DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

1.	(c)	**26.**	(a)	**51.**	(d)	**76.**	(a)	**101.**	(d)	**126.**	(b)
2.	(c)	**27.**	(b)	**52.**	(a)	**77.**	(a)	**102.**	(b)	**127.**	(b)
3.	(a)	**28.**	(d)	**53.**	(b)	**78.**	(b)	**103.**	(b)	**128.**	(a)
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5.	(a)	**30.**	(c)	**55.**	(a)	**80.**	(a)	**105.**	(c)	**130.**	(a)
6.	(c)	**31.**	(c)	**56.**	(c)	**81.**	(b)	**106.**	(a)	**131.**	(d)
7.	(b)	**32.**	(a)	**57.**	(c)	**82.**	(b)	**107.**	(c)	**132.**	(a)
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9.	(a)	**34.**	(d)	**59.**	(b)	**84.**	(d)	**109.**	(d)	**134.**	(d)
10.	(b)	**35.**	(b)	**60.**	(d)	**85.**	(c)	**110.**	(a)	**135.**	(d)
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14.	(b)	**39.**	(b)	**64.**	(d)	**89.**	(b)	**114.**	(b)	**139.**	(a)
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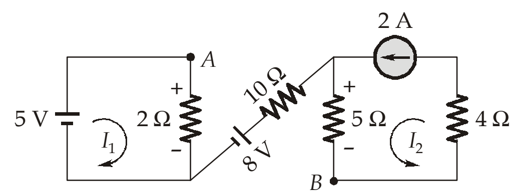
18.	(d)	**43.**	(a)	**68.**	(d)	**93.**	(d)	**118.**	(b)	**143.**	(a)
19.	(d)	**44.**	(d)	**69.**	(c)	**94.**	(c)	**119.**	(a)	**144.**	(d)
20.	(d)	**45.**	(c)	**70.**	(a)	**95.**	(c)	**120.**	(c)	**145.**	(a)
21.	(c)	**46.**	(d)	**71.**	(d)	**96.**	(b)	**121.**	(d)	**146.**	(b)
22.	(a)	**47.**	(c)	**72.**	(b)	**97.**	(d)	**122.**	(c)	**147.**	(b)
23.	(d)	**48.**	(d)	**73.**	(d)	**98.**	(b)	**123.**	(c)	**148.**	(a)
24.	(c)	**49.**	(d)	**74.**	(c)	**99.**	(b)	**124.**	(d)	**149.**	(b)
25.	(d)	**50.**	(b)	**75.**	(b)	**100.**	(d)	**125.**	(d)	**150.**	(c)

DETAILED EXPLANATIONS

1. (c)

The resistance of 3 Ω is connected across a short circuit. Hence, it gets shorted

$$I_1 = \frac{5}{2} = 2.5 \text{ A}$$
$$I_2 = 2 \text{ A}$$



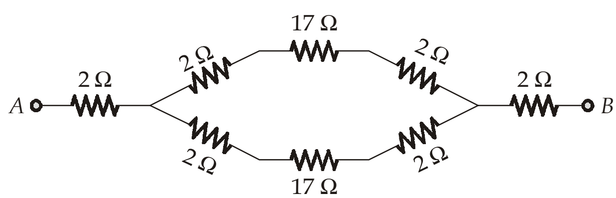
Potential difference, $V_{AB} = V_A - V_B$

writing KVL equation for the path A to B,

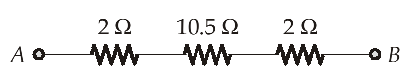
$$V_A - 2I_1 + 8 - 5I_2 - V_B = 0$$
$$V_A - 2(2.5) + 8 - 5(2) - V_B = 0$$
$$V_A - V_B = 7 \text{ V}$$

2. (c)

Converting the two outer delta network into equivalent star networks



The network can be further simplified as follows



$$R_{AB} = 14.5 \ \Omega$$

3. (a)

Meshes 2 and 3 form a supermesh,

writing current equation for supermesh

$$I_3 - I_2 = 0.5 \ V_1$$
$$V_1 = 2(I_1 - I_2)$$
$$I_3 - I_2 = 0.5 \times 2(I_1 - I_2) = I_1 - I_2$$
$$I_3 = I_1$$

Applying KVL to supermesh,

$$-2(I_2 - I_1) - 10I_3 - 6I_2 = 0$$
$$-2I_2 + 2I_1 - 10I_1 - 6I_2 = 0$$
$$I_1 = -I_2$$

Applying KVL to mesh-1,

$$110 - 14I_1 - 4I_1 - 2(I_1 - I_2) = 0$$
$$110 - 20I_1 + 2I_2 = 0$$
$$110 + 20I_2 + 2I_2 = 0$$
$$I_2 = -5 \text{ A}$$
$$I_1 = -I_2 = 5 \text{ A}$$

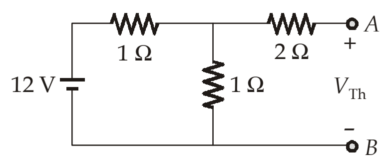
4. (b)

Step-I:

Calculation of V_{Th},

$$I_x = 0$$

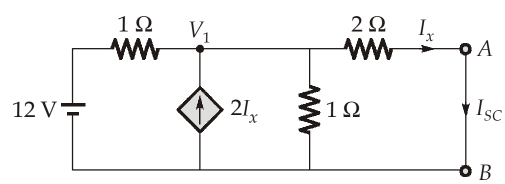
The dependent source $2I_x$ depends on the controlling variable I_x. When $I_x = 0$, the dependent source vanishes i.e. $2I_x = 0$



$$V_{Th} = 12 \times \frac{1}{1+1} = 6 \text{ V}$$

Step-II :

Calculation of I_{SC}



$$I_x = I_{SC}$$

Applying KCL at node-1,

$$\frac{V_1 - 12}{1} + \frac{V_1}{1} + \frac{V_1}{2} = 2I_x$$

$$V_1 + V_1 + \frac{V_1}{2} - 12 = 2\left(\frac{V_1}{2}\right)$$

$$1.5\ V_1 = 12$$
$$V_1 = 8 \text{ V}$$

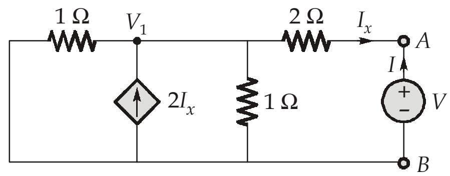
$$I_{SC} = \frac{V_1}{2} = 4 \text{ A}$$

Step-III:

Calculation of R_{Th},

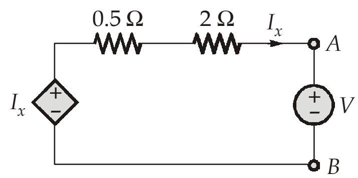
$$R_{Th} = \frac{V_{Th}}{I_{SC}} = 1.5\ \Omega$$

Alternative Solution:



$$R_{Th} = \frac{V}{I} = \frac{V}{-I_x}$$

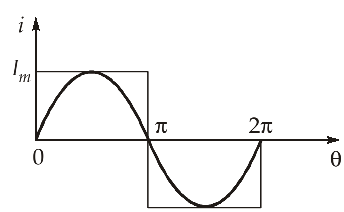
1 Ω and 1 Ω are in parallel



$$V + 2I_x + 0.5I_x - I_x = 0$$

$$R_{Th} = \frac{V}{-I_x} = 1.5\ \Omega$$

5. (a)



RMS value of the rectangular wave = I_m

RMS value of sinusoidal current wave = $\frac{I_m}{\sqrt{2}}$

Heating effect due to rectangular current wave

$$= I_m^2 RT$$

Heating effect due to sinusoidal current wave

$$= \left(\frac{I_m}{\sqrt{2}}\right)^2 RT = \frac{(I_m)^2}{2} RT$$

$$\text{Ratio of heating effects} = \frac{(I_m)^2}{2} RT : (I_m)^2 RT$$

$$= \frac{1}{2} : 1 = 1 : 2$$

6. (c)

$$\text{Dynamic resistance} = \frac{L}{CR} = \frac{0.2}{100 \times 10^{-6} \times 20} = 100\ \Omega$$

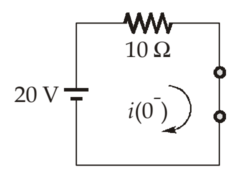
7. (b)

$$\text{Number of nodes, } n = b - l + 1$$
$$= 6 - 3 + 1 = 4$$

8. (c)

At $t = 0^-$, the network attains steady-state condition, Hence the inductor acts as a short circuit

$$i(0^-) = \frac{20}{10} = 2\text{ A}$$

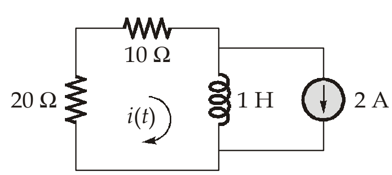


At $t = 0^+$, the inductor acts as a current source of 2 A,

$$i(0^+) = 2\text{ A}$$

writing KVL equation for $t > 0$,

$$-30i - 1\frac{di}{dt} = 0 \quad \text{...(i)}$$



At $t = 0^+$

$$-30i(0^+) - \frac{di}{dt}(0^+) = 0$$

$$\frac{di}{dt}(0^+) = -30 \times 2 = -60\text{ A/s}$$

Differentiating the equation (i), we get

$$-30\frac{di}{dt} - \frac{d^2i}{dt^2} = 0$$

At $t = 0^+$

$$-30\frac{di}{dt}(0^+) - \frac{d^2i}{dt^2}(0^+) = 0$$

$$\frac{d^2i}{dt^2}(0^+) = 1800\text{ A/s}^2$$

9. (a)

$$V_2 = -3I_2 \quad \text{...(i)}$$

Substituting in the given equation,

$$-3I_2 = 2I_1 + I_2$$

$$I_2 = -\frac{I_1}{2} \quad \text{...(ii)}$$

Substituting in the given equation,

$$V_1 = 5I_1 - I_1 = 4I_1$$

$$Z_1 = \frac{V_1}{I_1} = 4\ \Omega$$

10. (b)

When the coils are arranged in aiding connection, the inductance of the combination is

$$L_1 + L_2 + 2M = 0.4 \quad \text{...(i)}$$

and for opposing connection, it is

$$L_1 + L_2 - 2M = 0.2 \quad \text{...(ii)}$$

Solving the equations (i) and (ii), we get

$$4M = 0.2\text{ H}$$

$$M = 0.05\text{ H}$$

11. (c)

The average level of a sinusoidal current is 0.636 I_m for the positive half-cycle and –0.636 I_m for negative half-cycle and zero for the whole cycle.

12. (d)

The sum of the power dissipations in a network at any instant is always zero.

13. (b)

$$\nabla \cdot D = \frac{1}{r}\frac{d}{dr}(r \cdot D_r) + \frac{1}{r}\frac{d}{d\phi}(D_\phi) + \frac{d}{dz}(D_z)$$

$\because$ it has only $\vec{r}$ component

$$\nabla \cdot \vec{D} = \frac{1}{r}\frac{d}{dr}(r \cdot D_r)$$

$$\nabla \cdot D = -\frac{1}{r^3}$$

$$\Rightarrow \quad \nabla \cdot D \text{ at } r = \frac{1}{2} = -8$$

14. (b)

$$D_z = 9\varepsilon_0 E_z$$

$$\Rightarrow \quad \varepsilon_r = 9$$

15. (a)

$$E = -\nabla V$$

$$= -\left(\frac{\partial}{\partial x}(2x)\hat{a}_x + \frac{\partial}{\partial y}(3y)\hat{a}_y + \frac{\partial}{\partial z}(4z)\hat{a}_z\right)\text{V/m}$$

$$E = -2\hat{a}_x - 3\hat{a}_y - 4\hat{a}_z \text{ V/m}$$

16. (b)

$$D_{n1} = D_{n2}$$

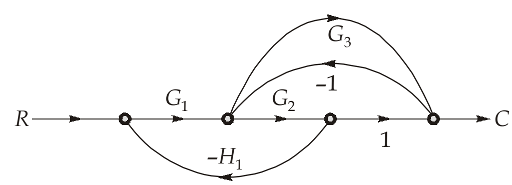
$$\Rightarrow \quad \varepsilon_1 E_{n1} = \varepsilon_2 E_{n2}$$

$$5\vec{E}_{n1} = 8\vec{E}_{n2}$$

And tangential component at electric field is continuous

$$\therefore \quad \vec{E}_{t1} = \vec{E}_{t2}$$

17. (c)



It is observed that,

$$P_1 = G_1G_2 \cdot 1, \qquad \Delta_1 = 1$$

$$P_2 = G_1G_3 \qquad \Delta_2 = 1$$

$$L_1 = G_2(-1) = -G_2,$$

$$L_2 = G_3(-1) = -G_3$$

$$L_3 = -G_1G_2H_1$$

There are no non-touching loops,

The graph determinates is

$$\Delta = 1 - (L_1 + L_2 + L_3)$$

$$= 1 + G_2 + G_3 + G_1G_2H_1$$

Using Mason's gain formula the transfer function is determined below,

$$\frac{C}{R} = \frac{P_1\Delta_1 + P_2\Delta_2}{\Delta}$$

$$= \frac{G_1G_2 + G_1G_3}{1-(-G_2 - G_3 - G_1G_2H_1)} = \frac{G_1G_2 + G_1G_3}{1 + G_2 + G_3 + G_1G_2H_1}$$

18. (d)

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)} = \frac{\dfrac{K}{s(1+sT)}}{1+\dfrac{K}{s(1+sT)}\cdot 1} = \frac{\dfrac{K}{T}}{s^2 + \dfrac{s}{T} + \dfrac{K}{T}}$$

Characteristic equation $s^2 + \frac{1}{T}s + \frac{K}{T} = 0$ compare with $s^2 + 2\xi\omega_n s + \omega_n^2 = 0$

$$2\,\xi\omega_n = \frac{1}{T}$$

$$\omega_n^2 = \frac{K}{T}$$

$$\therefore \quad \omega_n = \sqrt{\frac{K}{T}}$$

$$2\xi\sqrt{\frac{K}{T}} = \frac{1}{T}$$

$$\xi = \frac{1}{2T}\cdot\sqrt{\frac{T}{K}} = \frac{1}{2\sqrt{KT}}$$

Damping ratio, $\xi_1 = 0.3,$
$\xi_2 = 0.9$

$$\xi_1 = \frac{1}{2\sqrt{K_1 T}}$$

$$\xi_2 = \frac{1}{2\sqrt{K_2 T}}$$

$$\frac{\xi_1}{\xi_2} = \frac{1}{2\sqrt{K_1 T}}\cdot 2\sqrt{K_2 T}$$

$$\frac{K_2}{K_1} = \left(\frac{\xi_1}{\xi_2}\right)^2 = \left(\frac{1}{3}\right)^2$$

$$K_1 = 9K_2$$

Hence, the gain K_1 at which $\xi = 0.3$ should be multiplied by $\frac{1}{9}$ to increase the damping ratio from 0.3 to 0.9.

19. (d)

$$K_p = \lim_{s\to 0} G(s) = \lim_{s\to 0}\frac{108}{s^2(s+4)(s^2+3s+12)} = \infty$$

$$K_v = \lim_{s\to 0} s\cdot G(s) = \lim_{s\to 0}\frac{s\cdot 108}{s^2(s+4)(s^2+3s+12)} = \infty$$

$$K_a = \lim_{s\to 0} s^2\cdot G(s) = \lim_{s\to 0} s^2\cdot\frac{108}{s^2(s+4)(s^2+3s+12)} = \frac{108}{48}$$

$$r(t) = 2 + 5t + 2t^2$$

$$R(s) = \frac{2}{s} + \frac{5}{s^2} + \frac{4}{s^3}$$

$\therefore$
$$e_{ss} = \frac{R_1}{1+K_p} + \frac{R_2}{1+K_v} + \frac{R_3}{K_a}$$

$$= \frac{2}{1+\infty} + \frac{5}{\infty} + \frac{4\times 48}{108} = 1.77$$

20. (d)

Given that,
$$G(s)H(s) = \frac{as+1}{s^2}$$

Put,
$$s = j\omega$$

$$G(j\omega)\ H(j\omega) = \frac{1+ja\omega}{(j\omega)^2}$$

$\therefore$
$$\angle G(j\omega)H(j\omega) = -180° + \tan^{-1}a\omega$$

We know that,

$$\text{Phase margin} = 180° + \angle G(j\omega)H(j\omega)$$
$$= 180° + (-180° + \tan^{-1}a\omega)$$
$$= \tan^{-1}a\omega$$
$$\text{Phase margin} = 45° \text{ (given)}$$
$$45° = \tan^{-1}a\omega$$

taking tan on both sides

$$\tan 45° = \tan\tan^{-1}a\omega$$
$$1 = a\omega$$
$$\omega = \frac{1}{a}$$

This is the gain crossover frequency ω_{c1}

At gain crossover frequency,

$$|G(j\omega)H(j\omega)| = 1$$

$$\frac{\sqrt{1+a^2\omega^2}}{\omega^2} = 1$$

Put the value of ω,

$$\sqrt{1+a^2\cdot\frac{1}{a^2}} = \frac{1}{a^2}$$

$$a^2 = \frac{1}{\sqrt{2}}$$

$$a = 0.84$$

21. (c)

Given, $M_r = 1.4$

and $\omega_r = 3$ rad/sec

Since, $$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

$$1.4 = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

or, $\xi^4 - \xi^2 + 0.1275 = 0$

or, $\xi^2 = 0.15$ or 0.85

or, $\xi = 0.387$ or 0.921

As $\omega_r = \omega_n\sqrt{1-2\xi^2}$, hence M_r will exist for only the values at which $\xi < \frac{1}{\sqrt{2}}$ (or) $\xi < 0.707$

Since, $$\xi < \frac{1}{\sqrt{2}}$$

$\therefore$ $\xi = 0.387$

22. (a)

The characteristic equation is given by,

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

$$1 + \frac{K}{(s+2)(s+4)(s^2+6s+25)} = 0$$

or, $s^4 + 12s^3 + 69s^2 + 198s + (200 + K) = 0$

s^4	1	69	$200+K$
s^3	12	198	
s^2	52.5	$200+K$	
s^1	$198 - \frac{12(200+K)}{52.5}$		
s^0	$200+K$		

system will be stable when,

$$200 + K > 0$$

or, $K > -200$

$$198 - \frac{12(200+K)}{52.5} > 0$$

or, $K < 666.25$

Oscillations will occur when $K = 666.25$

Auxiliary equation :

$$52.5s^2 + (200 + K) = 0$$
$$52.5s^2 = -866.25$$
$$s^2 = -16.5$$
$$s = \pm j4.06$$

∴ Frequency of sustained oscillation = 4.06 rad/sec

23. (d)

$$A = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix}, \quad B = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}, \quad C = \begin{bmatrix} 1 & 0 & 2 \end{bmatrix}$$

$$AB = \begin{bmatrix} -1 \\ -2 \\ 0 \end{bmatrix}, \quad A^2B = \begin{bmatrix} 1 \\ 4 \\ 0 \end{bmatrix}$$

$$Q = \begin{bmatrix} B : AB : A^2B \end{bmatrix} = \begin{bmatrix} 1 & -1 & 1 \\ 1 & -2 & 4 \\ 0 & 0 & 0 \end{bmatrix}$$

Rank of the matrix = 2

Hence, the system is uncontrollable

$$Q' = \begin{bmatrix} C^T : A^TC^T : A^{T^2}C^T \end{bmatrix}$$

$$= \begin{bmatrix} 1 & -1 & 1 \\ 0 & 0 & 0 \\ 2 & 6 & 18 \end{bmatrix}$$

Rank of the matrix = 2

Hence, system is unobservable.

24. (c)

Transform network of the given circuit,

$$Z_1(s) = R_1$$

$$Z_2(s) = \frac{R_2 \cdot \frac{1}{sC}}{R_2 + \frac{1}{sC}} = \frac{R_2}{1 + sR_2C}$$

$$\frac{E_0(s)}{E_i(s)} = \frac{-Z_2(s)}{Z_1(s)} = \frac{-R_2}{R_1(1 + sR_2C)}$$

25. (d)

For the given signal flow graph

Forward paths:

$$P_1 = G_1G_2G_3$$

gains $\quad P_2 = G_3G_4$

Number of possible forward paths: 2

Individual loop gain:

$$L_1 = H_1H_2G_3G_4$$
$$L_2 = -G_1H_2H_3$$
$$L_3 = G_1G_2G_3H_1H_2$$

Number of individual loops for given signal flow graph is equal to 3.

26. (a)

$$W \propto f$$

$$\text{Dielectronics (W)} = \frac{E^2 f \in_r \tan\delta}{1.8\times 10^{12}} \text{W/cm}^3$$

27. (b)

The relation between the lattice constant and the density of the material of crystal is

$$a = \left[\frac{n}{N_A}\frac{M}{\delta}\right]^{1/3}$$

$$a \propto \delta^{-1/3}$$

Where, $\quad n$ = Number of atoms/cell

δ = Density of crystal material

M = atomic weight material

a = lattice constant

28. (d)

Point defects in the crystal will be formed by thermal fluctuations, by severe deformation (i.e. by hammering or rolling) and by bombarding with high energetic particles.

29. (d)

By inserting dielectric material of dielectric constant K, its capacitance increases by a factor K and charge on the plates remain constant.

$$\left[\because C = \frac{A \in_0 \in_r}{d}, C \propto \in_r\right]$$

30. (c)

The magnetic field produced by the solenoid,

$$H = \frac{NI}{l} = \frac{1000 \times 2.5}{0.25} = 10000 \text{ A/m}$$

The increase in magnetic induction when placed in oxygen

$$= 1.04 \times 10^{-8} \text{ Wb/m}^2$$
$$= \mu_0 M$$

This increase is due to magnetization (M)

$$M = \frac{1.04 \times 10^{-8}}{4\pi \times 10^{-7}} = 8.276 \times 10^{-3} \text{ A/m}$$

Magnetic susceptibility, $\chi_m = \frac{M}{H} = \frac{8.276 \times 10^{-3}}{10^4} = 8.276 \times 10^{-7}$

31. (c)

$$\text{Dielectric loss} = \frac{E^2 f \varepsilon_r \tan\delta}{1.8 \times 10^{12}} \text{W/cm}^3$$

$$= \frac{30^2 \times 10^6 \times 50 \times 4.8 \times 0.001}{1.8 \times 10^{12}}$$

$$= 1.2 \times 10^{-4} = 0.12 \text{ mW/cm}^3$$

32. (a)

Superconductors are perfect diamagnetic materials.

33. (a)

$$I_C = 2\pi r H_C$$
$$= 2\pi \times 0.5 \times 10^{-3} \times 15.85 \times 10^3$$
$$= 49.8 \text{ A}$$

34. (d)

Eddy current loss, $P_{eddy} = K_e f^2 B_{max}^2 C^2$

Also, $K_e = \frac{\pi^2}{\rho} = \pi^2 \sigma$ ($\sigma \rightarrow$ conductivity)

$$P_{eddy} = \pi^2 \sigma f^2 B^2_{max} \times C^2$$

$\Rightarrow$ $P_{eddy} \propto \sigma$

$\therefore$ $\frac{P_{eddy\,A}}{P_{eddy\,B}} = \frac{4}{9}$

35. (b)

Energy in magnetic system,

$$W_f = \int_0^{\lambda} i(\lambda)d\lambda$$

Given, $$\lambda = \frac{\sqrt{i}}{g} \text{ or } i = \lambda^2 g^2$$

$$W_f = \int_0^{\lambda} \lambda^2 g^2 d\lambda = g^2 \frac{\lambda^3}{3}$$

Mechanical force, $$F_f = \frac{-\partial W_f(\lambda, g)}{\partial g} = -\frac{\partial}{\partial g}\left[g^2 \frac{\lambda^3}{3}\right] = \frac{-2}{3}\lambda^3 g$$

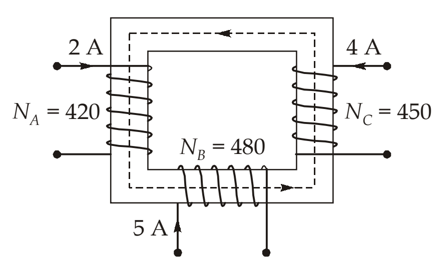
$i = 4$ A, $g = 5$ cm $= 5 \times 10^{-2}$ m

$$\lambda = \frac{\sqrt{4}}{5 \times 10^{-2}} = 40$$

$$|F_f| = \frac{2}{3} \times (40)^3 \times 0.05 = 2133.33 \text{ N}$$

36. (d)

For given figure,



flux by coil-B and coil-C are in same direction, in opposition of coil-A.

Net ampere turns $= -I_A T_A + I_B T_B + I_C T_C$

$= -2 \times 420 + 480 \times 5 + 450 \times 4$

$= 3360$ AT

Mean length of core, $l_i = 120$ cm $= 1.2$ m

cross section area, $a = 4 \times 10^{-2} \times 4 \times 10^{-2}$

$= 16 \times 10^{-4}$ m^2

Relative permeability : $\frac{2400}{\pi}$

Reluctance of iron path,

$$S_i = \frac{l_i}{\mu_0 \mu_r a} = \frac{1.2}{4\pi \times 10^{-7} \times \frac{2400}{\pi} \times 16 \times 10^{-4}} = 7.812 \times 10^5 \text{ AT/Wb}$$

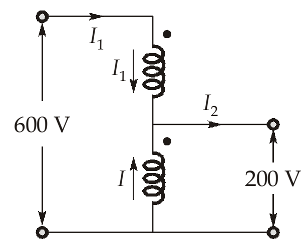
$$\phi = \frac{\text{Total ampere turns}}{\text{Total reluctance}}$$

$$= \frac{3360}{7.8125 \times 10^5} = 4.3 \text{ mWb in anticlockwise direction}$$

37. (c)

Given, autotransformer,

$$\text{Turn ratio, } a = \frac{600}{200} = 3$$



Current in series winding,

$$I_1 = \frac{40 \times 10^3}{400} = 100 \text{ A}$$

Current in common winding,

$$I = \frac{40 \times 10^3}{200} = 200 \text{ A}$$

Load current, $I_2 = I_1 + I = 300$ A

Rating of auto transformer = 300 A × 200 V

= 60 kVA

38. (d)

Core loss current component takes care of power to make up to hysteresis and eddy current losses in core. If the flux in core is sinusoidal in nature, eddy current in core are proportional to $\frac{d\phi}{dt}$ the eddy current is largest when the flux in the core is passing through 0 Wb, hence coreloss is greatest as flux passes through zero.

39. (b)

Given transformer rating : 50 kVA, 20 kV/220 V

Percent resistance : 1% : percent reactance : 8%

Taking hv side voltage of transformer as base line voltage i.e. 22000 V

Base apparent power, S_B = 50 kVA

As primary is Δ-connected,

Phase voltage, V_p = line voltage V_L

$\therefore$ Base impedance, $Z_{base} = \dfrac{3(V_{\phi,base})^2}{S_{base}} = \dfrac{3\times(22000)^2}{50\times10^3} = 29040\ \Omega$

The per unit impedance of transformer,

$$Z_{eq\text{ - }pu} = 0.01 + j0.08 \text{ p.u.}$$

$\therefore$ high voltage side impedance,

$$Z_{eq} = Z_{eq\text{-}pu} \times Z_{base}$$
$$= (0.01 + j0.08) \times 29040$$
$$= 290.40 + j2323.2\ \Omega$$

40. (d)

All above mentioned factors are responsible for different value of internal voltage, E_a and the output terminal voltage, V_t.

41. (b)

The real power generated is proportional to quantity, $E_a \sin\delta$, when resistances value are neglected in comparison to reactances.

42. (c)

The real power, $P = 2$ MW

reactive power, $Q = 2$ MVAR

$$\tan\phi = \frac{\text{Reactive power}}{\text{Active power}} = \frac{2}{2} = 1$$

$$\phi = \tan^{-1}(1) = 45°$$

$$\cos\phi = \cos 45° = 0.707 \text{ (lagging)} = \frac{1}{\sqrt{2}}$$

$\therefore$ Line current, $I_L = \dfrac{P}{\sqrt{3}\times V_L\times\cos\phi}$

$$= \frac{2\times10^6}{\sqrt{3}\times10^3\times\dfrac{x}{\sqrt{2}}} = \frac{2\sqrt{2}}{\sqrt{3}x}\times10^3\text{ A}$$

43. (a)

Total load, $P = 50$ kW

$\cos\phi = 0.866,$

$\phi = \cos^{-1}(0.866) = 30°$ lag

Reactive power of load, $Q = P\tan\phi$

$$= \frac{50}{\sqrt{3}}\text{kVAR}$$

Real power supplied by machine-1,

$$\frac{P}{2} = \frac{50}{2} = 25 \text{ kW}$$

Phase angle of machine-1,

$$\phi_1 = \cos^{-1} 1 = 0°$$

$$Q_1 = P_1 \tan \phi_1 = 0$$

$$\text{Real power, } P_2 = 25 \text{ KW}$$

$$\text{Reactive power, } Q_2 = Q - Q_1$$

$$Q_2 = \frac{50}{\sqrt{3}} \text{kVAR}$$

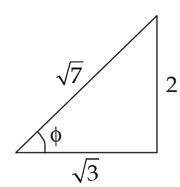
∴ Phase angle of machine-2,

$$\phi_2 = \tan^{-1}\frac{Q_2}{P_2} = \tan^{-1}\frac{50}{\sqrt{3}} \div 25$$

$$= \tan^{-1}\frac{50}{\sqrt{3}} \times \frac{1}{25}$$

$$\phi_2 = \tan^{-1}\frac{2}{\sqrt{3}}$$

by right angled triangle logic,



$$\cos \phi_2 = \sqrt{\left(\frac{3}{7}\right)} \text{ lag}$$

44. (d)

Given,

$$P = 6,$$

$$f_s = 50 \text{ Hz},$$

$$f_r = 2 \text{ Hz}$$

$$f_r = sf_s$$

$$s = \frac{f_r}{f_s} = \frac{2}{50} = 0.04$$

$$N = \frac{120 \times 50(1-0.04)}{6} = 20 \times 50(0.96) = 960 \text{ rpm}$$

45. (c)

The direction of rotation of motor is determined by whether the space angle of the magnetic field from auxiliary winding is 90° ahead or 90° behind the angle of main winding.

46. (d)

Given lap connected machine :

$$A = P$$

Armature ampere turn/pole

$$= \frac{I_a}{A} \times \frac{Z/2}{P} = 10000$$

or, $$I_a = \frac{(10000 \times 2 \times P \times A)}{Z} \quad \text{...(i)}$$

Average emf induced = (Average voltage between commutator seg) × (No. of turn per parallel path)

$$E_a = 15 \times \frac{Z/2}{A} = 7.5\ Z/A \quad \text{...(ii)}$$

Also, $$E_a I_a = 1200 \times 10^3$$

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

$$7.5 \times \frac{Z}{A} \times \frac{10^4 \times 2 \times P \times A}{Z} = 1200 \times 10^3$$

$$15 \times P = 120$$

or $$P = 8$$

47. (c)

By Gantt chart,

P_2	P_5	P_1	P_3	P_4

0 1 6 16 18 19

$$\text{The average waiting time} = \frac{1+6+16+18}{5} = \frac{41}{5} = 8.2 \text{ m-sec}$$

48. (d)

All given statements are correct. Von - Neumann Architecture is single memory architecture.

49. (d)

RISC supports less addressing modes as compared to CISC.

50. (b)

Given, data for direct mapped cache memory,

cache memory size = 64 kB

block size = 64 byte

Physical address = 28 bit

$$\text{Number of lines} = \frac{64 \text{ kB}}{64} = 2^{10}$$

Addres format :

tag	LO	WO
12 bit tag space	$\log_2 2^{10}$ → 10 bit	$\log_2 64$ → 6 bit

$$\text{Tag directory size} = \text{No. of lines in CM} \times \text{tag space}$$
$$= 2^{10} \times 12 \text{ bit} = 1024 \times 12 \text{ bit}$$

51. (d)

All given statements are correct.

53. (b)

At $t = 0$ only P_1 arrives and at $t = 1$, P_1 and P_2 both arrives but P_2 has shorter burst time.

54. (d)

$$h = 0.4,$$
$$T_1 = 15 \text{ ns}, T_2 = 120 \text{ ns}$$
$$T_s = hT_1 + (1 - h)T_2$$
$$= 0.4 \times 15 + 0.6 \times 120$$
$$= 78 \text{ ns}$$

55. (a)

$$\text{Capacity factor} = 0.7$$
$$\text{Capacity factor} = \frac{\text{Average loading}}{\text{Plant capacity}}$$
$$\text{Average loading} = \frac{90+50}{2} = 70 \text{ MW}$$
$$\therefore \quad \text{Plant capacity} = \frac{70}{0.7} = 100 \text{ MW}$$
$$\text{Reserve capacity} = \text{Plant capacity} - \text{peak load}$$
$$= 100 - 90 = 10 \text{ MW}$$

56. (c)

$$L = 2\times 10^{-7} \ln \frac{\sqrt[3]{d_1 d_2 d_3}}{r}$$
$$C = \frac{2\pi\varepsilon_0}{\ln \frac{\sqrt[3]{d_1 d_2 d_3}}{r}}$$

57. (c)

Given, $$\frac{X_m}{R_m} = \frac{X_n}{R_n}$$
$$(R_m + jX_m)I_m = (R_n + jX_n)I_n$$
$$R_m\left[1+\frac{jX_m}{R_m}\right]I_m = R_n\left[1+\frac{jX_n}{R_n}\right]I_n$$
$$I_m R_m = I_n R_n$$
i.e. both the current are in same phase
$$I = I_m + I_n$$
Hence total current I will be in phase with both I_m and I_n.

58. (c)

Since, the surge is travelling from a medium having low surge impedance to a medium with high surge impedance so the amplitude of the surge will be increased. But it will be less than 400 kV as magnitude is doubled only when load impedance is infinite i.e. line is open circuited.

59. (b)

$$Q \text{ at } G_1 = \text{Reactive power in load at sending end} + Q_S$$

$$Q_S = \frac{|V_S|}{X}(|V_S| - |V_R|\cos\delta)$$

$$Q_S = \frac{1}{0.05}(1 - \cos 30°) = 2.6794 \text{ p.u.}$$

Hence, $Q_{G1} = 2.67949 + 5$

$= 7.67949 \text{ p.u.} \approx 7.68 \text{ p.u.}$

60. (d)

Sending end phase voltage,

$$V_S = \frac{230}{\sqrt{3}} = 132.79 \text{ kV}$$

$$I_R = 0$$

$$V_S = AV_R + BI_R$$

$$\Rightarrow \quad V_R = \frac{V_S}{A} = \frac{132.79\angle 0°}{0.937\angle 1.2°} = 141.7\angle -1.2° \text{ kV}$$

$$I_C = CV_R = 0.001\angle 90° \times 141.7 \times 10^3\angle -1.2°$$

$$= 141.7\angle 88.8° \text{ A}$$

61. (a)

The reactive power output of bus-1 is given by,

$$Q_1 = \frac{|V_1|}{X}\left[|V_1| - |V_2|\cos\delta\right]$$

As there is real power flow between the buses

$\therefore$ $\delta \neq 0$, and $|V_1| = |V_2|$ so $Q_1 > 0$. Hence, bus-1 injects reactive power into transmission line.

The reactive power input to bus-2 is given by

$$Q_2 = \frac{|V_2|}{X}\left[|V_1|\cos\delta - |V_2|\right]$$

$\therefore$ $Q_2 < 0$ and thus bus delivers reactive power to transmission line.

62. (a)

The load is lagging pf and when a shunt capacitor is added, the current is leading in capacitor and thus total current decreases and power factor increases.

63. (a)

Corona loss ∝ $(f + 25)$

For 50 Hz,

$$\text{Corona loss} = 2\text{ kW/phase/km}$$

$$P_2 = \frac{P_1}{(f_1 + 25)} \times (f_2 + 25)$$

$$= \frac{50}{75} \times 2\text{ kW/phase/km} = 1.333\text{ kW/phase/km}$$

64. (d)

If the star neutral is grounded through reactor of impedance Z_n, an impedance $3Z_n$ appears in series with Z_0 in the sequence network and due to delta connection on secondary side, the line is open circuited on secondary side.

65. (a)

The short circuit current (in A) is independent of base kVA, therefore the short circuit current remains the same.

66. (b)

$$\frac{H_{12}}{180 f}\frac{d^2\delta_{12}}{dt} = P_m - P_e$$

$$\Rightarrow \left(\frac{6 \times 4}{6 + 4}\right) \times \frac{1}{180 \times 50}\frac{d^2\delta_{12}}{dt^2} = 1.0 - 0.4$$

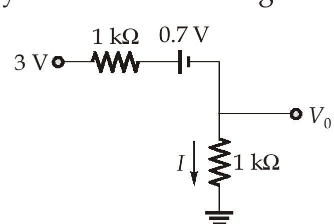
$$\Rightarrow \frac{d^2\delta_{12}}{dt^2} = \frac{0.6 \times 180 \times 50}{2.4} = 2250\text{ elec deg/sec}^2$$

67. (c)

Restricted earth fault protection means not to sense any fault outside the protected zone.

68. (d)

In common anode connection always the diode with highest anode voltage will be on



$$I = \frac{3 - 0.7}{2K} = 1.15\text{ mA}$$

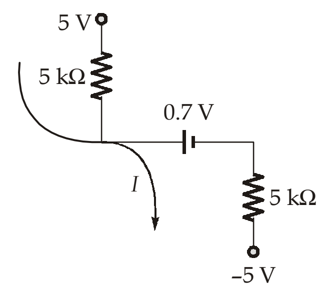
$$V_0 = 1.15\text{ V}$$

69. (c)

Both statements are correct.

70. (a)

In the circuit shown,



D_1 and $D_3 \rightarrow$ OFF and $D_2 \rightarrow$ ON (Assumption)

$$I = \frac{5 - 0.7 + 5}{10K} = 0.93 \text{ mA}$$

72. (b)

$$V_S = 30 - 10 = 20 \text{ V}$$

$$\text{Power dissipation} = \frac{V_s^2}{R_s} = \frac{20^2}{200} = 2 \text{ W}$$

73. (d)

Base width modulation in BJT refers to narrowing base width which leads to the early effect in BJT.

74. (c)

As β is not given,

$$I_C \approx I_E$$

Applying KVL to i/p loop,

$$I_C = \frac{4 - 0.7}{3.3 \times 10^3} = 1 \text{ mA}$$

$$V_C = 8 - 3.7 \times 10^3 \, I_C$$
$$V_C = 8 - 3.7$$
$$= 4.3 \text{ V}$$

75. (b)

A standard full wave centre tapped rectifier having input voltage equal to $V_m \sin(\omega_m t)$ requires 2 diodes with peak inverse voltage equal to $2V_m$ and has the ripple voltage frequency equal to $2\omega_m$.

76. (a)

If the bypass capacitor is disconnected, then due to negative feedback, voltage gain will decrease and the BW will increase.

77. **(a)**

Given, $SR = 0.5\ \text{V}/\mu\text{s}$

$$V_{\text{rms}} = \frac{V_m}{\sqrt{2}}$$

$$\Rightarrow \quad V_m = 2\sqrt{2}\ \text{V}$$

$$f_m = \frac{SR}{2\pi V_m} = \frac{0.5\times 10^6}{2\pi\times 2\sqrt{2}} = 28.134\ \text{kHz}$$

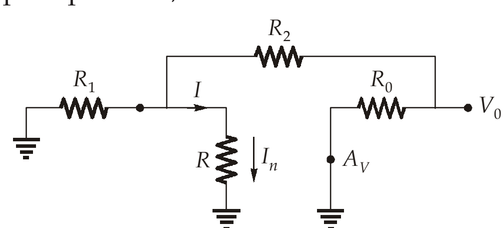
78. **(b)**

Apply superposition theorem,

$$V_0 = (1)\left(\frac{-12\text{k}}{4\text{k}}\right)+2\left(\frac{-12\text{k}}{6\text{k}}\right) = -7\ \text{V}$$

79. **(c)**

The equivalent diagram of op-amp circuit,



$R_0 \to \infty$ and for $V_0 = 0$

$$R = R_1 \,\|\, R_2$$

80. **(a)**

The ideal op-amp char are,

$R_i = \infty$,

$A_{0L} = \infty$, $R_0 = 0$

Bandwidth $= \infty$,

CMRR $= \infty$,

Slew rate $= \infty$

offset voltage $= 0$ V

81. **(b)**

$$1\times 5^2 + 2\times 5 + 3\times 5^0 = x\times y + 8$$

$$25 + 10 + 3 = xy + 8$$

$$38 = xy + 8$$

$$xy = 30$$

Here, $y > 8\ ;\ y > x$

$\therefore$ The possible combination are,

$x = 1;\quad y = 30$

$x = 2;\quad y = 15$

$x = 3;\quad y = 10$

$\therefore$ 3 possibilities.

82. (b)

In parallel binary adder (or) ripple carry adder for N-bit numbers addition.

Number of half adders required = 1.

Number of full adders required = $N - 1$.

Therefore, the number of full and half adders required to add 16 - bit numbers is 15 and 1 respectively.

83. (c)

The output g is

$$g = 1\bar{X}_1 + 0X_1 = \bar{X}_1$$

The output f is

$$f = g\bar{X}_2 + X_1X_2$$

$$f = \bar{X}_1\bar{X}_2 + X_1X_2$$

84. (d)

Clock	$D_3 = \bar{Q}_0$	Q_3 0	Q_2 0	Q_1 0	Q_0 0
1	1	1	0	0	0
2	1	1	1	0	0
3	1	1	1	1	0
4	1	1	1	1	1
5	0	0	1	1	1
6	0	0	0	1	1
7	0	0	0	0	1
8	0	0	0	0	0

Hence the switching sequence is 0, 8, 12, 14, 15, 7, 3, 1, 0.

85. (c)

SHLD instruction is example of direct addressing mode.

86. (c)

- STA 2400 H is an example of direct addressing mode.
- MOV A, B is an example of register addressing mode.

87. (d)

The program is for shifting of a 16-bit number left by 2-bits.

2501 H is stored with 96 H and 2502 is stored with 15 H.

	0001 (1)	0101 (5)	1001 (9)	0110 (6)
Result of one bit left shift	0010 (2)	1011 (*B*)	0010 (2)	1100 (*C*)
Result of another one bit left shift	0101 (5)	0110 (6)	0101 (5)	1000 (8)

The content of 2504 will be, 56 H -- MSB of result.

88. (c)

When $\overline{RD}$ signal goes low 8255 sends out data or status information to the CPU on the data bus. There are three modes of operation also including bidirectional mode.

89. (b)

CMP R instruction requires 4 T-states, in which content of register is subtracted from accumulator and status flags are set according to result of subtraction but result is discarded content of accumulator remains unchanged.

90. (b)

From the given equation,

$$A_c = 40$$

Comparing with,
$$X_{AM} = A_c \cos\omega_c t + \frac{1}{2}\mu A_c \cos(\omega_c + \omega_n)t + \frac{1}{2}\mu A_c \cos(\omega_c - \omega_n)t$$

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

$$\mu(40) = 20$$

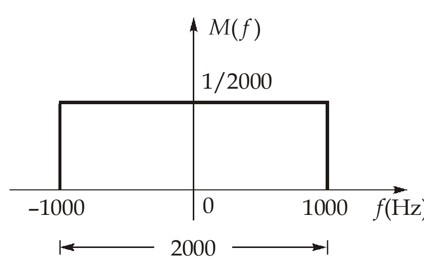
Modulation index, $\mu = 0.50$

91. (b)

$$m(t) = \text{sinc}(2000t)$$

$$\text{sinc}(t) \xleftrightarrow{\text{CTFT}} \text{rect}(f)$$

$$m(t) = \text{sinc}(2000t) \xleftrightarrow{\text{CTFT}} M(f) = \frac{1}{2000}\text{rect}\left(\frac{f}{2000}\right)$$



$$f_{m(\max)} = 1000 \text{ Hz} = 1 \text{ kHz}$$

BW of AM signal, $(BW)_{AM} = 2f_{m(\max)} = 2 \text{ kHz}$

92. (a)

In FM, 100% transmission efficiency is possible for some values of modulation index only. Those values are : 2.41, 5.53, 8.65, ...

93. (d)

Given that, $f_{LO} > f_c$

IF or $f_{IF} = 450$ kHz

$f_c = 1200$ kHz

$f_{\text{image}} = f_c + 2f_{IF} = 1200 + 2(450) \text{ kHz} = 2100 \text{ kHz}$

94. (c)

$$\cos\mu = 1 - \frac{\omega L_s I_d}{\sqrt{2}V_s}$$

95. (c)

$$V_d = 0.9Vs - \frac{2\omega L_s I_d}{\pi}$$
$$= 0.9 \times 120 - 4 \times 50 \times 10^{-3} \times 10$$
$$= 106 \text{ V}$$
$$p_d = V_d I_d$$
$$= 106 \times 10 = 1060 \text{ W}$$

96. (b)

RCT may be considered as a thyristor with a built in antiparallel diode.

97. (d)

In forward converter

$$V_0 = V_s D\left(\frac{N_2}{N_1}\right) = 48 \times 0.4 \times \left(\frac{1}{1.5}\right)$$
$$V_0 = 12.8 \text{ V}$$

98. (b)

$$DT = 0.4\,T \Rightarrow D = 0.4$$
$$D_1 T = 0.29\,T \Rightarrow D_1 = 0.29$$
$$V_0 = V_S\left(\frac{D}{D+D_1}\right)$$
$$= 24\left(\frac{0.4}{0.4+0.29}\right) = 13.91 \text{ V}$$

100. (d)

Average current through inductor

$$I = \frac{V_m}{\omega L} = \frac{230\sqrt{2}}{2\pi \times 50 \times 0.1} = 10.354 \text{ A}$$

Voltage across diode = 0, since it will conduct for 360°.

101. (d)

All statements are correct.

102. (b)

In unipolar switching

Harmonic order, $h = j(2m_f) \pm k$

$$h = j76 \pm k$$
$$f_H = (j76 \pm k) \times 47$$

$j = 1, k = 1 \Rightarrow$ $f_H = 3525, 3619$ Hz

103. **(b)**

Duty cycle,
$$\alpha = \frac{V_0}{V_s}$$
$$\alpha = \frac{5}{12}$$
$$\alpha = 0.4167$$

Ripple current,
$$\Delta I = \frac{\alpha(1-\alpha)V_s}{fL} = \frac{0.4167(1-0.4167)\times 12}{50\times 10^3\times 100\times 10^{-6}}$$
$$\Delta I = 0.5833 \text{ A}$$
$$I_C \text{ average during } \frac{T_{on}}{2} = \frac{\Delta I_C}{4} = \frac{0.5833}{4} = 0.146 \text{ A}$$

104. **(b)**

The total circuit resistance equals,
$$R_T = \frac{V_T}{I_T} = \frac{100\text{V}}{5\text{mA}} = 20 \text{ k}\Omega$$

The voltmeter resistance equals
$$R_V = 1000\ \Omega/\text{V} \times 150 \text{ V}$$
$$= 150 \text{ k}\Omega$$

Since the voltmeter is in parallel with the unknown resistance,
$$R_X = \frac{R_T R_V}{R_V - R_T} = \frac{20\times 150}{130} = 23.05 \text{ k}\Omega$$
$$\%\ \text{Error} = \frac{\text{Measured} - \text{Actual}}{\text{Actual}}\times 100\%$$
$$= \frac{20\text{k} - 23.05\text{k}}{23.05\text{k}}\times 100\% = -13.23\%$$

105. **(c)**

Expressing the guaranteed limits of both current and resistance in percentages
$$I = 2.00 \pm 0.01 \text{ A} = 2.00 \pm 0.5\%$$
$$R = 100 \pm 0.2\ \Omega = 100 \pm 0.2\%$$
$$P = I \times I \times R = I^2R$$

The error is ±1.2%, which is two times the 0.5% error of the current plus the 0.2% error of the resistor.

106. **(a)**

Rate of change of inductance with deflection
$$\frac{dL}{d\theta} = \frac{d}{d\theta}(10 + 5\theta - \theta^2) = 5 - 2\theta\ \mu\text{H/rad}$$

The deflection, $$\theta = \frac{1}{2}\frac{I^2}{K}\frac{dL}{d\theta}$$

or $$\theta = \frac{1}{2} \times \frac{(5)^2}{12 \times 10^{-6}} \times (5 - 2\theta) \times 10^{-6}$$

$$\theta = \frac{25}{24} \times (5 - 2\theta)$$

$$24\,\theta = 125 - 50\,\theta$$

$$74\,\theta = 125$$

$$\theta = 1.69 \text{ rad}$$

107. (c)

The d.c. sensitivity is:

$$S_{dc} = \frac{1}{I_{fs}} = \frac{1}{1 \times 10^{-3}} = 1000\ \Omega/\text{V}$$

For full wave rectifier circuit, a.c. sensitivity

$$S_{ac} = 0.9 \times 1000 = 900\ \Omega/\text{V}$$

Resistance of multiplier, $$R_s = S_{ac}\,V - R_m - 2R_d$$

$$= 900 \times 10 - 500 - 0$$

$$= 8500\ \Omega$$

108. (d)

As the current I_p increase, there is an increase in I_s and there is a decrease in ratio error and phase angle.

109. (d)

$$P_1 = 3000 \text{ W}$$

and $$P_2 = 1500 \text{ W}$$

$$\phi = \tan^{-1}\sqrt{3}\cdot\frac{P_1 - P_2}{P_1 + P_2} = \tan^{-1}\sqrt{3}\cdot\frac{3000 - 1500}{3000 + 1500}$$

$$= \tan^{-1}\frac{1}{\sqrt{3}} = 30°$$

Power factor $$\cos\phi = \cos 30° = 0.866$$

110. (a)

Actual energy consumed at half load during 138 sec

$$= VI\cos\phi \times t \times 10^{-3}$$

$$= 230 \times 5 \times 1 \times \frac{138}{3600} \times 10^{-3}$$

$$= 44.08 \times 10^{-3} \text{ kWh}$$

Energy recorded $$= \frac{\text{Number of revolutions made}}{\text{revolution/kWh}}$$

$$= \frac{80}{1800} = 44.44 \times 10^{-3}\,\text{kWh}$$

$$\therefore \quad \text{error} = \frac{44.44 - 44.08}{44.08} \times 100 = 0.817\%\ \text{fast}$$

111. (b)

The gauge factor is given by,

$$G_f = 1 + 2\upsilon + \frac{\Delta\rho/\rho}{\epsilon}$$

If piezoresistive effect is neglected, the gauge factor is given by

$$G_f = 1 + 2\upsilon$$

$$\therefore \quad \text{Poisson's ratio, } V = \frac{G_f - 1}{2} = \frac{4.2 - 1}{2} = 1.6$$

112. (c)

$$f_2 = 2.5 f_1$$

$$\frac{1}{2\pi\sqrt{L(C_2 + C_d)}} = \frac{2.5}{2\pi\sqrt{L(C_1 + C_d)}}$$

This reduces to

$$\frac{1}{C_2 + C_d} = \frac{6.25}{C_1 + C_d}$$

Solving for C_d, we obtain

$$C_d = \frac{C_1 - 6.25 C_2}{5.25}$$

Substituting the values for C_1 = 450 pF and C_2 = 60 pF, that the value of the distributed capacitance is C_d = 14.3 pF.

113. (c)

$$I = \int_4^\infty e^{-2t^2} \cdot \delta(t+5)\,dt$$

$$t = -5 \text{ is not in the interval 4 to } \infty$$

$$\therefore \quad I = 0$$

114. (b)

$$y(n) = x^2(n)$$

$y(n)$ depends only on $x(n)$ (only present value)

∴ system is causal

if $x(n) = \delta(n)$; $y(n) = \delta^2(n) = \delta(n)$

if $x(n) = -\delta(n)$; $y(n) = \delta^2(n) = \delta(n)$

∴ for two different inputs, output is same

∴ system is non-invertible.

115. (d)

$$\int_{-\infty}^{t} f(\tau)\cdot d\tau \Leftrightarrow \frac{F(j\omega)}{j\omega} + \pi F(0)\cdot\delta(\omega)$$

$$\Leftrightarrow \frac{1}{j\omega(\omega^2+1)}\cdot e^{\frac{-2\omega^2}{\omega^2+1}} + \pi\delta(\omega) \qquad \text{[Since } F(0) = 1\text{]}$$

116. (a)

$$X(k) = \sum_{n=0}^{3} x(n) e^{-j\frac{2\pi nk}{4}}$$

$$X(0) = \sum_{n=0}^{3} x(n) = j + 1 + j + 1 = 2 + 2j$$

$$X(1) = \sum_{n=0}^{3} x(n) e^{-j\frac{2\pi n}{4}} = x(n)\,(-j)^n$$

$$= j(-j)^0 + 1(-j)^1 + j(-j)^2 + 1(-j)^3$$

$$= j - j - j + j = 0$$

$$X(2) = \sum_{n=0}^{3} x(n) e^{-j\pi n}$$

$$= x(0) + x(1)e^{-j\pi} + x(2)e^{-2j\pi} + x(3)e^{-3j\pi}$$

$$= x(0) - x(1) + x(2) - x(3)$$

$$X(2) = j - 1 + j - 1 = -2 + 2j$$

$$X(3) = X^*(1) = 0$$

$\therefore \quad X(k) = [2 + 2j,\ 0,\ -2 + 2j,\ 0]$

117. (b)

$$\delta(\omega) \xrightarrow{\text{IFT}} \frac{1}{2\pi}$$

$$\delta(\omega-1) \xrightarrow{\text{IFT}} \frac{1}{2\pi}e^{jt}$$

$$\delta(\omega+1) \xrightarrow{\text{IFT}} \frac{1}{2\pi}e^{-jt}$$

$$[\delta(\omega-1)+\delta(\omega+1)] \xrightarrow{\text{IFT}} \frac{1}{\pi}\cos t$$

$$6[\delta(\omega-1)+\delta(\omega+1)] \xrightarrow{\text{IFT}} \frac{6}{\pi}\cos t$$

118. (b)

Using final value theorem

$$x(\infty) = \lim_{z \to 1}(1 - z^{-1})\frac{z-a}{(1-z)}$$

$$= \lim_{z \to 1}\frac{z-1}{z}\left(\frac{z-a}{1-z}\right)$$

$$= -(1 - a) = a - 1$$

119. (a)

Order of numerator should be less than (or) equal to order of denominator for causal system.

120. (c)

$$\text{L.T.} = \int_{-\infty}^{\infty} x(t)e^{-st} \cdot dt$$

$$\text{Fourier transform} = \int_{-\infty}^{\infty} x(t)e^{-j\omega t} \cdot dt$$

$$s = \sigma + j\omega$$

If $\sigma = 0$ (i.e. imaginary axis)

$$s = j\omega$$

$$\text{L.T.} = \text{F.T}$$

∴ Fourier transform is nothing but two sides Laplace transform on the imaginary axis of the s-plane.

121. (d)

$$f(x) = (4 - x^2)^2$$

$$f'(x) = 2(4 - x^2)(-2x)$$

$$= 4x(x^2 - 4)$$

Since $f(2) = 0$ and $f(-2) = 0$, so $y = f(x)$ crosses x-axis at –2 and 2.

$f' > 0$ when $x > 0$ and $x > 2$ so f is increasing in $(2, \infty)$

$f' < 0$ when $x > 0$ and $x < 2$ so f is decreasing in $(0, 2)$

$f' > 0$ when $x < 0$ and $x > -2$ so f is increasing in $(-2, 0)$

$f' < 0$ when $x < 0$ and $x < -2$ so f is decreasing in $(-\infty, -2)$

122. (c)

∞ . 0 forms rewriting in $\frac{\infty}{\infty}$ form

$$\lim_{x \to 1} \ln(1-x) \cdot \cot\frac{\pi x}{2} = \lim_{x \to 1}\frac{\ln(1-x)}{\tan\frac{\pi x}{2}}$$

Applying L' Hospital's rule,

$$= \lim_{x \to 1} \frac{\frac{1}{1-x} \cdot (-1)}{\frac{\pi}{2} \sec^2 \frac{\pi x}{2}} \; : \; \frac{\infty}{\infty} \text{ form}$$

Rewriting in $\frac{0}{0}$ form

$$= \lim_{x \to 1} \frac{-2}{\pi} \frac{\cos^2 \frac{\pi x}{2}}{1-x} \; : \quad \frac{0}{0} \text{ form}$$

Applying L' Hospital's rule,

$$= \lim_{x \to 1} -\frac{2}{\pi} \frac{2 \cdot \cos \frac{\pi x}{2} \cdot \left(-\sin \frac{\pi x}{2}\right) \cdot \frac{\pi}{2}}{-1} = 0$$

123. (c)

Characteristic equation is

$$\begin{vmatrix} 1-\lambda & 0 & -1 \\ 1 & 2-\lambda & 1 \\ 2 & 2 & 3-\lambda \end{vmatrix} = 0$$

$$(1-\lambda)[(2-\lambda)(3-\lambda)-2] - [2-2(2-\lambda)] = 0$$

$$\lambda^3 - 6\lambda^2 + 11\lambda - 6 = 0$$

$$(\lambda - 1)(\lambda - 2)(\lambda - 3) = 0$$

So, λ = 1, 2 and 3 are three distinct eigen values of A.

124. (d)

Given that, $P(A) = P(B) = 2\,P(C)$

Since only three students A, B, C are in race, the probability space is finite,

i.e. $P(A) + P(B) + P(C) = 1$

or $(2 + 2 + 1)\,P(C) = 1$

So, $P(C) = \frac{1}{5}$

and $P(A) = P(B) = \frac{2}{5}$

Now, $P(B \cup C) = P(B) + P(C)$

$$= \frac{2}{5} + \frac{1}{5} = \frac{3}{5}$$

125. (d)

$$P(A) = P(L_1)P\left(\frac{A}{L_1}\right) + P(L_2)P\left(\frac{A}{L_2}\right) + P(L_3)P\left(\frac{A}{L_3}\right) + P(L_4)P\left(\frac{A}{L_4}\right)$$

$$= (0.4)\ (0.2) + (0.3)\ (0.1) + (0.2)\ (0.5) + (0.3)\ (0.2)$$

$$= 0.27$$

126. (b)

Let,

X = random variable representing the number of bombs to be used

p = probability that the bombs hits the target = $\frac{3}{4}$

$\therefore \quad q = \frac{1}{4}$

n = number of bombs required to destroy the target

$$P(r) = {}^nC_r\left(\frac{3}{4}\right)^r\left(\frac{1}{4}\right)^{n-r},$$

$$r = 0, 1, 2 \ldots n$$

We require,

$$P(X \geq 2) \geq 0.99$$

$$\left[1 - \{P(X=0) + P(X=1)\}\right] \geq 0.99$$

$$\left(\frac{1}{4}\right)^n + n\left(\frac{3}{4}\right)\left(\frac{1}{4}\right)^{n-1} \leq 0.01$$

$$1 + 3n \leq (0.01)4^n$$

We obtain, $\quad n = 6$

127. (b)

Let, $\quad f(x) = 3x - \cos x - 1$

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

$\therefore$ Newton's iteration formula gives,

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} = x_n - \frac{3x_n - \cos x_n - 1}{3 + \sin x_n}$$

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

Given, $\quad x_1 = 0.6000$

$\therefore \quad x_2 = \dfrac{x_1 \sin x_1 + \cos x_1 + 1}{3 + \sin x_1}$

$$= \frac{0.6\sin 0.6 + \cos 0.6 + 1}{3 + \sin 0.6}$$

$$= \frac{0.6 \times 0.5729 + 0.82533 + 1}{3 + 0.5729} = 0.6071$$

128. (a)

The poles of $f(z) = \frac{\sin z}{\cos z}$ are given by $\cos z = 0$

i.e. $z = (2n+1)\frac{\pi}{2}$

Where, $n = 0, \pm 1, \pm 2 \ldots$

of these many poles, only $z = \frac{\pi}{2}, -\frac{\pi}{2}$ lies inside the circle

$$\therefore \quad \text{Res} f\left(\frac{\pi}{2}\right) = \lim_{z \to \frac{\pi}{2}} \frac{\sin z}{\frac{d}{dz}(\cos z)} = \lim_{z \to \frac{\pi}{2}} \frac{\sin z}{-\sin z} = -1$$

Similarly, $$\text{Res} f\left(\frac{-\pi}{2}\right) = \lim_{z \to -\frac{\pi}{2}} \frac{\sin z}{\frac{d}{dz}(\cos z)} = -1$$

Hence by residue theorem,

$$\int_c f(z)\, dz = 2\pi i \left\{\text{Res} f\left(\frac{\pi}{2}\right) + \text{Res} f\left(-\frac{\pi}{2}\right)\right\}$$

$$= 2\pi i \{-1 -1\} = -4\pi i$$

129. (b)

Given equation in symbolic form is $(D^2 + D)y = x^2 + 2x + 4$

$$\therefore \quad \text{P.I.} = \frac{1}{D(D+1)}(x^2 + 2x + 4)$$

$$= \frac{1}{D}(1+D)^{-1}(x^2 + 2x + 4)$$

$$= \frac{1}{D}(1 - D + D^2 - \ldots)(x^2 + 2x + 4)$$

$$= \frac{1}{D}\left[x^2 + 2x + 4 - (2x+2) + 2\right]$$

$$= \int (x^2 + 4)dx = \frac{x^3}{3} + 4x$$

130. (a)

By Trapezoidal rule,

$$\int_0^2 f(x)dx = \frac{h}{2}(y_0 + y_2 + 2y_1) = \frac{1}{2}(1+15+2(4)) = 12$$

But, error = Exact value – Approximate value

For exact value to find,

Let $f(x) = a_0 + a_1x + a_2x^2$

Given,

At $x = 0$,

$$f(x) = 1$$

$$\Rightarrow \quad 1 = a_0 + 0 + 0$$

$$a_0 = 1$$

At $x = 1$,

$$f(x) = 4$$

$$\Rightarrow \quad 4 = 1 + a_1 + a_2$$

$$a_1 + a_2 = 3 \quad \text{...(i)}$$

At $x = 2$,

$$f(x) = 15$$

$$15 = 1 + 2a_1 + 4a_2$$

$$2a_1 + 4a_2 = 14 \quad \text{...(ii)}$$

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

$$a_1 = -1 \text{ and } a_2 = 4$$

$$\therefore \quad f(x) = 1 - x + 4x^2$$

$$\text{Exact value} = \int_0^2 f(x)dx = \int_0^2 (1 - x + 4x^2)dx = \frac{32}{3}$$

$$\therefore \quad \text{error} = \frac{32}{3} - 12 = -\frac{4}{3}$$

132. (a)

Power dissipation in an ideal inductor is zero because its internal resistance is zero.

134. (d)

The lead compensator increases the bandwidth by increasing the gain crossover frequency. It increases the phase margin ie. increases the margin of stability.

135. (d)

The root locus is symmetrical about the real axis.

136. (c)

Pyroelectric materials posses a polar axis of symmetry which always the appearance of spontaneous electrical polarization.

137. (c)
When starting current becomes 5 times full load current, then full load torque becomes almost equal to starting torque.

138. (d)
Outer cage has high resistance and low reactance value in double cage rotor IM.

141. (a)
Conductor in overhead line is less expensive and for same power, size is lesser than that of cable. This is because of better dissipation of heat in overhead lines.

142. (c)
Capacitively coupled op-amp can't be used to amplify dc or very low frequency signals.

144. (d)
A de-mux can be used as decoder if the input lines treated as enable and the select line as the input.

145. (a)
both A and R are correct as due to angle modulation we are getting frequency components at output as

$$= f_c \pm nf_m, \quad n = 0, 1, 2.......$$

$f_c \rightarrow$ carrier frequency,

$f_m \rightarrow$ message signal frequency

$\therefore$ so it has infinite side bands so

$$\text{B.W.} = \infty.$$

So statement-II is exact reason for statement-I.

147. (b)
In square wave inverter magnitude of the output voltage is controlled by controlling input DC voltage.

148. (a)
The operating magnetic field in moving iron instrument is very weak and therefore eddy current damping is not used in them.

149. (b)

Signal $x(t) = \sin\left(\frac{2\pi}{t}\right)$, $0 < t \le 1$ has infinite number of maxima and minima in one time period.

$\therefore$ Fourier series does not converge for this signal.

150. (c)
Aliasing is an irreversible process once aliasing has occured then signal can not be recovered back.

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