DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Noida, Hyderabad, Bhopal, Jaipur, Lucknow, Bhubaneswar, Indore, Pune, Kolkata, Patna

ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 26

Full Syllabus Test 10 : Paper-II

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

NOTE*:* In question no. 36, option (b) and (d) both are correct.

DETAILED EXPLANATIONS

1. (c)

$$V_L = \frac{V_s j\omega L}{R_1 + j\omega L}$$

and $$V_{R2} = \frac{V_s R_2}{R_2 + \dfrac{1}{j\omega C}}$$

If V_L is to be equal to V_{R2} then

$$\frac{j\omega L}{R_1 + j\omega L} = \frac{R_2}{R_2 + \dfrac{1}{j\omega C}}$$

$$\frac{j\omega L}{R_1 + j\omega L} = \frac{R_2 j\omega C}{1 + R_2 j\omega C}$$

On simplification,

$$L + R_2 L j\omega C = R_1 R_2 C + R_2 j\omega LC$$

$$L = R_1 R_2 C$$

$$R_1 R_2 = \frac{L}{C}$$

Which is required condition.

2. (c)

By using super position theorem,

Voltage due to current I_1 alone,

$$V_1' = \frac{2\angle 0°(8 - j4)(-j20 + 4 + j8)}{8 - j4 - j20 + 4 + j8} = \frac{2\angle 0°(8 - j4)(4 - j12)}{8 - j4 - j20 + 4 + j8}$$

$$= \frac{(2\angle 0°)(8 - j4)(4 - j12)}{(12 - j16)} = (8 - j8) \text{ V}$$

Voltage due to current I_2 alone,

$$V_1'' = \frac{-1\angle -90°(4 + j8)}{8 - j4 - j20 + 4 + j8}(8 - j4) = -4 \text{ V}$$

Hence, $$V = V_1' + V_1'' = (4 - j8) \text{ V}$$

3. (d)

The characteristic equation for impedance parameters are:

$$V_1 = Z_{11}I_1 + Z_{12}I_2 \quad \text{...(i)}$$

$$V_2 = Z_{21}I_1 + Z_{22}I_2 \quad \text{...(ii)}$$

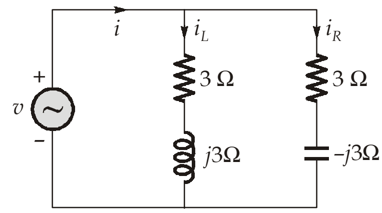
$$V_2 = -10I_2 \quad \text{...(iii)}$$

$$-10I_2 = 5 \times 2 + 10I_2$$

$$I_2 = -\frac{1}{2} = -0.5 \text{ A}$$

4. (c)

Given, Voltage, $v_R = 30$ V



$$i_R = \frac{v_R}{R} = 10\,\text{A}$$

Magnitude of voltage, $v_c = X_C i_R$

$$= 3 \times 10 = 30 \text{ V}$$

$$v = \sqrt{v_R^2 + v_C^2} = \sqrt{(30)^2 + (30)^2} = 30\sqrt{2} \text{ V}$$

Current i_R leads the voltage v by 45°. The current i_L is also 10 A but lags voltage v by 45°. Current i_R and i_L have a phase difference of 90°.

Thus, $$i = \sqrt{i_R^2 + i_L^2} = 10\sqrt{2}\,\text{A}$$

5. (a)

$$\text{Time constant} = RC = 1 \times 10^{-6} \times 50 \times 10^3$$

$$= 50 \text{ msec}$$

If $$V_R = V_C = \frac{100}{2} \text{ at } t_1$$

$$50 = 100 - [100 - (-20)]e^{\frac{-t_1}{50}}$$

$$50 = 100 - 120e^{\frac{-t_1}{50}}$$

$$120e^{-t_1/50} = 50$$

$$e^{\frac{-t_1}{50}} = \frac{50}{120}$$

$$-\frac{t_1}{50} = -0.875$$

$$t_1 = 43.8 \text{ msec}$$

6. (d)

The equivalent impedance of the circuit from the source side is

$$Z_{eq} = j\omega L + \frac{R \times \frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = j\omega L + \frac{R}{1 + j\omega RC}$$

$$= j(1.5 \times 0.4) + \frac{R}{1 + j(1.5 \times R \times 0.8)}$$

$$= j0.6 + \frac{R}{1+j(1.2R)} \times \frac{1-j1.2R}{1-j1.2R}$$

$$= \frac{R}{1+1.44R^2} + j\left(0.6 - \frac{1.2R^2}{1+1.44R^2}\right)$$

At resonance,

$$0.6 - \frac{1.2R^2}{1+1.44R^2} = 0$$

∴ $$R = \sqrt{\frac{1}{1.2\times 0.47}} = 1.33\ \Omega$$

7. (b)

$$X_L = \omega L = 3000 \times 0.01 = 30\ \Omega$$

Here the current lags the voltage by an angle 45°

∴ $$\tan 45° = \frac{X}{R}$$

⇒ $$X = R$$

Now, $$Z = \frac{V_m}{I_m} = \frac{400}{10\sqrt{2}} = 28.3\ \Omega$$

Again, $$Z^2 = R^2 + X^2 = 2R^2$$

∴ $$R = \frac{Z}{\sqrt{2}} = \frac{28.3}{\sqrt{2}} = 20\ \Omega \text{ and } X = 20\ \Omega$$

∴ $$X = X_L - X_C = 30 - X_C = 20$$

or $$X_C = 10\ \Omega$$

∴ $$\frac{1}{\omega C} = 10$$

$$C = \frac{1}{3000\times 10} = 33.33\ \mu\text{F}$$

8. (c)

$$\text{Impedance of the circuit} = \frac{\frac{250}{\sqrt{2}}\angle -10°}{\frac{10}{\sqrt{2}}\angle +50°} = 25\angle -60°$$

the resistance of the circuit = 25 cos (–60°)

= 12.5 Ω

9. (d)

For the given network,

$$Y = \frac{1}{R} + j\omega_0 C + \frac{1}{R_L + j\omega_0 L}$$

$$= \frac{1}{R} + j\omega_0 C + \frac{R_L - j\omega_0 L}{R_L^2 + \omega_0^2 L^2}$$

$$= \frac{1}{R} + \frac{R_L}{R_L^2 + \omega_0^2 L^2} + j\omega_0\left(C - \frac{L}{R_L^2 + \omega_0^2 L^2}\right)$$

At resonance, $\text{Img}(Y) = 0$

Therefore, $$C = \frac{L}{R_L^2 + \omega_0^2 L^2}$$

$$R_L^2 + \omega_0^2 L^2 = \frac{L}{C}$$

$$\omega_0^2 L^2 = \frac{L}{C} - R_L^2$$

$$\omega_0 = \sqrt{\frac{1}{LC} - \frac{R_L^2}{L^2}}$$

10. (c)

Let R_p and X_p be the resistive and reactive component of each phase impedance. Since the load is star connected, phase and line currents are equal,

$$P_{3-\phi} = 3I_L^2 R_p = 3I_P^2 R_p$$

$$1.8 \times 10^3 = 3 \times 10^2\, R_p$$

$$R_p = 6\ \Omega$$

Phase voltage, $$V_P = \frac{400}{\sqrt{3}}\text{V}$$

Phase impedance, $$Z_p = \frac{V_P}{I_P} = \frac{400}{\sqrt{3} \times 10} = \frac{40}{\sqrt{3}}$$

Reactive components of impedance

$$X_P = \sqrt{\left(\frac{40}{\sqrt{3}}\right)^2 - 6^2}$$

$$= \sqrt{\frac{1600}{3} - 36} = 22.30\ \Omega$$

11. (b)

For Δ-connection:

$$V_{ph} = V_L;$$

$$I_{ph} = \frac{I_L}{\sqrt{3}}$$

$$P_\Delta = \frac{3(V_{ph})^2}{R} = 3(I_{ph})^2 R = \frac{3V_L^2}{R}$$

For Y-connection:

$$V_{ph} = \frac{V_L}{\sqrt{3}}, \qquad I_{Ph} = I_L$$

$$P_Y = 3\left(I_{ph}^2\right)\cdot R = 3\left(\frac{V_{ph}}{R}\right)^2 \cdot R = 3\cdot\frac{V_L^2}{3R^2}\cdot R = \frac{V_L^2}{R}$$

Clearly $P_Y = \frac{P_\Delta}{3}$

Hence $P_Y = \frac{180}{3} = 60 \text{ kW}$

12. (c)

$$V_{rms} = \sqrt{\frac{0^2 + (10)^2 + (20)^2}{3}} = 12.9 \text{ V}$$

13. (b)

Let the distance between point P_1 and P_2 be x.

$$dV = -E\cdot dl \Rightarrow 8$$

$$= -\left(40\hat{a}_x\right)\cdot\left(-x\,\hat{a}_x\right)$$

$$8 = 40x$$

$$x = \frac{8}{40} = 0.2 \text{ i.e. } 20 \text{ cm}$$

$$\frac{dW}{dq} = dV$$

If it is a unit charge then work done = potential difference

Work done in bringing unit charge from P_2 to P_1 = 8 J

14. (d)

The equipotential surface due to line charge are concentric cylinders and solution of Poisson's equation and Laplace equation are not same.

15. (a)

Magnetic field at the centre due to circular coil of one turn of radius 'r', carrying a current 'I' is inversely proportional to 'r'. It is given by $B = \frac{\mu_0 I}{2r}$.

17. (c)

$$(3s^2 + 5s + 1)\,C(s) = \left[1 + 3e^{-2s}\right]R(s)$$

$$\frac{C(s)}{R(s)} = \frac{1 + 3e^{-2s}}{3s^2 + 5s + 1}$$

18. (a)

There are two forward paths and three loops. Therefore we have

$$P_1 = \frac{1}{s^3}; \qquad P_2 = \frac{1}{s}$$

$$L_1 = -\frac{1}{s^2}; \quad L_2 = -\frac{1}{s^2}; \qquad L_3 = \frac{1}{s^2}$$

$$\Delta = 1 + \frac{1}{s^2}; \quad \Delta_1 = \Delta_2 = 1$$

Therefore, $$\frac{Y(s)}{R(s)} = \frac{\frac{1}{s^3} + \frac{1}{s}}{1 + \frac{1}{s^2}} = \frac{(1+s^2)}{s(s^2+1)} = \frac{1}{s}$$

19. (b)

For open-loop sensitivity,

$$T(s) = A\,G(s)$$

Hence, $$\frac{\partial T}{\partial A} = G(s),$$

$$\frac{A}{T} = \frac{1}{G(s)}$$

Therefore, $$S_A^{\,T} = \frac{\partial T}{\partial A}\cdot\frac{A}{T} = 1$$

20. (d)

Let us calculate the response as follows:

$$\frac{Y(s)}{R(s)} = \frac{K}{s\tau + K + 1}$$

$$Y(s) = \frac{1}{s}\cdot\frac{K}{s\tau + K + 1} \qquad \left[\because R(s) = \frac{1}{s}\right]$$

Therefore, $$y_{ss} = \lim_{s\to 0} sY(s)$$

$$= \lim_{s\to 0} s\cdot\frac{1}{s}\cdot\frac{K}{s\tau + K + 1} = \frac{K}{K+1}$$

$$\frac{K}{K+1} = 0.8$$

$$1+\frac{1}{K} = \frac{1}{0.8}$$

$$\frac{1}{K} = 0.25$$

$$K = 4$$

21. (a)

For maximum peak overshoot $M_p \propto \frac{1}{\xi}$

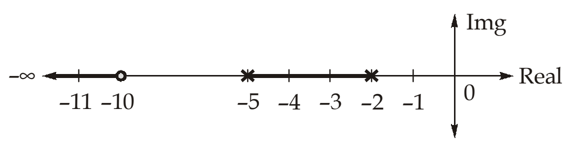
$\xi = 0.50$ for option (a) which is least among all options. Therefore correct option is (a).

22. (c)

The PD control improves the transient part and the PI control improves the steady-state part. A combination of PI and PD control improves the overall response of the system.

23. (b)

The pole-zero, shown in the following figure, indicates that the part of the real axis between $s = -2$ and $s = -5$ belongs to the root locus obviously, the breakaway point must exist between $s = -2$ and $s = -5$.



24. (a)

From the given magnitude plot we get the following data:

There are two simple poles at corner frequencies 10 and 250 rad/sec and there is a gain factor K which makes the initial part of the plot a straight line parallel to the ω-axis. To find out the value of K, we have

$$20 \log K = 40$$

$$\log K = 2$$

$$K = 100$$

So,

$$G(s) = \frac{100}{\left(1+\frac{s}{10}\right)\left(1+\frac{s}{250}\right)}$$

25. (a)

Let the transfer function be given by,

$$G(s) = K(1 + sT)$$

Then, in the frequency domain,

$$G(j\omega) = K(1 + j\omega T)$$

$$= K\sqrt{1+\omega^2T^2}\angle \tan^{-1} \omega T$$

$$\phi = \tan^{-1} 10T = 45° \quad \text{(from the given diagram)}$$
$$10T = \tan 45° = 1$$
$$T = 0.1$$

Now, $K\sqrt{1+0} = 5$ (from the given diagram)

$$K = 5$$

Therefore, $G(s) = 5(1 + 0.1s)$

26. (c)

$$H_C = H_0\left[1-\left(\frac{T}{T_c}\right)^2\right] \quad \text{...}H_C \text{ varies parabolically with temperature } T,$$

$H_C = 0$ at $T = T_C$ and $H_C = H_0$ at $T = 0$ K.

28. (a)

Magnetic leviation is a method by which an object is suspended with no support other than magnetic fields. Superconductors are perfect diamagnetic ($\mu_r = 0$) and have the property of completely expelling magnetic field due to Meissner effect.

30. (a)

$$P = \varepsilon_0 E[\varepsilon_r - 1]$$
$$= 8.85 \times 10^{-12} \times 600 \times 10^2 \times 1.28$$
$$= 6.78 \times 10^{-7} \text{ C/m}^2$$

31. (b)

Given, $\lambda = 1.4 \times 10^{-10}$ m

$$(h\ k\ l) = (1\ 1\ 1)$$
$$a = 1.4 \times 10^{-10} \text{ m}$$

$$\text{Interplanar spacing} = \frac{1.4\times10^{-10}}{\sqrt{1^2+1^2+1^2}} = \frac{1.4}{\sqrt{3}}\times10^{-10}$$

$\because$ $2d \sin\theta = n\lambda$ [where $n = 1$]

$$\sin\theta = \frac{1.4\times10^{-10}\times\sqrt{3}}{2\times1.4\times10^{-10}}$$

$$\sin\theta = \frac{\sqrt{3}}{2}$$

$\therefore$ $\theta = 60°$

32. (a)

Since, Thermal current, $J_T = -K\dfrac{AdT}{dx}$

$$J_T \propto A$$

$$J_T \propto \frac{dT}{dx}$$

33. (c)

All ferroelectric are pyroelectric but converse is not always true.

35. (a)

Leakage flux in a transformer is reduced by using shell type construction.

36. (b, d)

We know, $\frac{N_{\Delta(P)}}{N_{Y(P)}} = 3$

Also, $\frac{N_{\Delta(P)}}{N_{Y(P)}} = \frac{V_{\Delta P}}{V_{Y(P)}}$

$$V_{Y(P)} = \frac{440}{\sqrt{3}}\text{ V}$$

$$V_{\Delta(P)} = \frac{3\times 440}{\sqrt{3}} = 440\sqrt{3}\text{ V}$$

For delta side, $V_{\Delta(L)} = V_{\Delta(P)} = \frac{1320}{\sqrt{3}}\text{ V}$ or $440\sqrt{3}\text{ V}$

37. (c)

The flux in the circuit, $\phi = \frac{MMF}{\Re} = \frac{N_i i_i}{\frac{l}{\mu A}} = \frac{N_1 i_1 \mu A}{l}$

According to Faraday's law

The induced emf in second coil,

$$V_2 = -N_2\frac{d\phi}{dt} = -100\frac{d}{dt}\left[\frac{N_1 i_1 \mu A}{l}\right]$$

$$= -100\times\frac{N_1\mu A}{l}\frac{di_1}{dt}$$

$$= -100\times 200\times 500\times\frac{4\pi\times 10^{-7}\times 2\times 10^{-3}}{2\pi\times 10\times 10^{-2}}\times\frac{di_1}{dt}$$

$$= \frac{-2}{50}\times\frac{d}{dt}[4\sin 100\pi t] = \frac{-2}{50}\times 400\pi\cos 100\pi t$$

$$= -16\pi\cos 100\pi t\text{ V}$$

38. (c)

We know, Force, F = BIL sin θ

= 1 × 50 × 2.4 × sin 90°

= 120 N

Mechanical power = emf × I

= $Blv \times I = (I\,Bl)\times v$

= $F\times v$ = 120 × 5

P = 600 W

39. (b)

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

$$\text{Slip, } s = \frac{E_{(\text{injected})}}{E_{(\text{rotor})}} = \frac{18}{72} = 0.25$$

$$\text{The rotor speed, } N_r = N_s(1 - s)$$

$$= 1500\,(1 - 0.25) = 1500 \times 0.75 = 1125 \text{ rpm}$$

40. (b)

For maximum efficiency at unity power factor,

We know,
$$\text{kVA}_m = (\text{kVA}_{fl})\sqrt{\frac{P_i}{P_{cu}}}$$

$$= 450\sqrt{\frac{800}{3200}}$$

$$= 450\sqrt{\frac{1}{4}} = \frac{450}{2} = 225 \text{ kVA}$$

At maximum efficiency, $P_{cu} = P_i$

$$\%\eta_{max} = \frac{225}{225 + \frac{800}{1000} + \frac{800}{1000}}$$

$$= \frac{225}{225 + 1.6} = \frac{225}{226.6} = 99.29\%$$

41. (b)

Given,
$$r_2 = 4.0\ \Omega,$$
$$X_2 = 9.0\ \Omega$$
$$r_1 = x_1 = 0$$

$$T_{st} = \frac{3V_2^2 \cdot r_2'}{\omega_s\left[\left(r_2'^2\right) + X_2'^2\right]}; \text{ [At starting slip = 1]}$$

$$\omega_S = \frac{120 \times 50}{4} \times \frac{2\pi}{60} = 157.1 \text{ rad/sec}$$

$$100 = \frac{3}{157.1} \times \frac{V^2 \times 4.0}{[4.0^2 + 9.0^2]}$$

On solving, we get, $V_2 = 356.36$ V

42. (c)

We know, Torque, $\tau \propto \phi I_a$

$$\frac{\tau_1}{\tau_2} = \frac{\phi_1 I_{a1}}{\phi_2 I_{a2}}$$

$$\tau_2 = \frac{\phi_2 I_{a2}}{\phi_1 I_{a1}} \tau_1$$

$$\phi_2 = 1.2\ \phi,$$
$$I_{a1} = 20\ \text{A},$$
$$I_{a2} = 30\ \text{A},$$
$$\tau_1 = 40\ \text{Nm}$$

$$\tau_2 = \frac{1.2 \times 30}{20} \times 40 = 2.4 \times 30 = 72\ \text{Nm}$$

43. (a)

$$\text{Efficiency of dc motor, } \%\eta = \frac{P_{out}}{P_{in}} \times 100$$

$$\text{Motor input power, } P_{in} = \frac{P_{out}}{\eta} = \frac{8000}{0.8} = 10000\ \text{W}$$

$$\text{Motor line current, } I_L = \frac{P_{in}}{V} = \frac{10000}{200} = 50\,\text{A}$$

$$\text{Shunt field current, } I_{sh} = \frac{V}{R_{sh}} = \frac{200}{200} = 1\,\text{A}$$

$\therefore$ Armature current, $I_a = I_L - I_{sh} = 50 - 1 = 49$ A

Back emf, $E_b = V - I_a R_a$

$= (200) - (49)\ (1.2)$

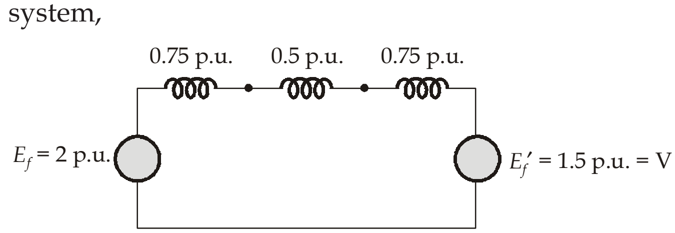
$= 200 - 58.8 = 141.20$ V

44. (d)

All above mentioned point are correct regarding limitations on region of operation of synchronous machine.

45. (b)

Equivalent circuit for system,



The power delivered, $P = \dfrac{EV}{X_s} \sin\delta$

Supplied power, $P = 0.75$ p.u.

$E = 2$ p.u.

$V = 1.5$ p.u.

$X_S = 0.75 + 0.5 + 0.75$

$= 2$ p.u.

$$0.75 = \frac{2 \times 1.5}{2} \sin\delta$$

or $\sin\delta = 0.5$

$\delta = 30°$

46. (c)

- Fifth harmonic mmf travel at one-fifth of synchronous speed in direction opposite to fundamental mmf wave and hence has braking affect.
- Seventh harmonic field rotates in direction of rotor movement.

47. (d)

The smallest and largest possible values that can be stored are 1×10^{-128} and $(2^{15} - 1) \times 10^{127}$.

48. (c)

Sequence of block addresses:

8, 12, 0, 12, 8

~~8~~ 0	Set 0
~~12~~ 8	
	Set 1

Total number of cache misses are 4.

49. (c)

Virtual memory $= 36$ bits

$= 2^{36}$ B

Physical memory $= 30$ bits

$= 2^{30}$ B

$$\# \text{ frames} = \frac{2^{30}\text{B}}{2^{12}\text{B}} = 2^{18} \text{ B}$$

Size of page table = # entries in page table × page table entry size

$$= \frac{2^{36}\text{B}}{2^{12}\text{B}} \times (18) \text{ bits}$$

$= 2^{24}$ B × 3 B

= 16 MB × 3 B = 48 MB

50. (c)

It is the program for swapping two number.

51. (b)

$$\text{Virtual address space} = 2^{32} \text{ Bytes}$$
$$\text{Physical address spaces} = 2^{30} \text{ Bytes}$$
$$\text{Page size} = 4 \text{ KB} = 2^{12} \text{ Bytes}$$
$$\text{No. of frames in physical memory} = \frac{2^{30}}{2^{12}} = 2^{18}$$

No. of Bits in each page table entry

Page Number	Overhead (offset)
← 20 bits →	← 12 bits →

$$\text{Page table size} = \text{No. of frames} \times (20 + 12) \text{ bits}$$
$$= 2^{18} \times 32 \text{ bits}$$
$$= 2^{18} \times \frac{32}{8} \text{ bytes}$$
$$\approx 2^{18} \times 2^2 \text{ bytes} \approx 2^{20} \text{ Bytes}$$

52. (a)

P_1	P_2	P_3	P_1	P_1	P_1	P_1	P_1

0 4 7 10 14 18 22 26 30

$$\text{Average waiting time} = \frac{\text{Wating time of } P_1 + \text{Waiting time of } P_2 + \text{Waiting time of } P_3}{3}$$
$$= \frac{6+4+7}{3} = 5.66$$

53. (c)

1100 → 2's complement = 0100
1001 → 2's complement = 0111
1000 → 2's complement = 1000
1111 → 2's complement = 0001

54. (d)

Average access time = Hit Ratio × Cache access time + Miss Ratio × Memory access time

Here, Memory access time = 1.5 μs i.e. 1500 ns

So, average access time = 0.98 × 12 ns + 0.02 × 1500 ns
= 11.76 ns + 30 ns = 41.76 ns

55. (d)

MD = 40 MW
Capacity factor = 0.5
Utilization factor = 0.8

$$\text{Load factor} = \frac{\text{Capacity factor}}{\text{Utilization factor}} = \frac{0.5}{0.8} = 0.625$$

$$\text{Plant capacity} = \frac{\text{Max. demand}}{\text{Utilization factor}} = \frac{40}{0.8} = 50 \text{ MW}$$

$$\text{Reserve capacity} = 50 - 40 = 10 \text{ MW}$$

56. (a)

Due to ferranti effect maximum voltage occurs at the end of the line. So, the leakage current through the conductance $I = GV$ is maximum at the end of line.

57. (b)

$$Z_c = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.87 \times 10^{-3}}{0.012 \times 10^{-6}}} = 269.26\ \Omega \approx 269\ \Omega$$

58. (b)

For long lossless line

$$|A| = |D| = \cos\beta x, \quad \beta = \omega\sqrt{LC}$$

$$|C| = \frac{\sin\beta x}{Z_c}, \quad |B| = Z_c \sin\beta x$$

As frequency increases, β increases and hence $|A| = |D|$ decreases and $|B|, |C|$ increases.

59. (c)

Since power factor of generator G_2 is unity.

$$Q_{\text{line}} = \frac{1}{0.2}[\cos 30 - 1] = -0.67 \text{ p.u.}$$

This means 0.67 p.u. power is injected into transmission line at receiving end.
Net Q supplied by capacitor = 5 + 0.67 = 5.67 p.u.

60. (a)

$$\text{Total voltage variation} = 525 - 500 = +25 \text{ V}$$
$$475 - 500 = -25 \text{ V}$$

i.e. ±25 V
So, maximum voltage variation is 25 V

$$\text{Line current with line voltage of 500 V} = \frac{100 \times 1000}{\sqrt{3} \times 500} = \frac{200}{\sqrt{3}} \text{ A}$$

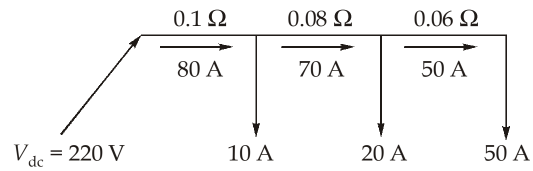
Rating of induction voltage regulator

$$= \sqrt{3} \times \frac{200}{\sqrt{3}} \times 25 \times 10^{-3} = 5 \text{ kVA}$$

61. (b)

The product of $(\varepsilon \cdot g)$ having the highest one is placed near the core next highest is placed next.

62. (b)



$$V_{min} = V_{dc} - I_1R_1 - I_2R_2 - I_3R_3$$
$$= 220 - (80 \times 0.1) - (70 \times 0.08) - (50 \times 0.06)$$
$$= 203.4 \text{ V}$$

63. (b)

If $I_{C1} = I_{C2}$, G_1 should always deliver 150 MW.

$$P_{1\,max} = 150 \text{ MW} \quad (\because I_{C1} = I_{C2})$$

G_2 can deliver upto 200 MW

$$P_{2\,max} = 200 \text{ MW}$$

$$\therefore \quad P_{1max} + P_{2max} = 200 + 150 = 350 \text{ MW}$$

64. (c)

Short circuit current is sinusoidal a.c. current and it is calculated in subtransient region. For maximum momentary current it is almost double of symmetrical short circuit and it is called as doubling effect.

65. (c)

Over voltages are developed when neutral is isolated and line carries line charging current so it must be an isolated neutral connected to a long transmission line.

66. (b)

$$\text{Primary line current} = I_{LP} = \frac{10 \times 10^6}{\sqrt{3} \times 132 \times 10^3} = 43.74 \text{ A}$$

CT connected to primary of transformer is delta connected.

So, the current in the primary of the CT is $\frac{5}{\sqrt{3}}$ A

$\therefore$ The CT ratio of primary of the transformer is, 43.74/(5/1.732)

The secondary line current of the transformer is,

$$I_{LS} = \frac{10 \times 10^6}{\sqrt{3} \times 66 \times 10^3}$$
$$I_{LS} = 87.47 \text{ A}$$

$\therefore$ The CT ratio on the secondary is, 87.47/5.

67. (d)

Type-1, bus modification = [0.3]

Type-2, bus modification,

$$Z_{\text{Bus (new)}} = \begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.3 + 0.5 \end{bmatrix} = \begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.8 \end{bmatrix}$$

68. (a)

The transfer function of filter is

$$\frac{V_0(s)}{V_i(s)} = \frac{-R_2}{(R_1 + sL)(1 + sC_2R_2)}$$

Hence low pass filter.

69. (a)

Here from virtual ground:

$$V_s = \frac{V_1 \times 1\,k}{1\,k + 49\,k} \Rightarrow V_1 = 50\,V_s \quad \text{...(i)}$$

$$V_2 = -V_1\left(\frac{40\,k}{10\,k}\right) \Rightarrow V_2 = -4\,V_1$$

$\therefore$ $$V_2 = -4(50\,V_s)$$

$\Rightarrow$ $$\frac{V_2}{V_s} = -200$$

70. (b)

$$\text{S.R.} = 2\pi f V_m$$

$\Rightarrow$ $$V_m = \frac{S.R.}{2\pi f} = \frac{6.28 \times 10^6}{2\pi \times 10^6} = 1\text{ V}$$

71. (a)

$V_{sat} = 9$ V (Because 1 zener is in forward bias and 1 is in breakdown region)

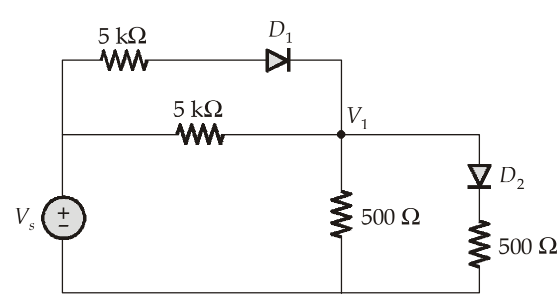
$$V_{UTP} = V_{sat}\left(\frac{R_2}{R_1 + R_2}\right) = 9\left(\frac{1}{10}\right) = 0.9\text{ V}$$

$$V_{LTP} = -V_{sat}\left(\frac{R_2}{R_1 + R_2}\right) = -9 \times \frac{1}{10} = -0.9\text{ V}$$

72. (b)

For $V_1 > 0.6$ V, D_2 will be ON.

If both diodes are ON.



$$\frac{V_s - 0.6 - V_1}{5} + \frac{V_s - V_1}{5} = \frac{V_1}{0.5} + \frac{V_1 - 0.6}{0.5}$$

$\Rightarrow$ $$\frac{V_s - 0.6 - V_1 + V_s - V_1}{5} = 2V_1 + 2V_1 - 1.2$$

$\Rightarrow$ $$V_1 = \frac{2V_s + 5.4}{22} > 0.6$$

$\Rightarrow$ $$V_s > 3.9\text{ V}$$

73. (a)

For $V_i > 0$, diode will be in forward bias condition $(2\text{k} \,||\, 2\text{k}) = 1\,\text{k}\Omega$

$$V_R = V_i - V_D = 2.7\text{ V} - 0.7\text{ V} = 2\text{ V}$$

$$I_{\max} = \frac{2\text{ V}}{1\text{ k}\Omega} = 2\text{ mA}$$

74. (d)

$$I_{\min} = I_{Z\min} + I_{L\min} = 2\text{ mA}$$
$$I_{\max} = I_{Z\max} + I_{L\max} = 12\text{ mA}$$
$$V_{i\min} = I_{\min} \cdot 5 \times 10^3 + 50 = 60\text{ V}$$
$$V_{i\max} = I_{\max} \cdot 5 \times 10^3 + 50 = 110\text{ V}$$

77. (a)

$$I_C = \frac{6 - V_C}{10}$$

$$I_E = \left(\frac{V_B - 0.7}{1}\right)\text{mA}$$

$\because$ $$I_C = \alpha I_E$$

$$I_C = \frac{\beta}{1+\beta} \cdot I_E$$

i.e. $$\left(\frac{6 - V_C}{10}\right) = \frac{50}{51}\left(\frac{V_B - 0.7}{1}\right)$$

i.e. $$V_B = V_C \text{ (given)}$$

$\Rightarrow$ $$V_B \approx 1.17\text{ V}$$

78. (b)

As Q_3 is in saturation,

$$V_{C_3} - V_{E_3} = 0.2$$

$$V_{E_3} = 8.8\text{ V}$$

$$V_{B_3} = V_1 = 8.8 + 0.7 = 9.5\text{ V}$$

I through 5 kΩ is

$$\frac{8.3}{8\text{k}} = 1.0374\text{ mA}$$

$$V_{E_3} - V_0 = 5 \times 10^3\, I = 5 \times 10^3 \times 1.0374 \times 10^{-3}$$

$$V_0 = 3.612\text{ V}$$

79. (c)

The stability factor is

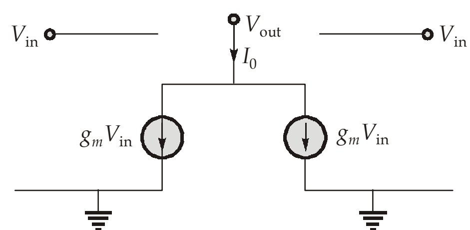
$$S = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_E+R_B}\right)} = \frac{1+\beta}{1+\beta\left(\frac{1}{1+\frac{R_B}{R_E}}\right)}$$

$S \to 1$ only when $\frac{R_B}{R_E} \to 0$

i.e. decreasing R_B and increasing R_E

80. (b)

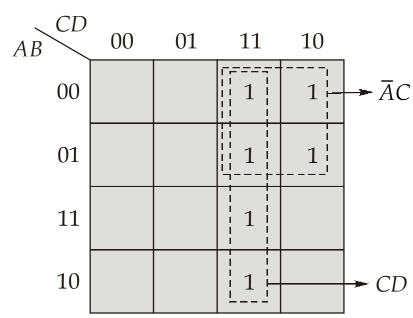
The small signal model of the circuit will be



$$g_{m(\text{net})} = \frac{I_0}{V_{in}} = \frac{g_m V_{in} + g_m V_{in}}{V_{in}} = 2g_m$$

81. (b)

$$f = \underset{(11)}{A\bar{B}CD} + \underset{(6,7)}{\bar{A}BC} + \underset{(7,15)}{BCD} + \underset{(2,3)}{\bar{A}\bar{B}C}$$



$$f = \bar{A}C + CD$$

82. (c)

$$Y = \bar{A}\bar{B}A + \bar{A}BB + A\bar{B}A + ABB$$

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

$$Y = A + B$$

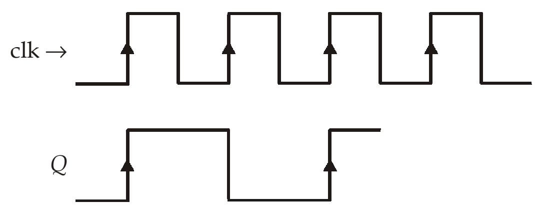
83. (d)

Conversion time for SAR is

$$n \cdot t_{clk} = \frac{8}{f_{clk}} = \frac{8}{10^6} = 8\ \mu s$$

84. (a)

J-K flip flop is in toggle mode so after every clock pulse output Q toggles so output Q will be as



and Q is input to MOD-3 counter then after 3 clock pulses of input clk there are 2 +ve edge of clock input Q so output of counter goes to $2 = (10)_2$

So, $AB = 10$

So Q, A, B respectively are 110.

85. (c)

The parity flag is reset (i.e. it is '0') if results contains odd number of 1's.

86. (d)

	LXI H,	2270 H	→	HL is loaded with 2070 H
	MVI B,	06 H	→	B is loaded with 05 H
	MVI A,	02 H	→	A is loaded with 02 H
STORE :	MOV M, A		→	Content of A is moved in HL pair
	INR, A		→	Content of A invoremented by 1
	INX, H		→	Content of HL is incremented by 1
	DCR, B		→	Content of B is decremented by 1
	JNZ,	STORE	→	Jump to store if $Z \neq 1$
	HLT			

Loop STORE is executed 6 times

2270 H – 02 H
2271 H – 03 H
2272 H – 04 H
2273 H – 05 H
2274 H – 06 H
2275 H – 07 H

∴ Content of 2275 H is 07 H

87. (b)

XCHG instruction requires 4 T states

$$\text{Time required for 1 T state} = \frac{1}{6}\mu\text{sec}$$

$$\text{Time required for 4 T states} = \frac{4}{6}\mu\text{sec} = 0.66\ \mu\text{sec}$$

88. (b)

Given instruction takes 3 machine cycles,

$$\left.\begin{array}{l} 1^{st}\text{ for opcode fetch} \\ 2^{nd}\text{ for MEMR} \\ 3^{rd}\text{ for MEMW} \end{array}\right\} \text{3 memory accesses}$$

89. (b)

Instruction 'ADD r' requires one machine cycle for execution. ADC M requires 2 machine cycle, STAX r_p, needs 2 machine cycles while STA Addr needs 4 machine cycle.

90. (c)

We know,

$$I_t = I_C\sqrt{1+\frac{\mu^2}{2}}\ ; \qquad I_{t1} = I_C\sqrt{1+\frac{\mu_1^2}{2}}$$

$$I_{t2} = I_C\sqrt{1+\frac{\mu_1^2+\mu_2^2}{2}}$$

$$\frac{1+\frac{\mu_1^2+\mu_2^2}{2}}{1+\frac{\mu_1^2}{2}} = \frac{2}{1.5} \quad \text{and} \quad \mu_1 = 1$$

$$\frac{3+\mu_2^2}{3} = \frac{2}{1.5}$$

$$\mu_2^2 = \frac{6}{1.5} - 3 = 1$$

$$\mu_2 = 1$$

91. (d)

The power dissipated by the FM wave is P

$$\therefore \quad P = \frac{A_c^2}{2R}\ \text{W}$$

$$\because \quad A_c = 25\ \text{V}$$

$$R = 100\ \Omega$$

$$\therefore \quad P = \frac{25^2}{2\times 100} = 3.125\ \text{W}$$

92. (b)

$$\text{Transmission BW} = f_{m_1} + f_{m_2} + f_g$$
$$= 10\text{ kHz} + 15\text{ kHz} + 0.5\text{ kHz}$$
$$= 25.5\text{ kHz}$$

93. (b)

$$\Delta f = \frac{1}{2\pi}\frac{d\theta(t)}{dt}\bigg|_{\max} - f_c = \frac{3\times 2000\pi + 5\times 2000\pi}{2\pi} = 8000\text{ Hz}$$

94. (a)

$$\Delta V_d = \frac{\omega L_s I_d}{2\pi} = 50 \times 5 \times 10^{-3} \times 10 = 2.5\text{ V}$$
$$V_d = V_{d0} - \Delta V_d$$
$$= \frac{120}{180}\times 90 - 2.5 = 57.5\text{ V}$$

95. (d)

Diode is uncontrolled rectifying device, their on an off state in controlled by power supply. BJT, MOSFET, IGBT, SIT, MCT are turned on and off by the application of control signals.

96. (a)

$$V_g I_g = 0.4\text{ W}$$
$$E_s = R_s I_g + V_g$$
$$15 = 120 I_g + \frac{0.4}{I_g}$$
$$120 I_g^2 - 15 I_g + 0.4 = 0$$
$$I_g = 38.56\text{ mA}, 86.44\text{ mA}$$

For minimum gate current of 45 mA,

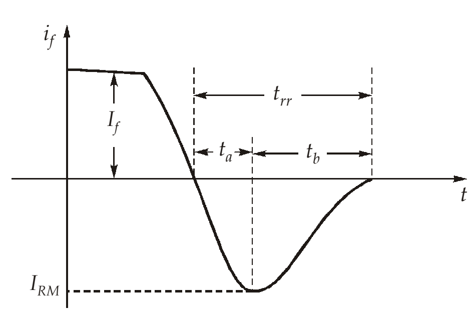
$$I_g = 86.44\text{ mA}$$

97. (b)

The reverse recovery time,

$$t_{rr} = 3.9\ \mu\text{s}$$

$$\text{Softness factor, } \left(\frac{t_b}{t_a}\right) = 0.3$$



$$t_{rr} = t_a + t_b = 3.9\ \mu s$$

$$t_a = \frac{3.9}{1.3} = 3\ \mu s$$

$$\frac{di}{dt} = \frac{I_{RM}}{t_a}$$

$$I_{RM} = 50 \times 3 = 150 \text{ Amp}$$

98. (d)

For unipolar switching

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

$$h = 2m_f - 1 = 2 \times 38 - 1 = 75$$

$$f_{75} = 75 \times 47 = 3525 \text{ Hz}$$

$$V_{D(75)} = \frac{V_d}{\sqrt{2}} \times m_a = \frac{300}{\sqrt{2}} \times 0.314 = 66.61 \text{ V}$$

99. (b)

$$I^2 \times \frac{1}{2f} = (4000)^2 \times \frac{1}{f}$$

$$I^2 = (4000)^2 \times 2$$

$$I = 4000\sqrt{2} \text{ A} = 5656.85$$

100. (a)

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

101. (c)

$$V_0 = \frac{V_m}{2\pi}(1 + \cos\alpha)$$

$$= \frac{400}{2\pi}(1 + \cos 60°) = \frac{300}{\pi} \text{V}$$

102. (a)

Output characteristic indicate the variation of drain current I_D as a function of drain-source voltage V_{DS}. PMOSFET has lower switching losses and higher conduction losses.

103. (a)

$$\text{D.R.F} = 1 - \text{string efficiency}$$

$$0.1 = 1 - \frac{6000}{n_s \times 1000} = 1 - \frac{1000}{n_p \times 200}$$

No. of series connected SCRs,

$$n_s = \frac{6000}{1000 \times 0.9} = 6.6 \simeq 7$$

No. of parallel - connected SCRs,

$$n_p = \frac{1000}{200 \times 0.9} = 5.5 \simeq 6$$

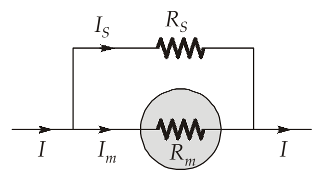
104. (a)

Instrument coil resistance, $R_m = 2\ \Omega$

Current flowing through the instrument for full scale deflection

$$I_m = \frac{\text{Full-scale reading in volts}}{R_m + \text{series resistance}}$$

$$= \frac{250}{2+5000} = 49.98\text{ mA}$$



Shunt resistance, $R_{sh} = 2 \times 10^{-3}\ \Omega$

Current through shunt resistance, $I_{sh} = \dfrac{I_m R_m}{R_{sh}} = \dfrac{49.98 \times 10^{-3} \times 2}{2 \times 10^{-3}} = 49.98\text{ A}$

Current range of instrument = Full-scale deflection current

$= I_m + I_{sh}$

$= 0.04998 + 49.98 \approx 50\text{ A}$

105. (c)

Wattmeter reading = Line current × Line current × sin ϕ

= 17 × 400 × 0.6 = 4080 W

106. (d)

Rms value of current under measurement,

I_{rms} = Hot-wire ammeter reading = 32 A

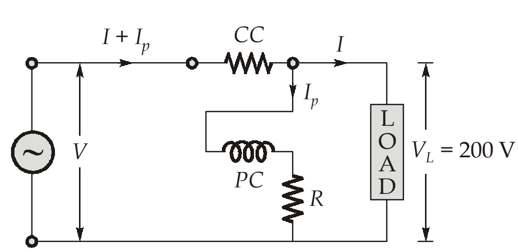
Average value of current under measurement,

$$I_{\text{avg}} = \frac{\text{Rectifier ammeter reading}}{1.11}$$

$$= \frac{30}{1.11}\text{A} = 27.027\text{ A}$$

Form factor, $K_f = \dfrac{I_{\text{rms}}}{I_{\text{avg}}} = \dfrac{32}{27.027} = 1.184$

107. (b)



$$\text{Wattmeter reading} = 250\text{ W}$$

$$\text{Pressure coil circuit resistance, } R_p = 2000\ \Omega$$

$$\text{Load voltage, } V_L = 200\text{ V}$$

$$\text{Power loss in pressure coil} = \frac{V_L^2}{R_P} = \frac{(200)^2}{2000} = \frac{200\times200}{2000} = 20\text{ W}$$

$$\text{Power taken by the load} = 250 - 20 = 230\text{ W}$$

108. (c)

$$\text{Energy consumption} = \frac{VI\cos\phi\times\text{hours}}{1000} = \frac{230\times4\times1.0\times6}{1000} = 5.52\text{ kWh}$$

$$\text{Meter constant in revolutions/kWh} = \frac{\text{Revolutions made by meter}}{\text{Energy consumed}}$$

$$= \frac{2208}{5.52} = 400$$

109. (a)

The resistance of standard resistor,

$$S = 0.02\ \Omega$$

Voltage drop across standard resistor,

$$V_S = 0.98\text{ V}$$

Voltage drop across resistor under test,

$$V_x = 0.735\text{ V}$$

$$\text{Resistance of resistor under test, } x = \frac{SV_x}{V_s} = \frac{0.02\times0.735}{0.98} = 0.015\ \Omega = 15\text{ m}\Omega$$

110. (b)

$$L_1 = \frac{CR_2}{R_4}\left[r(R_3+R_4)+R_3R_4\right]$$

$$= \frac{10\times10^{-6}\times1000}{1000}[469(218+1000)+218\times1000]$$

$$= 7.892\text{ H}$$

111. (b)

$$\text{Positive } Y\text{-peaks in pattern} = \frac{5}{2}$$

$$\text{Positive } X\text{-peaks in pattern} = 1$$

So,

$$\frac{f_y}{f_x} = \frac{5/2}{1} = \frac{5}{2}$$

$$\text{So frequency of vertical voltage} = \frac{5}{2}\times3 = 7.5\text{ kHz}$$

112. (c)

Since ratio error is given as

$$\text{Ratio error} = \frac{K_n - K_c}{K_c} = 0$$

Thus, $K_n = K_c$ the actual current ratio

As the burden is of unity power factor (i.e. purely resistive) and therefore, the secondary load angle γ is assumed zero

$$\text{Secondary current, } I_s = 5 \text{ A}$$

$$\text{Secondary voltage, } V_2 = \frac{\text{Load in VA}}{I_S} = \frac{5}{5} = 1 \text{ V}$$

$$\text{Secondary induced emf, } E_s = V_2 + I_sR_s$$

$$= 1 + 5 \times 0.02 = 1.1 \text{ V}$$

$$\text{Primary induced emf, } E_p = \frac{E_s}{\text{Turn-ratio}, K_T} = \frac{1.1}{198}$$

$$\text{Actual current ratio, } K_c = K_T + \frac{I_e}{I_s}$$

or,
$$200 = 198 + \frac{I_e}{5}$$

or,
$$I_e = 2 \times 5 = 10 \text{ A}$$

$$\text{Iron loss} = E_pI_e = \frac{1.1}{198} \times 10 = 55.55 \text{ mW}$$

113. (d)

If $x_1(n)$ is a sequence that is periodic with a period N_1 and $x_2(n)$ is another sequence that is periodic with a period N_2, then the sequence

$$x(n) = x_1(n) + x_2(n)$$

will always be periodic and the fundamental period is

$$N = \frac{N_1 \cdot N_2}{\text{gcd}(N_1, N_2)}$$

The same is true for the product $x(n) = x_1(n) \cdot x_2(n)$

114. (b)

Let $x(n)$ be any bounded input with $|x(n)| < \infty$

Then it follows that the output,

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

$$|y(n)| = |x^2(n)| < \infty$$

$\therefore$ $y(n)$ is also bounded,

$\therefore$ This system is stable,

$$y(n) = \frac{e^{x(n)}}{x(n-1)}$$

This system is clearly not stable. For example, note that the response of the system to a unit sample $x(n) = \delta(n)$ is infinite for all values of n except $n = 1$

$$y(n) = \log(1+|x(n)|)$$

if $x(n)$ is bounded, $|x(n)| < \infty$

$$|y(n)| = |\log(1+|x(n)|)| \le 1+|x(n)| < \infty \qquad [\because \log(1+x) \le x]$$

∴ Therefore, the output is bounded and the system is stable.

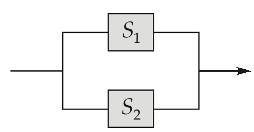
115. (a)

If both systems S_1 and S_2 are linear, then the parallel connection will also be linear,

Let, S_1 be $y(t) = x(t) + x(2t) + 7$

and S_2 be $y(t) = x(t) - x(2t) - 7$

Here both systems S_1 and S_2 are non-linear and time varying



$$y(t) = x(t) + x(2t) + 7 + x(t) - x(2t) - 7$$

$$\therefore \quad y(t) = 2\,x(t)$$

This system is linear and time invariant

∴ Both statements 2 and 3 are incorrect.

116. (b)

$$\text{Z-transform of } x(n) = \sum_{k=0}^{\infty} W(n-kN) \text{ is } X(z) = \frac{W(z)}{1-z^{-N}}$$

$$\text{Z-transform of } x(n) = \sum_{k=0}^{\infty} W(n-4k) \text{ is } X(z) = \frac{W(z)}{1-z^{-4}}$$

$$\omega(n) = \delta(n-1) + 2\delta(n-2) + \delta(n-3)$$

$$\therefore \quad W(z) = z^{-1} + 2z^{-2} + z^{-3}$$

$$= z^{-1}[1 + 2z^{-1} + z^{-2}]$$

$$\therefore \quad X(z) = \frac{z^{-1}[1+2z^{-1}+z^{-2}]}{1-z^{-4}}$$

118. (c)

$$x(t) = \sum_{n=-\infty}^{\infty} \delta(t-5n)$$

$$\text{Fourier transform of } x(t) = W_0 \sum_{n=-\infty}^{\infty} \delta(\omega - k\omega_0)$$

Where, $$\omega_0 = \frac{2\pi}{T}$$

and $$\delta(\omega) = \frac{1}{2\pi}\delta(f)$$

$$\therefore \quad \frac{2\pi}{5}\sum_{n=-\infty}^{\infty} \delta\left(2\pi\left(f - \frac{n}{5}\right)\right) = \frac{1}{5}\sum_{n=-\infty}^{\infty} \delta\left(f - \frac{n}{5}\right)$$

119. (a)

$$\cos(\omega t + \alpha) - \cos(\omega t - \alpha) = \cos \omega t \cos \alpha - \sin \omega t \cdot \sin \alpha - \cos \omega t \cos \alpha - \sin \omega t \cdot \sin \alpha$$
$$= -2 \sin \omega t \cdot \sin \alpha$$

$$L[-2\sin\omega t \cdot \sin\alpha] = -2\frac{\omega}{s^2 + \omega^2}\sin\alpha$$

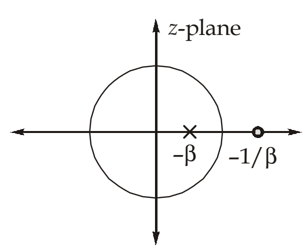
120. (c)

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

Also, $|\beta| < 1$ and ROC: $|z| < |\beta|$ (left side signal)

it is clear that the system $H(z)$ has a zero at $\frac{-1}{\beta}$ and pole at $-\beta$.

$\therefore$ $|\beta| < 1$ thus zero> pole



This system represents an all pass filter.

121. (a)

$$\text{The characteristic equation of } A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

$$|A - \lambda I| = \begin{vmatrix} 1-\lambda & 2 \\ 3 & 4-\lambda \end{vmatrix} = 0$$

$$(1 - \lambda)(4 - \lambda) - 6 = 0$$

$$4 - \lambda - 4\lambda + \lambda^2 - 6 = 0$$
$$\lambda^2 - 5\lambda - 2 = 0$$

Now, $A^4 - 5A^3 - A^2 - 5A - 2I = A^4 - 5A^3 - 2A^2 - 5A - 2I + A^2$

$$= A^2(A^2 - 5A - 2I) + A^2 - 5A - 2I$$
$$= 0$$

122. (c)

The above system will have non-trival solution if

$$A = \begin{vmatrix} 3 & -2 & 1 \\ \lambda & -14 & 15 \\ 1 & 2 & -3 \end{vmatrix} = 0$$

$$3(42 - 30) + 2(-3\lambda - 15) + 1(2\lambda + 14) = 0$$
$$36 - 6\lambda - 30 + 2\lambda + 14 = 0$$
$$-4\lambda = -20$$
$$\lambda = 5$$

123. (c)

$$f(x, y) = x^2 + y^2 + 6x + 12$$
$$\frac{\partial f}{\partial x} = 2x + 6 ; \qquad r = \frac{\partial^2 f}{\partial x^2} = 2$$
$$\frac{\partial f}{\partial y} = 2y ; \qquad s = \frac{\partial^2 f}{\partial x \partial y} = 0$$
$$t = \frac{\partial^2 f}{\partial y^2} = 2$$

For maxima and minima, $\frac{\partial f}{\partial x} = 0$

and $\frac{\partial f}{\partial y} = 0$

$$2x + 6 = 0$$

and $2y = 0$

$$x = -3$$

and $y = 0$

At (–3, 0), $rt - s^2 = 2 \times 2 - 0 = 4 > 0$

$$r = 2 > 0$$

Hence $f(x, y)$ is minimum when $x = -3$ and $y = 0$.

Minimum value $= f(-3, 0)$

$$= 9 + 0 - 18 + 12$$
$$= 3$$

124. (a)

The characteristic equation is:

$$m^2 - 8m + 16 = 0$$

$$m_1 = m_2 = 4$$

The solution takes the form:

$$x(t) = A_1 e^{4t} + A_2 te^{4t}$$

The arbitrary constants are evaluated using the initial conditions,

$$x(0) = 2 = A_1$$

$$x'(t) = 4A_1 e^{4t} + A_2 t\, 4e^{4t} + A_2 e^{4t}$$

$$x'(0) = 4A_1 + A_2 = 4$$

$$A_2 = -4$$

Thus, the general solution is: $2e^{4t} - 4te^{4t}$

125. (b)

Since C is the unit circle, its equation is

$$|z| = 1$$

or $$z = e^{i\theta}$$

$\therefore$ $$dz = ie^{i\theta}d\theta$$

$$\oint_C \ln z\, dz = \int_0^{2\pi} \ln e^{i\theta} \cdot ie^{i\theta} d\theta$$

$$= i\int_0^{2\pi} i\theta \cdot e^{i\theta} d\theta = -\int_0^{2\pi} \theta \cdot e^{i\theta} d\theta$$

$$= \left[\left\{\frac{\theta \cdot e^{i\theta}}{i}\right\}_0^{2\pi} - \int_0^{2\pi} \frac{e^{i\theta}}{i} d\theta\right]$$

$$= -\frac{1}{i}\left[\left(2\pi e^{2\pi i} - 0\right) - \left(\frac{e^{i\theta}}{i}\right)_0^{2\pi}\right]$$

$$= -\frac{1}{i}\left[2\pi - \frac{1}{i}\left(e^{2\pi i} - e^0\right)\right]$$

$$= -\frac{1}{i}\left[2\pi - \frac{1}{i}(1-1)\right]$$

$$= \frac{-2\pi}{i} = 2\pi i$$

126. (c)

Three tickets can be drawn out of 100 in $^{100}C_3$ ways. These are exhaustive number of cases. Out of 100 tickets, 50 are odd numbered.

Hence 3 tickets out of there 50 can be drawn in $^{50}C_3$ ways. They are favourable number of cases

$$\therefore \quad \text{Required probability} = \frac{^{50}C_3}{^{100}C_3} = \frac{50 \times 49 \times 48}{3 \times 2 \times 1} \times \frac{3 \times 2 \times 1}{100 \times 99 \times 98} = \frac{4}{33}$$

127. (c)

We have,

$$x_{k+1} = x_k - \frac{f(x_k)}{f'(x_k)}$$

$$f(x) = x^3 - x - 1$$

$$f(x_k) = x_k^3 - x_k - 1$$

$$f'(x_k) = 3x_k^2 - 1$$

$$\therefore \quad x_{k+1} = x_k - \frac{x_k^3 - x_k - 1}{3x_k^2 - 1}$$

$$= \frac{3x_k^3 - x_k - x_k^3 + x_k + 1}{3x_k^2 - 1} = \frac{2x_k^3 + 1}{3x_k^2 - 1}$$

128. (d)

Since,

$$\sin 2t \sin 3t = \frac{1}{2}[\cos t - \cos 5t]$$

$$= \frac{1}{2}\left[\frac{s}{s^2+1} - \frac{s}{s^2+25}\right]$$

$$= \frac{12s}{(s^2+1)(s^2+25)}$$

129. (b)

$$f(x) = x(x-1)(x-2)$$

$$= x(x^2 - 3x + 2) = x^3 - 3x^2 + 2x$$

$$f'(x) = 3x^2 - 6x + 2$$

$$f(0) = 0 \quad \text{...(i)}$$

$$f(0.5) = \frac{1}{2} \times \frac{-1}{2} \times \frac{-3}{2} = \frac{3}{8} \quad \text{...(ii)}$$

$$f'(c) = 3c^2 - 6c + 2 \quad \text{...(iii)}$$

Given mean value theorem,

$$f(b) - f(a) = (b-a) f'(c) \quad \text{...(iv)}$$

Substituting (i), (ii) and (iii) in equation (iv),

$$\left(\frac{3}{8}-0\right) = \left(\frac{1}{2}-0\right)(3c^2-6c+2)$$

$$\frac{3}{4} = 3c^2 - 6c + 2$$

$$3 = 12c^2 - 24c + 8$$

$$12c^2 - 24c + 5 = 0$$

Hence,
$$c = \frac{24 \pm \sqrt{(24)^2 - 4\times 12\times 5}}{24}$$

$$= \frac{24 \pm \sqrt{576-240}}{24}$$

$$= \frac{24 \pm 18.33}{24} = 0.236,\ 1.764$$

0.236 is correct choice for c value.

130. (c)

Let, $\phi = x^2y^2z^2$

Directional derivative of ϕ, $\nabla\phi = \left(\hat{i}\frac{\partial}{\partial x}+\hat{j}\frac{\partial}{\partial y}+\hat{k}\frac{\partial}{\partial z}\right)(x^2y^2z^2)$

$$\nabla\phi = 2xy^2z^2\hat{i} + 2yx^2z^2\hat{j} + 2zx^2y^2\hat{k}$$

Directional derivative of ϕ at (1, 1, –1)

$$= 2(1)(1)^2(-1)^2\hat{i} + 2(1)(1)^2(-1)^2\hat{j} + 2(-1)(1)^2(1)^2\hat{k}$$

$$= 2\hat{i} + 2\hat{j} - 2\hat{k}$$

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$

$$= e^t\hat{i} + (\sin 2t + 1)\hat{j} + (1-\cos t)\hat{k}$$

Tangent vector, $\vec{T} = \frac{d\vec{r}}{dt} = e^t\hat{i} + 2\cos 2t\,\hat{j} + \sin t\,\hat{k}$

Tangent (at $t = 0$) $\vec{T} = \hat{i} + 2\hat{j}$

Required directional derivative along tangent

$$= \left(2\hat{i}+2\hat{j}-2\hat{k}\right)\frac{(\hat{i}+2\hat{j})}{\sqrt{1+4}} = \frac{2+4+0}{\sqrt{5}} = \frac{6}{\sqrt{5}}$$

131. (d)

If $R_{Th} = 0$, then the Thevenin's equivalent circuit behaves as an ideal voltage source. It is not possible to apply source transformation to the ideal sources. Thus it is not always possible to obtain Norton's equivalent from Thevenin's equivalent.

132. (d)

Superposition theorem is applicable only for linear bilateral network. It is not directly applicable for power calculations.

133. (b)

Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).

137. (d)

In parallel operation equivalent leakage impedances in ohms are inversely proportional to their respective kVA rating.

138. (c)

Power transformers are designed for maximum efficiency occurring near the rated output. It is the distribution transformer which are designed for maximum efficiency at (75 - 80%) of full load.

139. (b)

Universal motor can operate on 1-ϕ ac, supply and dc supply and hence are called universal motor.

141. (c)

In LLG fault, $V_{R1} = V_{R2} = V_{R0}$

and $I_f = 3\, I_{R0}$

So statement (I) is true but statement (II) is false.

142. (c)

Including a resistor R_s in the source lead results in reduction of gain.

143. (c)

The output impedance for most FET configurations is determined primarily by R_D. For the source follower configuration it is determined by R_S and g_m.

149. (d)

Consider the system function,

$$H(s) = \frac{e^s}{s+1}, \quad \text{Re}(s) > -1$$

For this system, the ROC is to the right of the right most pole. Therefore the impulse response must be right sided.

$$e^{-t} \cdot u(t) \xleftrightarrow{\text{L.T.}} \frac{1}{s+1}, \qquad \text{Re}(s) > -1$$

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

So that the impulse response associated with the system is

$$h(t) = e^{-(t+1)}\, u(t+1)$$

Which is non zero for $-1 < t < 0$.

Hence the system is not causal. The causality implies that the ROC is to the right of the right most pole, but the converse is not true.

❍❍❍❍