. (b)

Properties of delta function:

1. $$\int_{-\infty}^{\infty} \delta(t)\, dt = 1$$
2. $$x(t)\ \delta(t) = x(0)\ \delta(t)$$
3. $$x(t)\ \delta(t - t_0) = x(t_0)\ \delta(t - t_0)$$
4. $$\delta(at) = \frac{1}{|a|}\delta(t)$$
5. $$\int_{-\infty}^{\infty} x(t)\,\delta(t)\, d\tau = x(0)$$

So option (b) does not represent a property of delta function.

126. (d)

Given : $$X(z) = 5z^3 + z^2 - z^{-2} - 5z^{-3}$$

Applying inverse z-transform, we get

$$x(n) = 5\delta(n + 3) + \delta(n + 2) - \delta(n - 2) - 5\delta(n - 3)$$

$\therefore$ $$x(n) = \{5,1,0,\underset{\uparrow}{0},0,-1,-5\}$$

As $x(n) \neq 0$, $n < 0 \Rightarrow$ non-causal.

$$x(-n) = -x(n) \quad \Rightarrow \quad \text{odd symmetric.}$$

127. (d)

Given : $$Y(s) = \frac{s+3}{s^2+4s+4} = \frac{s+3}{(s+2)^2}$$

$$= \frac{s+2}{(s+2)^2} + \frac{1}{(s+2)^2}$$

$$= \frac{1}{(s+2)} + \frac{1}{(s+2)^2}$$

$$y(t) = e^{-2t} + te^{-2t};\ \text{for } t > 0$$

128. (d)

$$x(t) \xleftrightarrow{F.T.} X(\omega)$$

$$y(t) = x(t-2) \xleftrightarrow{F.T.} X(\omega).e^{-j2\omega} = Y(\omega)$$

$$|X(\omega)| = |Y(\omega)|$$

$$\angle X(\omega) \neq \angle Y(\omega)$$

$$\angle Y(\omega) = \angle X(\omega) - 2\omega$$

When a signal is shifted in time domain, magnitude spectrum will remains same but phase spectrum will change.

129. (c)

$\frac{d^2y}{dt^2} + 2t\frac{dy(t)}{dt} + 5y(t) = x(t)$ is time variant because the coefficient are function of time.

$$y(t) = e^{-2x(t)}$$

$$y_1(t) = T[x(t-t_o)] = e^{-2x(t-t_o)}$$

$$y(t-t_o) = e^{-2[x(t-t_o)]}$$

$$y_1(t) = y(t-t_o) = \text{TIV}$$

$$y(t) = \left[\frac{d}{dt}x(t)\right]^2$$

$$y_1(t) = T[x(t-t_o)] = \left[\frac{d}{dt}x(t-t_o)\right]^2$$

$$y(t-t_o) = \left[\frac{d}{dt}x(t-t_o)\right]^2$$

$$y_1(t) = y(t-t_o) - \text{TIV}$$

$$y(t) = \frac{d}{dt}[e^{-2t}x(t)]$$

$$y_1(t) = T[x(t-t_o)] = \frac{d}{dt}[e^{-2t}x(t-t_o)]$$

$$y(t-t_o) = \frac{d}{dt}[e^{-2(t-t_o)}x(t-t_o)]$$

$$y_1(t) \neq y(t-t_o) - \text{TV}$$

130. (c)

$$= \int_{-10}^{5} 3t\delta(t+5)dt + \int_{-10}^{5} 9\delta(t)dt + \int_{-10}^{5} t^2\delta(2t+16)dt$$

$$= 3 \times (-5) + 9 + \frac{1}{2} \times (-8)^2$$

$$= -15 + 9 + 32 = 26$$

131. (b)

Given matrix : $$A = \begin{bmatrix} 1 & 2 & 3 \\ 1 & 4 & 2 \\ 2 & 6 & 5 \end{bmatrix}$$

Applying $R_2 \to R_2 - R_1$ and $R_3 \to R_3 - 2R_1$ so that the given matrix

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 2 & -1 \\ 0 & 2 & -1 \end{bmatrix}$$

Obviously, the 3rd order minor of A vanishes. Also, its 2nd order minors formed by its 2nd and 3rd rows are all zero. But another 2nd order minor is $\begin{bmatrix} 1 & 3 \\ 0 & -1 \end{bmatrix} = -1 \neq 0$.

$\therefore$ $\rho(A) = 2$. Hence, the rank of the given matrix is 2.

132. (d)

All the statements are correct.

133. (b)

For $x \to 0^+$: $\lim\limits_{x\to 0} \dfrac{\ln x}{\cot x}$ $\left(\text{form } \dfrac{\infty}{\infty}\right)$

Applying L'Hospital's rule

$$\lim_{x\to 0} \frac{1/x}{-\text{cosec}^2 x} = -\lim_{x\to 0} \frac{\sin^2 x}{x}$$

$$= \lim_{x\to 0} \frac{2\sin x \cos x}{1} = 0$$

134. (a)

Given : $$u = x^2 \tan^{-1} \frac{y}{x} - y^2 \tan^{-1} \frac{x}{y}$$

We have, $$\frac{\partial u}{\partial y} = x^2 \cdot \frac{1}{1+\left(\frac{y}{x}\right)^2} \cdot \frac{1}{x} - \left\{ 2y \tan^{-1} \frac{x}{y} + y^2 \cdot \frac{1}{1+\left(\frac{x}{y}\right)^2} \cdot \left(\frac{-x}{y^2}\right) \right\}$$

$$= \frac{x^3}{x^2+y^2} - 2y \tan^{-1} \frac{x}{y} + \frac{xy^2}{x^2+y^2}$$

$$= x - 2y \tan^{-1} \frac{x}{y}$$

$$\therefore \qquad \frac{\partial^2 u}{\partial x \partial y} = \frac{\partial}{\partial x}\left\{x - 2y\tan^{-1}\frac{x}{y}\right\}$$

$$= 1 - 2y \cdot \frac{1}{1+\left(\frac{x}{y}\right)^2} \cdot \frac{1}{y}$$

$$= 1 - \frac{2y^2}{x^2+y^2} = \frac{x^2-y^2}{x^2+y^2}$$

Similarly,
$$\frac{\partial u}{\partial x} = 2x\tan^{-1}\frac{y}{x} - y$$

and
$$\frac{\partial^2 u}{\partial y \partial x} = \frac{\partial}{\partial y}\left\{2x\tan^{-1}\frac{y}{x} - y\right\} = \frac{x^2-y^2}{x^2+y^2}$$

135. (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

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

136. (d)

$$\text{Divergence of } \vec{A} = \text{div}\,\vec{A} = \nabla \cdot \vec{A}$$

$$\nabla \cdot \vec{A} = \frac{\partial}{\partial x}(2x^2z) + \frac{\partial}{\partial y}(-xy^2z) + \frac{\partial}{\partial z}(3yz^2)$$

Thus,
$$\nabla \cdot \vec{A} = 4xz - 2xyz + 6yz$$

$$\nabla \cdot \vec{A}\Big|_{(1,1,1)} = 4 - 2 + 6 = 8$$

137. (b)

The integrand is not analytic at the point $z = -1$ which lies inside C. Using the Cauchy integral formula for derivatives ($n = 3$) with $f(z) = 3z^4 + 5z^2 + 2$, we obtain

$$I = \frac{2\pi i}{3!}\left[\frac{d^3}{dz^3}(3z^4 + 5z^2 + 2)\right]_{z=1}$$

$$= \left\{\frac{2\pi i}{6}[72z]_{z=-1}\right\} = -24\pi i$$

138. (a)

The order of a differential equation is the order of the highest order derivative occuring in the equation.

139. (b)

We know, $$L(\cos at) = \frac{s}{s^2+a^2}$$

$$L(t\cos at) = \frac{-d}{ds}\left(\frac{s}{s^2+a^2}\right) = -\frac{[(s^2+a^2)(1)-s(2s)]}{(s^2+a^2)^2} = -\frac{(s^2+a^2-2s^2)}{(s^2+a^2)^2}$$

$$L(t\cos at) = \frac{s^2-a^2}{(s^2+a^2)^2}$$

Alternate Solution:

$$f(t) = t.\cos at$$
$$f'(t) = -at.\sin at + \cos at$$
$$f''(t) = -a(at\cos at + \sin at) - a\sin at$$
$$f''(t) = -a^2 t\cos at - 2a\sin at$$
$$f(0) = 0, f'(0) = 1$$

Using theorem for 2nd derivative

$$L\{-a^2 t\cos at - 2a\sin at\} = s^2 L\{t\cos at\} - s.0 - 1$$

Rearranging,

$$(s^2+a^2)L\{t\cos at\} = 1 - 2aL\{\sin at\}$$
$$= 1 - 2a\cdot\frac{a}{s^2+a^2}$$
$$= \frac{s^2-a^2}{s^2+a^2}$$

$\therefore$ $$L\{t\cos at\} = \frac{s^2-a^2}{(s^2+a^2)^2}$$

140. (a)

$$f(x) = 3x - \cos x - 1$$
$$f'(x) = 3 + \sin x$$

$\therefore$ Newton's iteration formula gives

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

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

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

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

141. (c)

The d.c. electronic voltmeters may be used to measure a.c. voltages by first detecting the alternating voltage. In some situations, rectification takes place before implication in which case a simple diode circuit precedes the amplifier. In another method, rectification takes place after amplification this method generally uses a high open-loop gain and large negative feedback to overcome the non linearity of the rectifier diodes.

142. (a)

The deflection is independent of ratio e/m in CRO.

143. (b)

$$C_d = \frac{C_1 - n^2 C_2}{n^2 - 1}$$

Here, $n = 2$

$$C_d = \frac{C_1 - 4C_2}{3} = \frac{250 - 4 \times 50}{3}$$

$$= 16.67 \text{ pF}$$

145. (b)

The performance of a 12 bit PCM is better than that of 8-bit PCM, because in 12-bit PCM quantization noise is very less. Bandwidth of 12-bit PCM is more than that of 8-bit PCM.

146. (c)

$$Q = \frac{\omega_o}{B.W}$$

Hence, Statement-I is correct. Statement-II is incorrect.

147. (d)

Break point can exist anywhere on the complex plane, need not be on real axis. If it is on real axis, then at that point, system is critically damped. If point is on complex plane, it is underdamped system.

149. (a)

The frequency sampling structures are efficient because some sampled DFT coefficients are zero when the filter is narrow band.

150. (d)

Due to positive temperature coefficient of resistance, MOSFETs are best suitable for parallel operation.

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