DETAILED SOLUTIONS

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ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

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

Note: Answer key has been updated of **Q.26** and In **Q. 82** ('*' indicates) mark to all.

DETAILED EXPLANATIONS

1. (d)

All statements are correct.

2. (b)

KVL equation for figure (a),

$$V_A = L_A \frac{di_1}{dt} - M\frac{di_2}{dt} \quad ...(i)$$

$$V_A = (7+4)\frac{di_1}{dt} + L_3\frac{di_2}{dt} \quad ...(ii)$$

Comparing equation (i) and (ii),

We get, $M = -L_3 = +4$

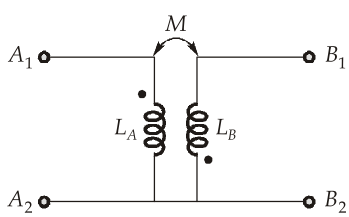


Fig. (a)

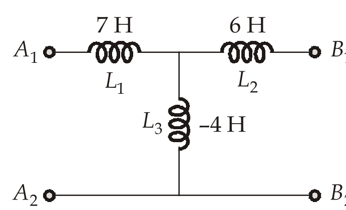


Fig. (b)

3. (a)

Since conductances in parallel add,

$$G_{eq} = G_1 + G_2 + G_3 + G_4 = 0.25S$$

and then, $R_{eq} = \dfrac{1}{G_{eq}} = 4\ \Omega$

From ohm's law the voltage across the current source is

$$V_{in}(t) = R_{eq}\, i_{in}(t) = \begin{cases} 20e^{-t}\text{V} & t \ge 0 \\ 0 & t < 0 \end{cases}$$

Using the current division formula

We have, $i_2(t) = \dfrac{G_2}{G_{eq}} i_{in}(t)$

$$= \frac{0.15}{0.25} i_{in}(t) = \begin{cases} 3e^{-t}\text{A} & t \ge 0 \\ 0 & t < 0 \end{cases}$$

To compute the power absorbed by R_2 for $t \ge 0$,

$$P_2(t) = V_{in}(t) \times i_2(t)$$

$$= [i_2(t)]^2 R_2 = 60e^{-2t}\ \text{W}$$

4. (b)

$$V_R = 31.6 \text{ V},$$
$$R = 5\ \Omega$$

$\therefore$ $$I_{\text{eff}} = \frac{31.6}{5} = 6.32 \text{ A}$$

$\therefore$ $$P = I_{\text{eff}}^2 R = (6.32)^2 \times 5 = 200 \text{ W}$$

$$Q = I_{\text{eff}}^2 X_L = (6.32)^2 \times 15 = 600 \text{ Var}$$

$\therefore$ $$S = (200 + j600) \text{ A}$$

5. (b)

Power delivered, $$P = Vi$$

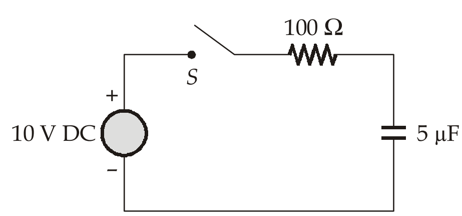
$$i = i_1 - ai_1 = i_1(1 - a)$$

$$= \frac{V}{R}(1-a)\text{Amp} \qquad \left[\because i_1 = \frac{V}{R}\right]$$

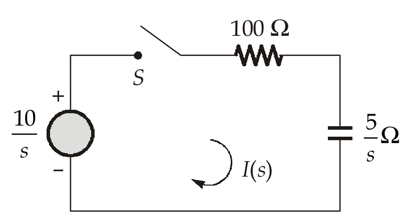
$$P = Vi = V\left(\frac{V}{R}(1-a)\right)$$

$$P = \frac{V^2}{R}(1-a)\text{Watts}$$

6. (d)



Converting time domain to ‘s’ domain the equivalent circuit as



Apply KVL in the loop,

$$\frac{-10}{s} + I(s)\left[100 + \frac{5}{s}\right] = 0$$

$$I(s) = \frac{10}{s\left(100 + \frac{5}{s}\right)}$$

$$I(t) = \frac{10}{100} e^{-t/\tau}$$

$$\tau = RC = 5 \times 10^{-3} \text{ sec}$$

$$I(t) = 0.1\, e^{-200t}$$

The maximum value of current occurs at $t = 0$, immediately after turning on the switch

$$I(t) = 0.1 \text{ A}$$

7. (c)

$$P = \sqrt{3} V_L I_L \cos\phi$$

$$I_L = \frac{20 \times 10^3}{\sqrt{3} \times 800 \times 0.8} = 18.04 \text{ A}$$

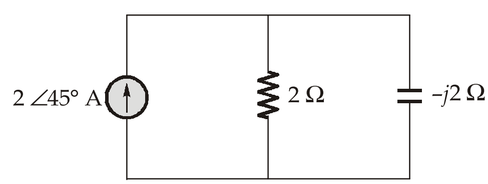
8. (a)

At half power frequency,

$$|z| = \sqrt{2}R$$

9. (c)

Switch S is opened at $t = 0$.



$$V_R = \frac{-j2}{2 - j2}(2\angle 45°) \times 2$$

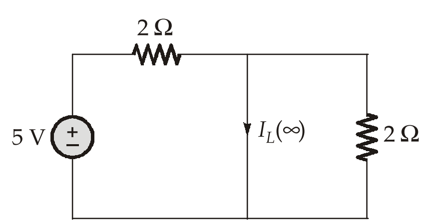
$$= \frac{2\angle -90°}{2\sqrt{2}\angle -45°}(2\angle 45°)\,(2)$$

$$V_R = 2\sqrt{2}\angle 0°$$

$\Rightarrow$ $$V_R = 2\sqrt{2}\cos(t) \text{ V}$$

10. (c)

At steady state, circuit becomes,



As $t \to \infty$ Source voltage is 5 V.

Inductor is short circuited.

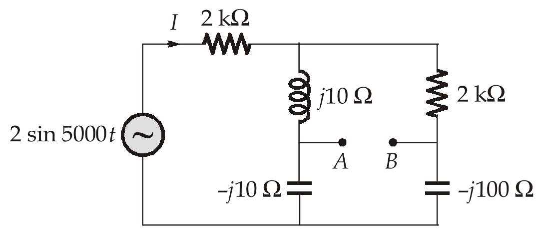
$$I_L(\infty) = \frac{5}{2} = 2.5 \text{ A}$$

Energy stored in inductor, $E = \frac{1}{2}LI_L^2(\infty) = \frac{1}{2}\times 1\times\frac{25}{4} = \frac{25}{8}$

$$= 3.125 \text{ J}$$

11. (a)

$$\omega = 5000 \text{ rad/sec}$$



In the parallel branch,

$$j10 - j10 = 0$$

As short circuit exist, therefore current I flows in the short circuit branch,

$$I = \frac{2\sin(5000t)}{2k + j10 - j10}$$

$$I = \sin(5000t) \text{ mA}$$

$$V_{AB} = V_A - V_B$$

$V_B = 0$ as current is zero.

$$V_A = I(-j10)$$

$$V_{AB} = V_A = \sin(5000t) \times 10^{-3}\ (10 \angle -90°)$$

$$V_{AB} = \frac{1}{100}\sin(5000t - 90°) = -0.01\cos(5000t) \text{ V}$$

12. (d)

RMS value of $p(t)$, $$P' = \sqrt{\frac{1}{T}\int_0^T p^2(t)\cdot dt}$$

$$T = 5 \text{ sec}$$

$$P' = \sqrt{\frac{1}{5}\left[\int_0^2 \left(\frac{t}{4}\right)^2 \cdot dt + \int_2^5 \left(\frac{1}{2}\right)^2 \cdot dt\right]}$$

$$P' = \sqrt{\frac{1}{5}\left[\frac{(t^3)_0^2}{16\times 3} + \frac{3}{4}\right]}$$

$$P' = \sqrt{\frac{1}{5}\left[\frac{3}{4}+\frac{8}{16\times 3}\right]}$$

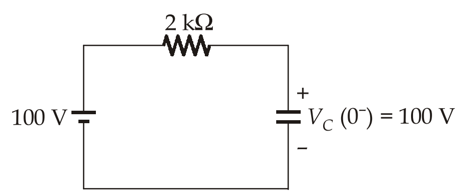
$$P' = \sqrt{\frac{1}{5}\left(\frac{3}{4}+\frac{1}{6}\right)}$$

$$P' = \sqrt{\frac{11}{60}}$$

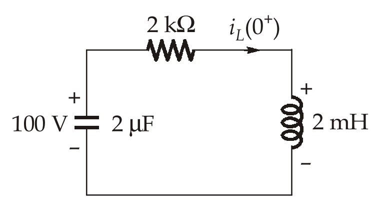
13. (c)

At $t = 0^-$,

Capacitor is charged to 100 V



At $t = 0^+$



$$V_c(0^+) = 100\text{ V}$$

$$i_L(0^+) = i_L(0^-) = 0\text{ A}$$

$$100 = \frac{L\,di_L(0^+)}{dt}$$

$$\frac{di_L(0^+)}{dt} = \frac{100}{L} = \frac{100}{2}\times 10^3$$

$$= 50 \times 10^3\text{ A/sec}$$

14. (a)

$$\phi = 2x^2 + y^2 + Bz^2$$

In source free region,

$$\nabla\cdot\vec{D} = 0$$

$$\varepsilon(\nabla\cdot\vec{E}) = 0$$

$$\vec{E} = -\nabla\phi$$

Now, $$\nabla V = \frac{\partial\phi}{\partial x}\hat{a}_x + \frac{\partial\phi}{\partial y}\hat{a}_y + \frac{\partial\phi}{\partial z}\hat{a}_z$$

$$-\vec{E} = 4x\,\hat{a}_x + 2y\,\hat{a}_y + 2Bz\,\hat{a}_z$$

$$\nabla \cdot \vec{E} = 0$$

$$\frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z} = 4 + 2 + 2B = 0$$

$$B = -3$$

15. (d)

Voltage distribution across capacitance is in the ratio 2 : 3 : 4 and applied voltage is 270 V

Then,

$$V_{C1} = 60 \text{ V}$$

$$V_{C2} = 90 \text{ V}$$

$$V_{C3} = 120 \text{ V}$$

Hence,

$$C_1 = \frac{6000}{60} = 100\ \mu\text{F}$$

$$C_2 = \frac{6000}{90} = \frac{200}{3}\ \mu\text{F}$$

$$C_3 = \frac{6000}{120} = 50\ \mu\text{F}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{100} + \frac{3}{200} + \frac{1}{50}$$

$$= \frac{2+3+4}{200} = \frac{9}{200}$$

$$C_{eq} = \frac{200}{9}\ \mu\text{F}$$

Alternate Solution:

We know that,

$$Q = C_{eq} \cdot V$$

$$C_{eq} = \frac{Q}{V} = \frac{600\ \mu\text{C}}{270\text{V}}$$

$$C_{eq} = \frac{200}{9}\ \mu\text{F}$$

16. (b)

$$L = \mu_0 \frac{N^2 A}{l}$$ Where, $A = \pi\rho^2 = \pi \times (2.5 \times 10^{-2})^2$

$$= \frac{4\pi \times 10^{-7} \times (500)^2 \times \pi \times (2.5 \times 10^{-2})^2}{0.5}$$

$$= 1.233 \text{ mH}$$

17. (c)

Capacitors store energy temporarily in AC circuits, but do not consume or retain energy over time.

18. (c)

Transfer function from Mason's gain formula,

From figure (I), eliminating first loop,

$$\frac{Y(s)}{U(s)} = \frac{\frac{10}{s(s+1)}}{1-\left(\frac{-20}{s+1}-\frac{10}{s(s+1)}\right)} = \frac{\frac{10}{s(s+1)}}{\frac{s(s+1)+20s+10}{s(s+1)}}$$

$$= \frac{10}{s^2+21s+10} \qquad \text{...(i)}$$

For the figure (II),

$$\frac{Y(s)}{U(s)} = \frac{\frac{10}{s(s+1)}}{1+\frac{10H(s)}{s(s+1)}} = \frac{10}{s^2+s+10H(s)} \qquad \text{...(ii)}$$

Comparing (i) and (ii),

$$s^2 + 10\,H(s) + s = s^2 + 21s + 10$$

$$H(s) = 2s + 1$$

19. (d)

- The frequency at which the phase angle is –180° is called the phase crossover frequency.
- The frequency at which $|G(j\omega)H(j\omega)| = 1$ is called the gain crossover frequency.
- For a system to be stable, both its gain margin and phase margin must be positive in most practical systems, a good GM ensures a good PM and vice versa. However, the cases of systems with a good GM but a poor PM and systems with a good PM but a poor GM also exist.

20. (c)

Characteristic equation is $s^2 + \frac{B}{J}s + \frac{K}{J}$

$$2\xi\,\omega_n = \frac{B}{J}$$

$$\xi\,\omega_n = \frac{B}{J\times 2}$$

$$t_s \text{ (2\% tolerance)} = \frac{4}{\frac{B}{J2}} = \frac{8}{\left(\frac{B}{J}\right)} \text{ is independent of gain '}K\text{'}$$

21. (c)

$$K_p = \lim_{s\to 0} G(s)H(s) = \frac{10}{s(s+1)(s+5)} \times \frac{1}{s} = \infty$$

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

$$K_a = \lim_{s\to 0} s^2 G(s)H(s) = 2$$

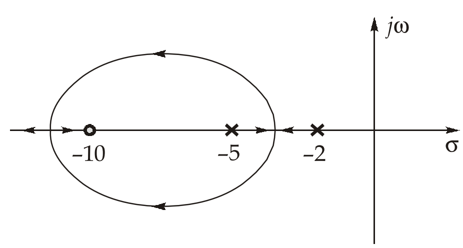
22. (a)

s^5	1	3	6
s^4	1	3	4
s^3	ξ	2	0
s^2	$\frac{3\xi - 2}{\xi} = -\text{ve}$	4	
s^1	$\frac{\left(\frac{3\xi-2}{\xi}\right)\times 2 - 4\xi}{\frac{3\xi-2}{\xi}} = +\text{ve}$		
s^0	4		

Number of sign changes = 2

∴ RHP = 2

23. (d)



Poles, s = –2, –5

Zeros, s = –10

∴ Breakaway point exist between –2 and –5

24. (a)

Given, $$G(s) = \frac{K}{s(s+4)(s^2+4s+20)}$$

Poles, s = 0, –4, –2 + j4, –2 – j4

Angle of departure,

$$[\phi_D] = 180° - \angle G(s)\big|_{s=-2+j4}$$

Now, $\angle G(s) = \angle \left.\dfrac{K}{s[s+4][s+2+j4][s+2-j4]}\right|_{s=-2+j4}$

$$= \angle K - \angle -2 + j4 - \angle 2 + j4 - \angle j8 - \angle 0$$

$$= 180° - \tan^{-1}\left(\frac{4}{2}\right) + \tan^{-1}\left(\frac{4}{2}\right) + 90°$$

$$= 270°$$

$$\phi_D\big|_{s=-2+j4} = 180° - \{270°\} = -90°$$

25. (b)

$$\text{OLTF is } G(s)H(s) = \frac{-1}{2s(1-20s)}$$

(or) $$G(j\omega)H(j\omega) = \frac{-1}{2j\omega(1-20j\omega)}$$

$$M = |G(j\omega)H(j\omega)| = \frac{1}{2\omega\sqrt{1+400\omega^2}}$$

$$\phi = 180° - 90° - \tan^{-1}\left(\frac{-20\omega}{1}\right)$$

$$= 90° + \tan^{-1}(20\,\omega)$$

At $\omega = 0$; $M = \infty$;

$\phi = 90°$

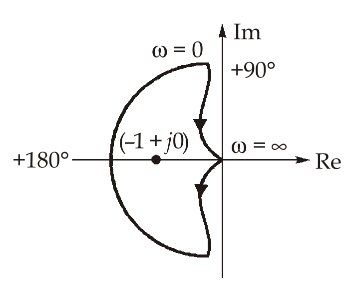
At $\omega = 0.1$; $M = 2.24$;

$\phi = 153.43°$

At $\omega = \infty$; $M = 0$;

$\phi = 180°$

We get the Nyquist plot as,



26. (b)

$$\frac{K\left(1+\frac{s}{2}\right)}{s\left(1+\frac{s}{50}\right)}$$

$$20\log\left(\frac{K}{\omega}\right)\Bigg|_{\omega=2} = 14$$

$$K = 10.02 \approx 10$$

$$\text{T.F.} = \frac{10\left(1+\frac{s}{2}\right)}{s\left(1+\frac{s}{50}\right)} = \frac{10(1+0.5s)}{s(1+0.02s)}$$

27. (c)

Stability cannot be determined by just looking at magnitude or phase response. Both are required to determine stability.

Magnitude response of S_1 and S_2 are same

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

∴ Phase response is also required to determine the relative stability.

28. (a)

On adding a pole at origin,

$$P - Z = 3 - 1 = 2$$

Angle of asymptotes = 90°, 270°

Also, centroid will come negative.

29. (b)

The loss tangent is given by,

$$\tan\delta = \frac{\varepsilon_r''}{\varepsilon_r'} = \frac{1.5}{2.25} = 0.66$$

30. (b)

Here, $\chi_m = 3.7 \times 10^{-3}$

and $H = 10^4$ A/m

So $M = \chi_m H = 3.7 \times 10^{-3} \times 10^4$

$= 37$ A/m

31. (a)

In magnetic materials Alnico having maximum energy product used for making permanent magnet.

32. (d)

Magnetization, $M = \chi_m H$

where $\chi_m \rightarrow$ magnetic susceptibility

$H \rightarrow$ magnetic field intensity

So, in terms of magnitude, $M \propto H$

According to Curie law,

$$\chi_m = \frac{C}{T}$$

$$\Rightarrow \quad \chi_m \propto \frac{1}{T}$$

So, for constant H, $M \propto \dfrac{1}{T}$

33. (c)

The hall coefficient is measured using the Hall effect, which occurs when a magnetic field is applied perpendicular to the direction of current in a conductor or semiconductor. The hall voltage developed across the material gives information.

- The sign of the charge carries (positive for holes, negative for electrons)
- The type of semiconductor (n-type or p-type).

This makes the Hall coefficient a key parameter for identifying, whether the majority charge carries are positive or negative.

37. (c)

- High dielectric strength ensures good insulation properties.
- Low dielectric loss indicates efficient performance with minimal energy wastage.

39. (a)

$$\cos\phi = 0.6 \text{ leading}$$

$$\Rightarrow \quad \phi = 53.13° \text{ or } 53.13° \text{ leading}$$

$$\Rightarrow \quad \sin\phi = 0.8$$

$$X_{\text{p.u.}} = 0.05 \text{ p.u.}$$

$$\%V_{\text{reg}} = [R_{\text{p.u.}} \cos\phi - X_{\text{p.u.}} \sin\phi] \times 100$$

$$-3.4\% = [R_{\text{p.u.}} \times 0.6 + 0.05 \times (0.8)] \times 100$$

$$R_{\text{p.u.}} = 0.01 \text{ p.u.}$$

Full load ohmic loss,

$$P_{cu\,(fl)} = R_{\text{p.u.}} = 0.01 \text{ p.u.}$$

% load at maximum efficiency,

$$x\% = \sqrt{\frac{P_i}{P_{cu(fl)}}} \times 100 = \sqrt{\frac{0.0036}{0.01}} \times 100$$

$$x\% = 60\%$$

40. (b)

Torque, $$T = \frac{60}{2\pi N}\times E_b I_a = \frac{60}{2\pi N}\times[V_t - I_a(R_a + R_{se})]I_a$$

$$\Rightarrow \quad \frac{120}{\pi} = \frac{60}{2\pi\times 625}[250 - I_a(0.25+0.25)]I_a$$

$$0.5I_a^2 - 250I_a + 2500 = 0$$

$$\Rightarrow \quad I_a^2 - 500I_a + 5000 = 0$$

$$I_a = \frac{-(-500)\pm\sqrt{(-500)^2 - 4\times 1\times 5000}}{2\times 1}$$

$$= \frac{500\pm\sqrt{230000}}{2} = 250\pm 50\sqrt{23} = 489.8 \text{ A and } 10.2 \text{ A}$$

$$\Rightarrow \quad I_a = 10.2 \text{ A} \qquad (\because 489.8 \text{ A will exceed the machine rating})$$

41. (a)

f = 60 Hz,
P = 6
P_i = 18.65 kW
%η = 80%
slip, s = 3% = 0.03

Speed of the motor, $$\omega_m = (1-s)\times\frac{2f}{P}\times 2\pi$$

$$= (1-0.03)\times\frac{4\pi\times 60}{6} = 121.9 \text{ rad/sec}$$

Output power, $P_0 = P_i \times \eta = 18.65 \times 0.8$ kW = 14.92 kW

Per phase shaft torque, $$T = \frac{(P_0/3)}{\omega_m} = \frac{(14.92\times 10^3/3)}{121.9} = 40.8 \text{ N-m}$$

42. (a)

Synchronous speed of motor,

$$N_s = \frac{120 f_1}{P_1} = \frac{120\times 60}{4} = 1800 \text{ rpm}$$

For alternator, $$N_s = \frac{120 f_2}{P_2} = 1800 \text{ rpm}$$

$$\Rightarrow \quad \frac{120\times f_2}{24} = 1800$$

$$\Rightarrow \quad f_2 = 360 \text{ Hz}$$

43. (b)

- **From O.C. test :** (On LV side)

$$\cos\phi_0 = \frac{P_0}{V_0 I_0} = \frac{50}{220\times 2} = 0.114 \text{ lagging}$$

- **From S.C. test :** (On HV side at rated current of 4.55 A)

$$R_e = \frac{P_{sc}}{I_{sc}^2} = \frac{150}{(4.55)^2} = 7.25\ \Omega$$

$$Z_e = \frac{V_{sc}}{I_{sc}} = \frac{100}{4.55} = 21.98\ \Omega$$

$$X_e = \sqrt{Z_e^2 - R_e^2} = \sqrt{21.98^2 - 7.25^2} = 20.75\ \Omega$$

$$Z_{Base(Hv)} = \frac{2200^2}{10\times 10^3} = 484\ \Omega$$

$$\therefore \quad R_{p.u.} = \frac{R_e}{Z_{Base(Hv)}} = \frac{20.75}{484} = 0.043 \text{ p.u.}$$

And voltage regulation is

$$\% V_{reg} = x(R_{p.u.}\cos\phi + X_{p.u.}\sin\phi)\times 100$$

When x = % of full load

ϕ = load p.f. angle

Since load p.f. is not known hence % V_{reg} cannot be determined.

44. (c)

2-point starter is used for starting DC series motor because 2-point starter circuit provides protection against high starting torque due to low armature resistance and also provides protection for the no-load condition.

45. (c)

The friction and windage loss can be reduced as under:

- Design the rotor fans with improved aerodynamics to minimize the windage loss.
- Use good-quality bearings to reduce the friction loss.

46. (c)

Comparison between core and shell type transformers:

- In core type, the windings are wound around two legs of the magnetic core. In shell type the windings are wound around central limb of a three-legged magnetic core.
- For given rating, core-type transformer requires less iron but more conductor material as compared to shell-type transformer.
- Core-type transformer has two-legged core whereas shell-type has three-legged core.
- Core-type construction is used for high-voltage, high-current transformers where as shell type transformers are preferred for low-voltage, low-power level transformers.
- Core-type transformer uses concentric coils whereas shell-type transformer uses sandwiched coils.

47. (a)

The number of turns and cross-section of field winding depands upon the type of D.C. machine as under:

- For DC shunt machine, large number of turns of small cross-section are used.
- For DC series machine, small number of turns of large cross-section are used.
- For DC compound machine, both shunt (thin wire) and series (thick wire) field windings are used.

48. (b)

The relative advantages of cage motor over a wound-rotor motor of the same power rating, are given below:

- A cage rotor requires considerably less conductor materials than a wound rotor. Consequently I^2R loss in cage rotor is less. Therefore, cage motor is a little more efficient than a wound-rotor motor.
- Wound-motor construction requires slip rings, brushes short-circulating devices etc. As a result of it, a wound-rotor motor is costlier than a cage induction motor.

49. (d)

Reactive power supplied by the generator can be reduced by decreasing the generator field current.

50. (b)

$$\text{1 revolution} = 360°$$

$$\text{No. of steps in 1 revolution} = \frac{360}{2.5} = 144 \text{ steps}$$

$$\text{No. of steps in 25 revolution} = 25 \times 144 = 3600 \text{ steps}$$

51. (d)

$$r_a = r_2 \cdot \frac{z}{a^2}$$

$$a = P \text{ [for lap wound]}$$

$$a = 2 \text{ [for wave wound]}$$

$$\frac{r_{a(\text{lap})}}{r_a(\text{wave})} = \frac{a_{\text{wave}}^2}{a_{\text{lap}}^2} = \left(\frac{2}{6}\right)^2 = \frac{4}{36} = \frac{1}{9}$$

$$r_{a(\text{wave})} = 0.04 \times 9 = 0.36\ \Omega$$

52. (b)

$$\vec{I}_0 = 2\angle{-78.46°} \text{ A},$$

$$\vec{I}_2' = I_2 \times \frac{100}{200} = 7.5\angle{-36.86°}$$

$$I_1 = \sqrt{I_2'^2 + I_0^2 + 2I_2' \cdot I_0 \cos(78.46° - 36.86°)}$$

$$= \sqrt{7.5^2 + 2^2 + 2\times 7.5\times 2\cos(41.60°)}$$

$$I_1 = 9.1 \text{ A}$$

53. (c)

$$\text{Basic RAM} = 32\text{ K} \times 1$$

$$\text{Design RAM} = 256\text{ K} \times 8$$

$$\text{No. of RAM} = \frac{256\text{K}\times 8}{32\text{K}\times 1} = \frac{2^{18}\times 2^3}{2^{15}\times 2^0} = 64$$

It require 8 parallel line and in each parallel line 8 serial RAM chip are required.

54. (c)

5 bits	5 bits

5 bits to identify first and 5 bits to identify second including the case when one of them not present. So total bits required = 10

55. (b)

Since there is an arrow from running to ready, so it is pre-emptive.

56. (c)

RR Queue:

P1 P2 P1 P3 P2 P1 P3 P2

0 1 2 3 4 6 8 10

P1	P2	P1	P3	P2	P1	P3	P2

0 2 4 6 8 10 11 13 16

⇒ P1, P3, P2

FCFS: P1, P2, P3

Therefore option (c) is correct.

FCFS : P1, P2, P3

RR2 : P1, P3, P2

57. (c)

In virtual memory system, Address Space specified by the address lines of CPU must be larger than the physical memory size and smaller than the secondary storage size.

58. (d)

Virtual memory allows the user can run the programs larger than the physical memory size.

59. (c)

$$\text{Number of entries in page table} = \frac{2^{32}}{2^{12}} = 2^{20}$$

$$\text{Frame size} = \frac{2^{26}}{2^{12}} = 2^{14}$$

∴ PT have to be stored in one frame so entry size must be 2 bytes, hence size of PT

$$= 2^{20} \times 2 = 2^{21} = 2 \text{ MB}$$

60. (b)

Effective access time = [(1 – p)* access time when no page fault +p* access time during page fault]

$$= \left[1-\left(\frac{1}{10^6}\right)\right] * 20\,\text{ns} + \left(\frac{1}{10^6}\right) * 10\,\text{ms}$$

$$= \left(\frac{10^6 - 1}{10^6}\right) * 20\,\text{ns} + \left(\frac{1}{10^6}\right) * 10 * 10^6\,\text{ns} \approx 30 \text{ ns}$$

61. (d)

None of the condition which is given guaranteed to deadlock. So none of these is correct.

62. (a)

$$(35)_6 + (63)_8 + (87)_{10} + (x)_5 = 194$$

$$(23)_{10} + (51)_{10} + (87)_{10} + (x)_5 = 194$$

$$x = 194 - 161$$

$$= 33$$

$$(x)_{10} = (113)_5$$

63. (b)

Since current concentrates at the surface, the effective cross-sectional area decreases, leading to increased resistance.

64. (b)

Corona discharge produces ozone and oxides of nitrogen, which can deteriorate the cable insulation and reduce its life span.

65. (b)

One drawback of toughened glass insulators is that moisture easily forms.

66. (b)

In practice surge impedance load (SIL) is always less than the rated capacity of a line. If the load is less than SIL, reactive voltamperes are generated and the receiving-end voltage will be greater than the sending-end voltage on the other hand. If the load is greater than SIL, reactive voltamperes are absorbed by the line. In this case the receiving-end voltage is less than the sending-end voltage. The compensation requirement and power loss increase when the load on the system is greater than the natural load. If the resistance and shunt conductance are neglected and the load is equal to the natural load the receiving-end voltage will be equal to the sending-end voltage.

67. (a)

$$C_{RY} = 0.7\ \mu\text{F/km}$$
$$l = 10\ \text{km}$$
$$V_L = 11\ \text{kV}$$
$$f = 50\ \text{Hz}$$

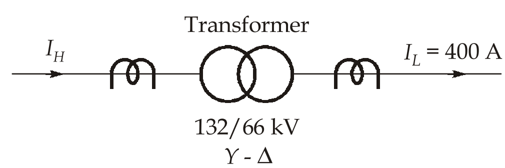
Per phase capacitance over 10 km line,

$$C_{ph} = 2C_{Ry} \times l$$
$$= 2 \times 0.7\ \mu\text{F} \times 10$$
$$= 14\ \mu\text{F}$$

$$\text{Line charging current} = \frac{V_{ph}}{X_C} = V_{ph}\ \omega C_{ph}$$

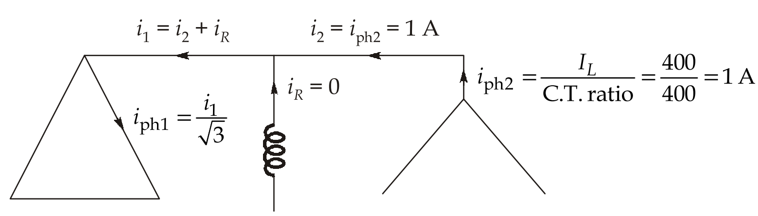
$$= 100\pi\left(\frac{11}{\sqrt{3}}\times 10^3\right)\times 14\times 10^{-6} = 27.9\ \text{A}$$

68. (c)



$$I_H = \frac{400}{\left(\frac{132}{66}\right)} = 200\ \text{A} \rightarrow \text{C.T. primary current}$$

C.T. connection will be Δ - Y



where i_1 and i_2 are the pilot wire currents and $i_{ph\,1}$ and $i_{ph\,2}$ are the CTs phase current

$$i_1 = 1 + 0 = 1\ \text{A}$$

$$\therefore \quad i_{ph\,1} = \frac{1}{\sqrt{3}}\text{A}$$

$$\Rightarrow \quad \text{C.T. ratio of H.V. side} = \frac{I_H}{C_{ph1}} = \frac{200}{\frac{1}{\sqrt{3}}} = \frac{200\sqrt{3}}{1}$$

69. (d)

All the statements are correct.

70. (c)

Given, $H = 5\text{ MJ/MVA}$; $\delta_0 = 30°$

$P_{max} = 2\text{ p.u.}$; $f = 50\text{ Hz}$

$$\omega_n = \sqrt{\frac{2\pi f \times S_{p0}}{2H}} \quad \text{...(i)}$$

where, S_{p0} = Synchronising power coefficient at initial rotor angle

$= P_{max} \cos \delta_0 = 2 \cos 30°$

$$= 2 \times \frac{\sqrt{3}}{2} = 1.73\text{ p.u.}$$

$$\therefore \quad \omega_n = \sqrt{\frac{2\pi \times 50 \times 1.73}{2 \times 5}} \quad \text{(From (i)]}$$

$$= \sqrt{\frac{173\pi}{10}} = \sqrt{54.35}$$

$\Rightarrow$ $\omega_n = 7.37\text{ rad/sec}$

71. (c)

Utilization factor is more for the base load power plant.

72. (d)

Given, $R = 3\ \Omega$, $X = 4\ \Omega$

$\cos \phi_R = 0.8$ leading

$\Rightarrow$ $\phi_R = -36.87°$

$\sin \phi_R = -0.6$

$V_R = 100\text{ kV}$ and $P_R = 50\text{ MW}$

Receiving end current, $$I_R = \frac{P_R}{V_R \cos\phi_R} = \frac{50 \times 10^3}{100 \times 0.8} = 625\text{ A}$$

$\therefore$ Line drop as a percentage of load/receiving end voltage

= % voltage regulation

$$= \frac{I_R(R\cos\phi_R + \sin\phi_R)}{V_R} \times 100$$

$$= \frac{625(3 \times 0.8 - 4 \times 0.6)}{100 \times 10^3} \times 100 = 0\%$$

Alternate method:

Without calculating I_R ,

$R \cos \phi_R + X \sin \phi_R = 3 \times 0.8 + 4 \times (-0.6)$

$= 0$

$\therefore$ $\%\ V_{reg} = 0\%$

73. (b)

$$X_{L\,sh} = 1750\ \Omega$$

$$B = |\beta|\angle\beta = 70\angle 80°\,\Omega$$

We know that,

$$X_{Lsh} = \frac{|B|}{1-|A|}$$

$$1750 = \frac{70}{1-|A|}$$

$\Rightarrow$

$$|A| = 0.96$$

74. (d)

$$K_{Cse} = 60\%\ \text{or}\ 0.6$$

$$K_{c\,sh} = 60\%\ \text{or}\ 0.6$$

SIL of compensated line,

$$(\text{SIL})_C = (\text{SIL})\sqrt{\frac{(1+K_{csh})}{(1-K_{cse})}}$$

$$= (\text{SIL})\sqrt{\frac{(1+0.6)}{(1-0.6)}} = (\text{SIL})\sqrt{\frac{1.6}{0.4}} = (\text{SIL}) \times 2$$

$\therefore$ % increase in SIL,

$$\frac{(SIL)_c-(SIL)}{(SIL)}\times 100 = \frac{2-1}{1}\times 100 = 100\%$$

75. (b)

Given,

$$P_{\max 1} = 1.5\ \text{p.u.}$$

$$V_S = 1.05\ \text{p.u.}$$

$$V_R = 1.0\ \text{p.u.}$$

$$P_{\max 2} = 1.95\ \text{p.u.}$$

$$P_{\max 1} = \frac{V_S V_R}{X_L}$$

$$1.5 = \frac{1.05\times 1.0}{X_L}$$

$$X_L = 0.7\ \text{p.u.}$$

For mid-point compensation

$$P_{\max 2} = \frac{V_S V_m}{\left(\frac{X_L}{2}\right)}$$

$$1.95 = \frac{1.05 \times V_m}{\left(\frac{0.7}{2}\right)}$$

$$V_m = 0.65 \text{ p.u.}$$

76. (d)

For a 3-ϕ fully transposed transmission line,

$$C_{ph} = \frac{2\pi\varepsilon_0\varepsilon_r}{\ln\left[\frac{(D_1D_2D_3)^{1/3}}{r}\right]} \text{F/m}$$

$$= \frac{2\pi\varepsilon_0}{\ln\left[\frac{er}{r}\right]} \text{F/m} \qquad [\because \varepsilon_r = 1 \text{ for air}]$$

$$= 2\pi\varepsilon_0$$

77. (a)

$$6 - 0.7 = (\beta + 1)\, I_B \times 530$$

$$5.3 = (\beta + 1) \times 0.53 \times 0.5$$

$$\beta = 19$$

$$V_{CE} = 10 - I_C \times 200 - 530 \times I_E$$

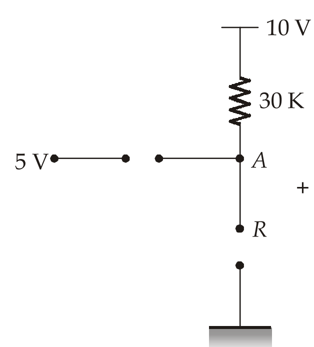
$$= 10 - \beta I_B \times 200 - (\beta + 1) \times 530 I_B$$

$$= 10 - 19 \times 0.5 \times 200 \times 10^{-3} - 20 \times 530 \times 0.5 \times 10^{-3}$$

$$= 2.8 \text{ V}$$

78. (a)

Case I : All diodes are off

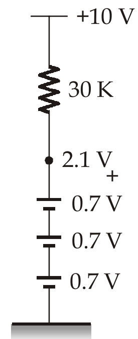


Voltage node (A), $V_A = 10$ V

Voltage node (R), $V_R = 0$ V

∴ $V_{AK} = 10$ V, D_1, D_2 and D_3 are ON first.

Case II: D_1, D_2 and D_3 are ON, the actual circuit becomes



From the circuit it can be observed the D_4 and D_5 are OFF

$$V_0 = 2.1 \text{ V}$$

79. (b)

Thermal runway is not possible in FET because as temperature of FET increass, mobility decreases.

80. (c)

Assume active region of operation

Applying KVL

$$\frac{0.7-5}{20 \text{ k}\Omega} + \frac{0.7+10}{100 \text{ k}\Omega} + I_B = 0$$

$$I_B = 0.108 \text{ mA}$$

$$I_C = \beta I_B = 3.24 \text{ mA}$$

$$V_C = 12 - (2 \text{ k}\Omega)\, I_C$$

$$= 12 - (2)\,(3.24)$$

$$V_C = 5.52 \text{ V and } V_B = 0.7 \text{ V}$$

$$V_C > V_B \quad \Rightarrow \quad \text{Region of operation is active}$$

81. (c)

For common collector, voltage gain (A_V) = 1. So, it can be also called as buffer amplifier.

82. (*)

$$\text{Drain current, } I_D = I_{DSS}\left[1-\frac{V_{GS}}{V_P}\right]^2 = 10\left[1-\frac{3}{6}\right]^2 = 2.5 \text{ mA}$$

83. (a)

It is a fixed bias circuit

$$(V_{GS})_Q = -V_{GS} = -2 \text{ V}$$

$$V_G = V_{GS} + V_S$$

$$V_G = V_G = -2 \text{ V} \qquad \text{(Where } V_S = 0\text{)}$$

84. (a)

$$V_0 = \frac{-5\text{k}\Omega}{1\text{k}\Omega} \times 4\text{V} + \left[1 + \frac{5\text{k}\Omega}{1\text{k}\Omega}\right] \times 6\text{V} \times \frac{8\text{k}\Omega}{8\text{k}\Omega + 1\text{k}\Omega}$$

$$= -20 + 32 = 12 \text{ V}$$

85. (d)

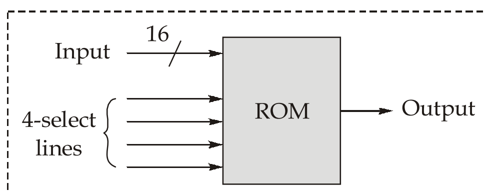
$$V_0 = 4 \times \frac{60}{20} = 12 \text{ V}$$

86. (a)

This is a clipper circuit when diode is in upward direction its clips below the reference voltage.

88. (b)

16 : 1 MUX has 16 inputs, 4 select lines and one output



ROM as 16 : 1 MUX

We know, size of ROM = 2^{x+y}

where, 'x' is the number of inputs to ROM 'y' is the number of outputs

$\therefore$ Size of ROM = $2^{(16+4)} \times 1 = 2^{20} \times 1$

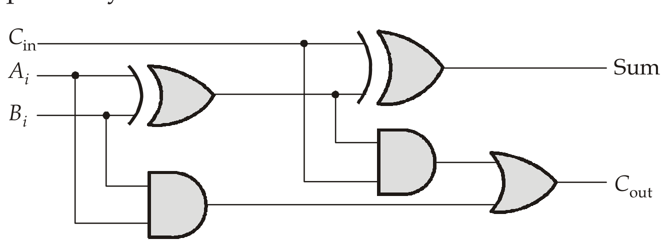
= 1 Mbits

89. (c)

Required number of 2 to 4 decoders = $\left\lceil \frac{512}{4} \right\rceil + \left\lceil \frac{128}{4} \right\rceil + \left\lceil \frac{32}{4} \right\rceil + \left\lceil \frac{8}{4} \right\rceil$ = 128 + 32 + 8 + 2 = 170

90. (b)

In a full adder circuit, as shown in the following figure, the input carry has to propagate through 2 gates to produce output carry.



An n-bit ripple carry adder consists n-full adders. So, the carry has to propagate through $2n$ gates.

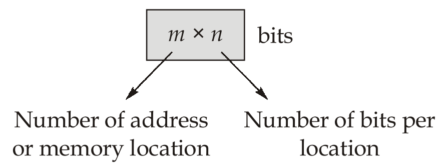
In the given question, for a 6-bit binary ripple carry adder, input carry has to propagate through 12 gates.

91. (b)

PCHL is also known as 1-B unconditional JUMP.

92. (d)

Representation of a memory chip is



Given, 4096 × 256 bits

$$\begin{aligned} \text{No. of bits per location} &= 256 \\ \text{i.e., Data buses/lines} &= 256 \\ \text{Memory capacity} &= 4096 \times 256 \\ &= 2^{12} \times 2^{8} \\ &= 2^{12} \times 2^{5} \times 2^{3} \\ &= 2^{17} \times 8 \text{ bits} \\ &= 2^{17} \text{ B} = 2^{7} \times 2^{10} \text{ B} \\ &= 128 \text{ kB} \end{aligned}$$

93. (b)

- There are 8 software interrupts in 8085 microprocessor i.e., RST0, RST1, RST3, RST4, RST5, RST6 and RST7.
- RST 4.5, also known as TRAP, is a non-maskable interrupt.

95. (c)

From FM signal,

$$f_i = f_c + k_f m(t)$$

$$\theta_i = 2\pi f_c t + 2\pi k_f \int_{-\infty}^{t} m(t)\,dt$$

Maximum phase deviation,

$$\Delta\phi_{max} = \left| 2\pi k_f \int_{-\infty}^{t} m(t)\,dt \right|_{max}$$

$$\left| \int_{-\infty}^{t} m(t)\,dt \right|_{max} = \text{Area under } m(t)$$

$$= 5 \times 10^{-3} \times 2 \text{ V-sec} = 10 \times 10^{-3} \text{ V-sec}$$

So, $$\Delta\phi_{max} = 2\pi \times 2.5 \times 10^{3} \times 10 \times 10^{-3} \text{ rad}$$

$$= 50\pi \text{ rad}$$

97. (c)

Given that, $\mu = 0.8$

$A_c = 5$ V

Maximum value of the envelope of the AM signal,

$$E_{max} = A_c(1 + \mu) = 5 \times 1.8 = 9 \text{ V}$$

Minimum value of the envelope of the AM signal,

$$E_{min} = A_c(1 - \mu) = 5 \times 0.2 = 1 \text{ V}$$

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

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

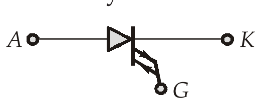
So, $$\Delta f_{max} = \frac{k_p}{2\pi}\left|\frac{dx(t)}{dt}\right|_{max} = 2\left[\frac{k_p}{2\pi}\left|\frac{dm(t)}{dt}\right|_{max}\right] = 20 \text{ kHz}$$

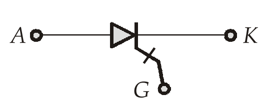
101. (c)

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.

102. (c)

Gate Turn-off thyristor

Symbol 

or 

103. (b)

Given,

$$R = 5\ \Omega,$$
$$E = 140\ \text{V}$$
$$V_{sr} = 230\ \text{V}$$
$$\Rightarrow \quad V_m = 230\sqrt{2}\ \text{A}$$

Amplitude of fundament component source current is

$$\hat{I}_{s1} = \frac{80}{\pi}\text{A}$$
$$\Rightarrow \quad \frac{4I_0}{\pi} = \frac{80}{\pi}$$

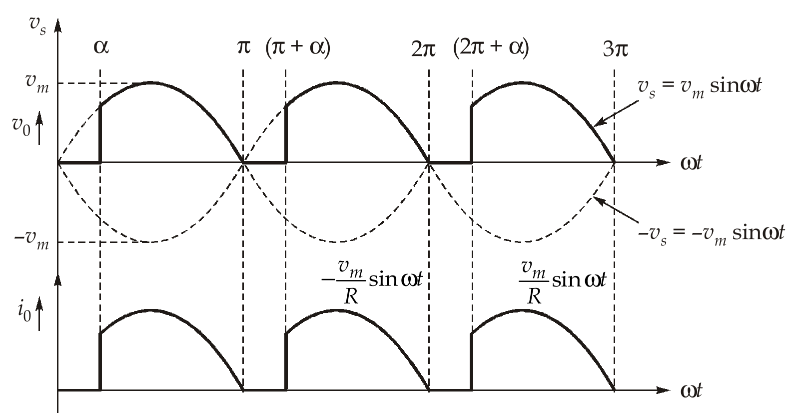
$\Rightarrow$ Average load current, $I_0 = \frac{80}{\pi} \times \frac{\pi}{4} = 20\ \text{A}$

Rms load current, $I_{0r} = I_0 = 20\ \text{A}$ ($\because$ load current is ripple free and continuous)

Average output power, $P_0 = I_{0r}^2 R + I_0 E$

$$= 20^2 \times 5 + 20 \times 140$$
$$= 4800\ \text{W}$$

104. (a)



- The load current is non-zero for duration (π – α).
- At $\omega t = \alpha$

$$i_0 = \frac{v_m}{R}\sin\alpha$$

At $\omega t = \pi + \alpha$

$$i_0 = \frac{-v_m}{R}\sin(\pi + \alpha) = \frac{v_m}{R}\sin\alpha$$

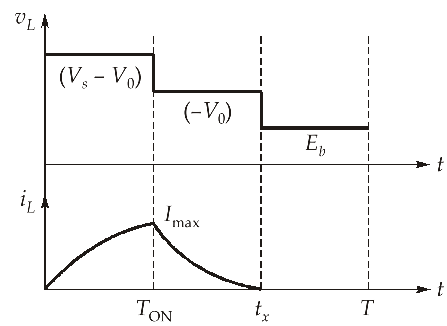
At $\omega t = 2\pi + \alpha$

$$i_0 = \frac{v_m}{R}\sin(2\pi + \alpha) = \frac{v_m}{R}\sin\alpha$$

- Load current remains zero for 'α' duration.

105. (a)

Inductor voltage and current waveforms are



Average inductor voltage,

$$(v_L)_{avg} = 0$$

$$\Rightarrow \quad \frac{(V_s - V_0)T_{ON} + (-V_0)(t_x - T_{ON}) + E_b(T - t_x)}{T} = 0$$

$$\Rightarrow \quad (V_S - V_0)\frac{T_{ON}}{T} + V_0\left(\frac{T_{ON}}{T} - \frac{t_x}{T}\right) + E_b\left(1 - \frac{t_x}{T}\right) = 0$$

$$\Rightarrow \quad (V_S - V_0)\alpha + V_0\left(\alpha - \frac{t_x}{T}\right) + E_b\left(1 - \frac{t_x}{T}\right) = 0$$

$$\Rightarrow \quad \alpha V_s + V_0\left(\frac{t_x}{T}\right) + E_b\left(1 - \frac{t_x}{T}\right) = 0$$

$$\Rightarrow \quad V_0 = \left[\alpha V_s + \left(1 - \frac{t_x}{T}\right)E_b\right] \times \frac{T}{t_x}$$

106. (c)

- In Buck converter, ripple in output voltage is

$$\Delta V_0 = \Delta V_c = \frac{\alpha(1-\alpha)V_s}{8f^2LC}$$

- During continuous conduction mode

$$V_{01} = \alpha V_s$$

- During discontinuous conduction mode

$$V_{02} = \frac{\alpha}{\beta}V_s = \frac{V_{01}}{\beta}$$

$$V_{02} = V_{01} \qquad (\because \beta < 1)$$

107. (b)

On state voltage drop and the associated loss is more in a GTO.

109. (a)

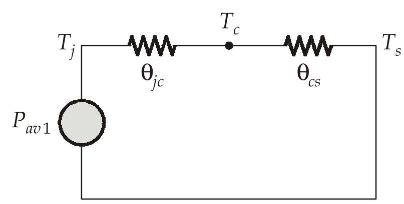
Let I and I_{sb} be the one-cycle and sub-cycle surge current ratings of the SCR respectively

$$I^2T = I_{sb}^2 \cdot t$$

$$I^2 \times \frac{1}{100} = (2000)^2 \times \frac{1}{200}$$

$$I = \frac{2000}{\sqrt{2}} = 1414.21 \text{ A}$$

110. (b)



$$T_j = T_s + P_{av1}(\theta_{jc} + \theta_{cs})$$

∴ Average power loss,

$$P_{avg1} = \frac{T_j - T_s}{\theta_{jc} + \theta_{cs}} = \frac{120 - 80}{0.16 + 0.08}$$

$$= \frac{40}{0.24} = 166.66 \text{ W}$$

111. (d)

Use of freewheeling diode:

- Reduces reactive power demand of the converter.
- Improves the displacement factor or fundamental.
- Improves the current distortion factor.
- Improves input power factor.
- Reduces THD.

112. (c)

Average load current,
$$I_0 = \left(\frac{I_1 + I_2}{2}\right) = \frac{12 + 16}{2} = 14 \text{ A}$$

Average load voltage,
$$V_0 = I_0 R = 14 \times 10 = 140 \text{ V}$$

∴ Duty cycle,
$$\alpha = \frac{T_{on}}{T_{on} + T_{off}} = \frac{V_0}{V_s} = \frac{140}{200} = 0.7$$

$$1 + \frac{T_{off}}{T_{on}} = \frac{1}{0.7}$$

$$\frac{T_{on}}{T_{off}} = \frac{0.7}{0.3} = 2.33$$

113. (a)

Given, N_1 = 1, N_2 = 500 and I_s = 5 A, Load R_2 = 1 Ω

Magnetizing ampere turns = 200 AT

$$I_0 = \frac{200}{1} = 200 \text{ A}$$

$$\text{Transformation ratio, } n = \frac{N_2}{N_1} = 500$$

The phase angle between primary and secondary current is

$$\theta = \frac{180}{\pi}\left(\frac{I_0 \cos(\alpha+\delta)}{nI_s}\right) \qquad (\because \alpha = 0, \delta = 0)$$

$$= \frac{180}{\pi}\left(\frac{200\cos(0)}{500\times 5}\right) \approx 4.6°$$

114. (b)

PMMC = Average value measuring instrument

$$= 10\times\frac{4}{16} = 2.5 \text{ V}$$

M.I = RMS value measuring instrument.

$$= 10\times\sqrt{\frac{4}{16}} = 5 \text{ V}$$

115. (c)

θ_1 = 90°; I_1 = 1 A; θ_2 = 45°; I_2 = ?

The response of the meter is square law

$$\theta \propto I^2$$

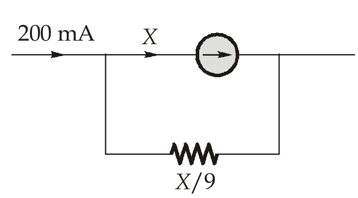
$$\frac{I_2}{I_1} = \left[\frac{45}{90}\right]^2$$

$$I_2 = 0.707 \text{ A}$$

116. (a)

Given, m = 10

I_{total} = 200 m



Let assume meter resistance = $X\Omega$

$$R_{sh} = \frac{X}{m-1} = \frac{X}{9}\ \Omega$$

$$\frac{V}{X} + \frac{V}{X/9} = 200$$

$$\frac{V}{X}[1+9] = 200$$

$$I_{\text{meter}} = \frac{V}{X} = \frac{200}{10} = 20 \text{ mA}$$

Alternate Solution:

$$\frac{I}{I_M} = M$$

$$\Rightarrow \quad I_M = \frac{I}{M} = \frac{200}{10} = 20 \text{ mA}$$

117. (d)

Reactive power $Q = \sqrt{3}\, V_{ph} I_{ph} \sin\phi$

Given, $0 = \sqrt{3}\, V_{ph} I_{ph} \sin\phi$

$\sin\phi = 0$

Power factor $\cos\phi = 1$

118. (d)

If we make $C = L/r^2$ then the error caused by pressure coil inductance is almost completely eliminated.

119. (b)

A phase sequence inductor is a device used to determine the order of the three phase (R, Y, B). If the original phase sequence is RYB and the indicator rotates clockwise then changing the phase sequence will cause the indicator to rotate anticlockwise.

120. (b)

The standardization of a.c. potentiometers is typically done by using d.c. standard sources and transfer instruments since potentiometers work on the principle of comparing voltages, d.c. sources and transfer instruments are used for accurate calibration and standardization.

121. (d)

Wien's bridge is used to measure the frequency of an oscillator of signal. It works by balancing the impedances in the bridge and it is often used in the measurement of unknown frequencies. Especially in audio and radio frequency applications. The other bridges mentioned are used for different purposes, such as measuring resistance, capacitance or inductances.

122. (a)

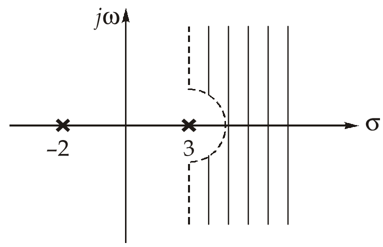
In a cathode ray tube, the focusing anode is typically located between the pre-accelerating anode and the accelerating anode to focus the electron beam properly.

123. (c)

Given, $$H(s) = \frac{s}{s^2 - s - 6} = \frac{s}{(s-3)(s+2)}$$

$$= \frac{3/5}{(s-3)} + \frac{2/5}{(s+2)}$$

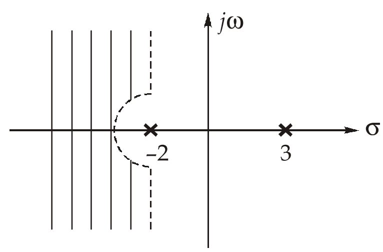
Causal:



$\sigma > 3$

$\Rightarrow$ $$h(t) = \frac{3}{5}e^{3t}u(t) + \frac{2}{5}e^{-2t}u(t)$$

Anticausal:



$\sigma < -2$

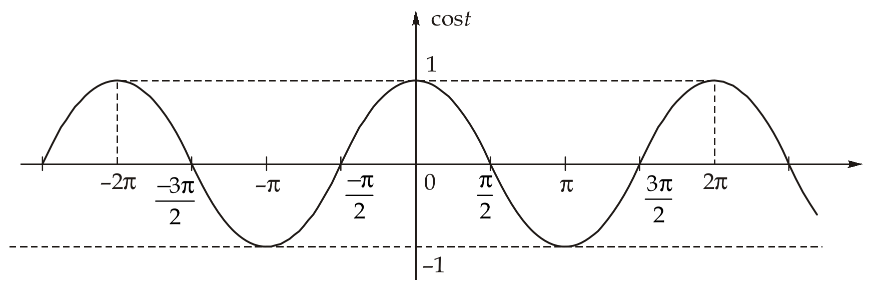
$\Rightarrow$ $$h(t) = \frac{-3}{5}e^{3t}u(-t) - \frac{2}{5}e^{-2t}u(-t)$$

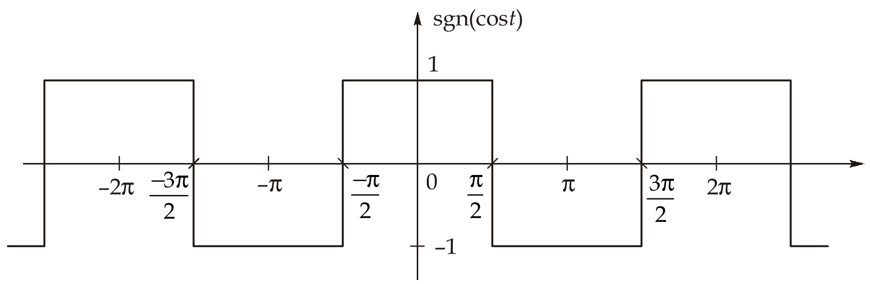
124. (a)

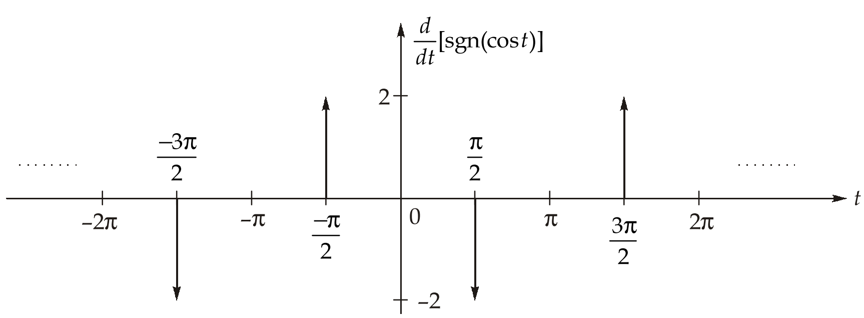
Given, $$x(t) = \frac{d}{dt}[\text{sgn}(\cos t)]$$

We know, $$\text{sgn}(t) = 1\,; \quad t > 0$$
$$= -1\,; \quad t < 0$$

$\Rightarrow$ $$\text{sgn}(\cos t) = 1\,; \quad \cos t > 0$$
$$= -1\,; \quad \cos t < 0$$







$$\therefore \qquad x(\pi) = \frac{d}{dt}[\text{sgn}(\cos t)]\Big|_{t=\pi} = 0$$

125. (d)

Given,

$$x[n] = [\underset{\uparrow}{2}, 5, 7, 9]$$

$$y[n] = [\underset{\uparrow}{2}, 5, 7, 9, 2, 5, 7, 9, 2, 5, 7, 9]$$

Output is the repetition of input implies impulse response is the impulse train,

Here, output is the repetition of input which is having 4 samples, ↑ for three times,

$$\therefore \qquad h[n] = \sum_{m=0}^{3-1} \delta[n - 4\text{m}]$$

$$\Rightarrow \qquad h[n] = \sum_{m=0}^{2} \delta[n - 4\text{m}]$$

126. (c)

We have,
$$f(t) = t\,u(t-5)$$
$$= (t-5)\,u(t-5) + 5u(t-5)$$

Take Laplace transform on both sides,
$$F(s) = \frac{1}{s^2}(e^{-5s}) + \frac{5e^{-5s}}{s}$$
$$\Rightarrow \quad F(s) = \frac{(1+5s)e^{-5s}}{s^2}$$

127. (d)

Given,
$$\frac{dy(t)}{dt} + 2y(t) = \int_{-\infty}^{+\infty} x(\tau)\cdot z(t-\tau)d\tau$$
$$\Rightarrow \quad \frac{dy(t)}{dt} + 2y(t) = x(t) * z(t)$$

Take Fourier transform on both sides,
$$j\omega\, Y(j\omega) + 2Y(j\omega) = X(j\omega)\cdot Z(j\omega) \quad \text{...(i)}$$

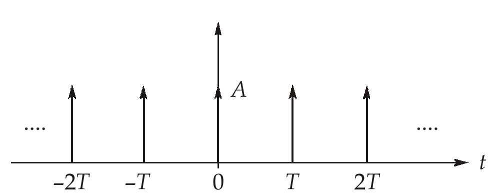
We have,
$$z(t) = \delta(t-5)$$
$$\Rightarrow \quad Z(j\omega) = e^{-j5\omega} \quad \text{...(ii)}$$

Using equation (ii) in (i),
$$j\omega\, Y(j\omega) + 2Y(j\omega) = e^{-j5\omega}\cdot X(j\omega)$$
$$Y(j\omega)\,[2 + j\omega] = e^{-j5\omega}\cdot X(j\omega)$$
$$\Rightarrow \quad H(j\omega) = \frac{Y(j\omega)}{X(j\omega)} = \frac{e^{-j5\omega}}{(2+j\omega)}$$

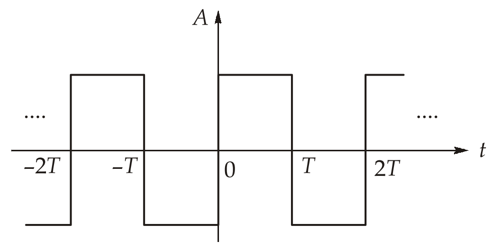
Take inverse fourier transform on both sides,
$$\Rightarrow \quad h(t) = e^{-2(t-5)}\,u(t-5)$$

$\therefore$ At $t = 4$,
$$h(4) = 0$$

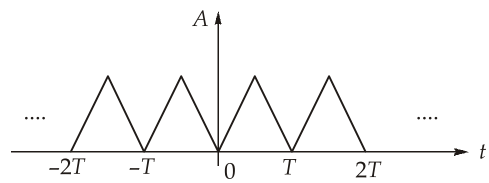
128. (c)



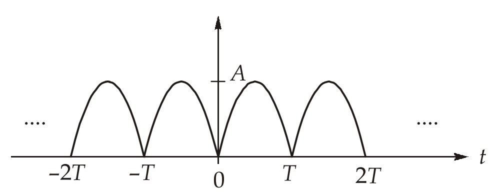
$$\Rightarrow \quad C_n = \frac{A}{T}\ ;\ 'C_n' \text{ is independent of } 'n'$$



$$\Rightarrow \qquad C_n = \frac{-j2A}{n\pi} \text{ ; '}C_n\text{' = 0 for even '}n\text{'}$$



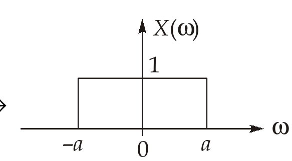
$$\Rightarrow \qquad C_n = \frac{-2A}{(n\pi)^2} \text{ ; '}C_n\text{' = 0 for even '}n\text{'}$$



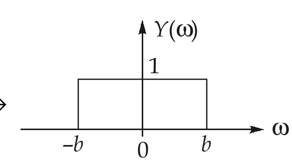
$$\Rightarrow \qquad C_n = \frac{2A}{\pi(1-4n^2)} \text{ ; '}C_n\text{' contains only even harmonics}$$

129. (c)

$$x(t) = \frac{\sin at}{\pi t} \xleftrightarrow{\text{F.T.}}$$



$$y(t) = \frac{\sin bt}{\pi t} \xleftrightarrow{\text{F.T.}}$$



$$z(t) = x(t) * y(t) \leftrightarrow Z(\omega) = X(\omega) \cdot Y(\omega)$$

But $\quad Z(t) = y(t)$

$\Rightarrow \quad Z(\omega) = Y(\omega)$

In order to satisfy this condition,

$$a > b$$

130. (a)

Given, $$X(s) = \left(\frac{8s+9}{3s+2}\right)$$

Convert $X(s)$ into strictly proper function

$$\Rightarrow \quad X(s) = \frac{8}{3} + \frac{\left(\frac{11}{3}\right)}{3s+2}$$

According to initial value theorem,

if $x(t) = 0$, for $t < 0$ and if it is contains no impulses or higher-order singularities at the origin, then

$$x(0^+) = \lim_{s\to\infty} sX(s)$$

$$\Rightarrow \quad x(0^+) = \lim_{s\to\infty} s\left[\frac{\frac{11}{3}}{3s+2}\right] = \lim_{s\to\infty}\left[\frac{\frac{11}{3}}{3+\frac{2}{s}}\right]$$

$$\Rightarrow \quad x(0^+) = \frac{\left(\frac{11}{3}\right)}{(3)} = \frac{11}{9}$$

131. (b)

Given, $$X(e^{j\omega}) = \cos^7(7\omega)$$

$$\sum_{n=-\infty}^{+\infty} x[n](-1)^n = \sum_{n=-\infty}^{+\infty} x[n]\cdot e^{-j\pi n} = X(e^{j\pi})$$

$$\Rightarrow \quad \sum_{n=-\infty}^{+\infty} x[n](-1)^n = X(e^{j\pi}) = \cos^7(7\pi)$$

$$= (-1)^7 = (-1)$$

132. (d)

Given, $$x[n] = 9^{|n|} = \begin{cases} 9^n; & n \ge 0 \\ 9^{-n}; & n < 0 \end{cases}$$

$$\Rightarrow \quad x[n] = 9^n\, u[n] + 9^{-n}\, u[-n-1]$$

$$= \underbrace{9^n u[n]}_{\text{ROC}:|z|>9} + \underbrace{9\left(\frac{1}{9}\right)^n u[n-1]}_{\text{ROC}:|z|<\left(\frac{1}{9}\right)}$$

As there is no common ROC, the signal $x[n]$ does not have z-transform.

133. **(b)**

A system is said to posses memory if its output signal depends on past or future values of the input signal.

134. **(a)**

$$I = \int_{0.5}^{3.5} (3x + 0.5)dx$$

Here, $y = f(x) = 3x + 0.5$

$a = 0.5$

$b = 3.5$

$n = 4$ (given)

∴ step size, $h = \dfrac{b-a}{n} = \dfrac{3.5-0.5}{4} = 0.75$

x	0.5	1.25	2	2.75	3.5
$y = f(x)$	2	4.25	6.5	8.75	11
	y_0	y_1	y_2	y_3	y_4

Trapezoidal rule :

$$I = \frac{h}{2}[y_0 + 2(y_1 + y_2 + y_3) + y_4]$$

$$= \frac{0.75}{2}[2 + 2(4.25 + 6.5 + 8.75) + 11] = 19.5$$

135. **(c)**

$$\frac{1}{f(D)}x^n = [f(D)]^{-1} x^n$$

136. **(b)**

For $f(x)$ to be a valid probability density function

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

$$\Rightarrow \quad \frac{1}{A}\int_{3}^{6}(4x + 5)dx = 1$$

$$\Rightarrow \quad \frac{1}{A}\left|\frac{4x^2}{2} + 5x\right|_3^6 = 1$$

$$A = [2(6)^2 + 5(6)] - [2(3)^2 + 5(3)]$$

$$= (72 + 30) - (18 + 15)$$

$$= 102 - 33 = 69$$

137. (c)

For a matrix to be square of other matrix its determinant should be positive.

138. (b)

For infinitely many solutions, we must have

$$\frac{K+1}{K} = \frac{8}{K+3} = \frac{4K}{3K-1}$$

$$K = 1$$

139. (d)

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

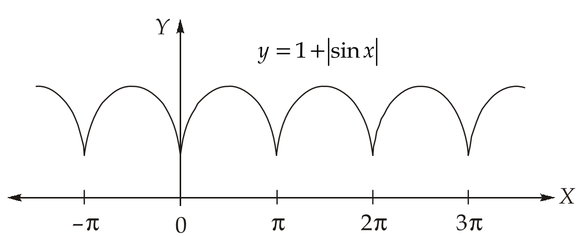
$$= \lim_{x\to 0}\frac{\sin\pi(\pi-\pi\sin^2 x)}{x^2}$$

$$= \lim_{x\to 0}\frac{\sin\pi(\pi\sin^2 x)}{x^2} \qquad [\because \sin(\pi - \theta) = \sin\theta]$$

$$= \lim_{x\to 0}\frac{\sin\pi\sin^2 x}{\pi\sin^2 x}\times(\pi)\left(\frac{\sin^2 x}{x^2}\right)$$

$$= \pi \qquad \left[\because \lim_{x\to 0}\frac{\sin\theta}{\theta}=1\right]$$

140. (d)



Clearly, $y = 1 + |\sin x|$ is continuous for all x, but not differentiable at infinite number of points.

141. (b)

Given,

$$y = a + bx$$

$$y' = b,$$

$$y'' = 0,$$

$$y''' = 0$$

$$x^3(0) + 2(x^2)(0) + 2(a + bx) = 10x$$

$$a + bx = 5x$$

$$\therefore \quad b = 5\,;$$

$$a = 0$$

$$a^2 + b^2 = 0 + 25 = 25$$

142. (a)

$$f(z) = \frac{\sin z}{z^{2022}}$$

Clearly $z = 0$ is singular point

$$f(z) = \frac{1}{z^{2022}} \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)} z^{2n+1}$$

$$= \frac{1}{z^{2022}} \left[z - \frac{z^3}{3!} + \frac{z^5}{5!} + ... + \frac{1}{2021!} z^{2021} - \frac{1}{2023!} z^{2023} + ... \right]$$

$$= \frac{1}{z^{2021}} - \frac{1}{3!} \frac{1}{z^{2019}} + \frac{1}{2021!} \frac{1}{z} - \frac{1}{(2023)!} z + ...$$

$$= \underbrace{\left(\frac{-1}{(2023)!} z + ... \right)}_{\text{(Analytic part)}} + \underbrace{\left(\frac{1}{(2021)!} \frac{1}{z} + ... \right)}_{\text{(Principle part)}}$$

$$\text{Residue} = \text{Coefficient of } \frac{1}{z} = \frac{1}{(2021)!}$$

143. (b)

Let the mean of Poisson random variable be λ. The variance of Poisson random variable is also λ. Since, the mean and variance of Poisson distribution are same,

Given, Mean + Variance = 8

$$2\lambda = 8$$

$$\lambda = 4$$

∴ Standard deviation = 2

144. (c)

Given improper integral,

$$\int_0^9 \frac{1}{(x-1)^{2/3}} dx = \int_0^1 \frac{1}{(x-1)^{2/3}} dx + \int_1^9 \frac{1}{(x-1)^{2/3}} dx$$

$$= \lim_{a \to 1^-} \int_0^1 \frac{1}{(x-1)^{2/3}} dx + \int_1^9 \frac{1}{(x-1)^{2/3}} dx$$

$$= \lim_{a \to 1^-} 3(x-1)^{1/3} \Big|_0^a + \lim_{a \to 1^+} 3(x-1)^{1/3} \Big|_0^a$$

$$= 3[0-(-1)] + 3\left[(2)^{3\frac{1}{3}} - 0 \right] = 9$$

145. (c)

Thevenin's theorem can be applied to networks having initial conditions.

147. (c)

MOSFET has positive temperature coefficient which avoid problem of thermal runaway. Also MOSFET parallel operation is easy.

148. (d)

Δ-Δ transformer is satisfactory for a balanced and unbalanced load.

150. (a)

Bandwidth of AM signal depends on bandwidth of the modulating signal

$$BW_{AM} = 2f_m$$

Where f_m is bandwidth of modulating signal.

Amplitude modulated signal contains f_c, $f_c \pm f_m$ frequency signal.

$$\text{highest frequency present} = f_c + f_m$$

$$\text{lowest frequency present} = f_c - f_m$$

$$BW_{AM} = 2f_m$$

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