DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 24

Full Syllabus Test 8 : Paper-II

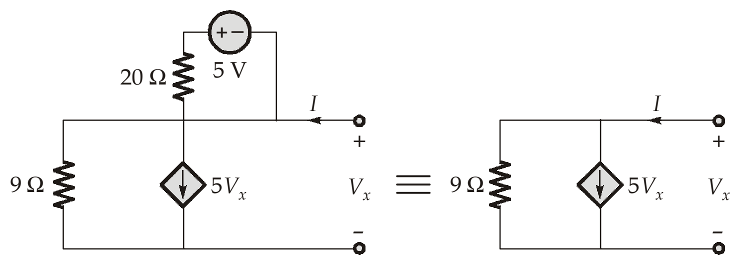
1.	(d)	**26.**	(a)	**51.**	(c)	**76.**	(b)	**101.**	(b)	**126.**	(b)
2.	(c)	**27.**	(b)	**52.**	(a)	**77.**	(d)	**102.**	(a)	**127.**	(c)
3.	(a)	**28.**	(c)	**53.**	(c)	**78.**	(c)	**103.**	(b)	**128.**	(a)
4.	(d)	**29.**	(a)	**54.**	(b)	**79.**	(a)	**104.**	(c)	**129.**	(d)
5.	(b)	**30.**	(a)	**55.**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

NOTE: Question No. 39 Answer key has been updated.

DETAILED EXPLANATIONS

1. (d)

For calculation of R_{th}, the circuit can be redrawn as



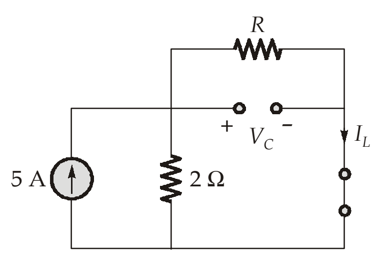
Using KCL, we get

$$\frac{V_x}{9} + 5V_x = I$$

$$46\ V_x = 9I$$

or $$\frac{V_x}{I} = \frac{9}{46} = 0.195\ \Omega$$

2. (c)



Under steady state conditions,

$$I_L = \frac{2}{2+R} \times 5 = \frac{10}{2+R}$$

$$V_C = I_L \times R = \frac{10R}{2+R}$$

Energy stored in capacitor = Energy stored in inductor

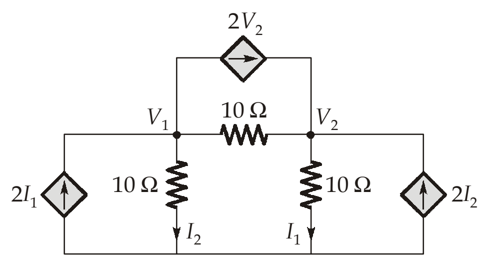
$$\frac{1}{2}CV_c^2 = \frac{1}{2}L\,I_L^2$$

$$\frac{1}{2} \times 160 \times 10^{-6} \times \left(\frac{10R}{2+R}\right)^2 = \frac{1}{2} \times 4 \times 10^{-3} \times \left(\frac{10}{2+R}\right)^2$$

$$R^2 = \frac{4 \times 10^{-3}}{160 \times 10^{-6}} = 25$$

$$R = 5\ \Omega$$

3. (a)



From the figure,

$$I_1 = \frac{V_2}{10} \text{ and } I_2 = \frac{V_1}{10}$$

Applying KCL at node-1,

$$2I_1 = \frac{V_1}{10} + \frac{V_1 - V_2}{10} + 2V_2$$

$$2\left(\frac{V_2}{10}\right) = \frac{V_1}{10} + \frac{V_1}{10} - \frac{V_2}{10} + 2V_2$$

$$2\,V_2 = V_1 + V_1 - V_2 + 20\,V_2$$

$$2V_1 + 17\,V_2 = 0 \qquad \text{...(i)}$$

Applying KCL at node-2,

$$2I_2 + 2V_2 = \frac{V_2 - V_1}{10} + \frac{V_2}{10}$$

$$2\left(\frac{V_1}{10}\right) + 2V_2 = \frac{V_2}{10} - \frac{V_1}{10} + \frac{V_2}{10}$$

$$3V_1 + 18V_2 = 0 \qquad \text{...(ii)}$$

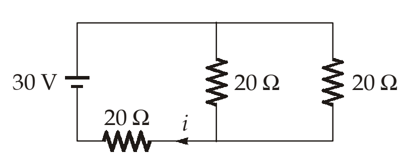
Solving (i) and (ii), we get

$$V_1 = V_2 = 0 \text{ V}$$

4. (d)

At $t = 0^-$

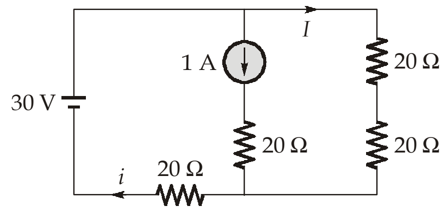
The inductor will be short,



$$\therefore \qquad i = \frac{30}{30} = 1 \text{ A}$$

current through inductor at $t = 0^+$

$$I_L(0^-) = I_L(0^+) = 1 \text{ A}$$



Applying KVL in outer loop,

$$30 = (20 + 20)I + 20i \quad \text{...(i)}$$

$$i = I + 1 \quad \text{...(ii)}$$

$$30 = 40I + 20(I + 1)$$

$$I = \frac{1}{6}\text{A}$$

Hence current, $i = I + 1 = \frac{7}{6}\text{A} = 1.16 \text{ A}$

5. (b)

Charge, $Q = CV = 4 \times 12 = 48 \text{ C}$

After closing the switch,

charge $Q = (C_1 + C_2)V_1$

Where V_1 is common terminal voltage

$$48 = (4 + 2)V_1$$

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

The energy stored after closing the switch

$$= \frac{1}{2}CV_1^2 = \frac{1}{2}(4+2)8^2 = 192 \text{ J}$$

6. (b)

$$i = \frac{60}{12} + \frac{60}{4} = 20 \text{ A}$$

$$i = \frac{100 - 60}{R}$$

$$R = \frac{40}{20} = 2\ \Omega$$

7. (c)

At resonance, $2\pi f L = \frac{1}{2\pi f C}$

$\therefore$ $C = \frac{1}{(2\pi \times 50)^2 \times 0.4} = 25.3\ \mu\text{F}$

9. (d)

Solving the equations,

$$V_1 = 10I_1 + 4I_2 \quad \text{...(i)}$$
$$V_2 = 4I_1 + 2I_2 \quad \text{...(ii)}$$
$$V_2 = -6I_2 \quad \text{...(iii)}$$
$$V_1 = 8I_1$$

Hence, input impedance $= \dfrac{V_1}{I_1} = 8\ \Omega$

10. (c)

The 8 H and 4 H coils can be replaced by a single coil having an inductance of

$$L = \frac{L_1L_2 - M^2}{L_1 + L_2 - 2M} = \frac{8\times4-2^2}{8+4-2\times2}$$
$$= \frac{28}{8} = 3.5 \text{ H}$$

Hence the equivalent inductance of the circuit is obtained as

$$L_{eq} = 6.5 + 3.5$$
$$= 10 \text{ H}$$

11. (c)

Writing KCL for the node, assuming node voltage, V

$$\frac{V-10}{10} + \frac{V-12}{20} - 3 = 0$$
$$\frac{2V-20+V-12}{20} = 3$$
$$3V = 60 + 32$$

Node voltage, $V = \dfrac{92}{3}$ V

Power delivered by the current source

$$= \frac{92}{3}\times 3 = 92 \text{ W}$$

12. (b)

For the power transfer to be maximum, the load impedance should be complex conjugate of the source impedance.

Hence $Z_L = 5.4 + j7.8\ \Omega$

$$\text{Current, } I = \frac{V}{Z_{\text{total}}} = \frac{12+j0}{5.4-j7.8+5.4+j7.8}$$
$$= \frac{12+j0}{10.8+j0} = 1.11 \text{ A}$$
$$P_L = I^2R = (1.11)^2\,(5.4) = 6.67 \text{ W}$$

13. (d)

Consider the length of the coaxial cable as L

Let V_0 be the potential difference between the inner and outer conductors so that,

$$V_{(\rho = a)} = 0$$

and

$$V_{(\rho = b)} = V_0$$

$$\vec{J} = \sigma\vec{E} = \frac{-\sigma V_0}{\rho \ln \frac{b}{a}}\hat{a}_\rho$$

$$\vec{dS} = -\rho d\phi\, dz\, \hat{a}_\rho$$

$$I = \int \vec{J}\cdot\vec{dS} = \int_{\phi=0}^{2\pi}\int_{z=0}^{L} \frac{V_0\sigma}{\rho\ln\frac{b}{a}}\rho\, d\phi\, dz = \frac{2\pi L\sigma V_0}{\ln\frac{b}{a}}$$

$$R = \frac{V_0}{I} = \frac{\ln\left(\frac{b}{a}\right)}{2\pi\sigma L}$$

The conductance per unit length is,

$$\frac{G}{L} = \frac{1}{RL} = \frac{2\pi\sigma}{\ln\left(\frac{b}{a}\right)}$$

14. (b)

According to Ampere's law,

$$I_{\text{enc}} = \oint_{r=r_0} \vec{H}\cdot dl$$

$$= \int_0^{2\pi} \frac{10^4}{r_0}\left(\frac{4r_0^2}{\pi^2}\sin\frac{\pi}{2} - \frac{2r_0^2}{\pi}\cos\frac{\pi}{2}\right)\cdot r_0\, d\phi$$

$$= 10^4 \int_0^{2\pi} \frac{4r_0^2}{\pi^2}\, d\phi$$

$$I_{\text{enc}} = 10^4 \cdot \frac{4r_0^2}{\pi} \times 2 = \frac{8}{\pi}\text{ Ampere}$$

15. (a)

The expression for force per meter length is,

$$F = \frac{\mu_0 I_1 I_2}{2\pi D}$$

Where, $I_1 = I_2 = 40$ A

distance, $D = 5 \times 10^{-2}$ m

$$F = 2\times10^{-7} \times \frac{40\times40}{5\times10^{-2}}$$

$$F = 6.4 \times 10^{-3}\text{ N}$$

The force will be repulsive in nature.

16. (c)

The magnetic flux density is,

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

$$= \frac{1}{r^2 \sin\theta} \begin{vmatrix} \hat{a}_r & r\,\hat{a}_\theta & r\sin\theta\hat{a}_\phi \\ \frac{\partial}{\partial r} & \frac{\partial}{d\theta} & \frac{\partial}{\partial \phi} \\ 0 & r(10\sin\theta) & 0 \end{vmatrix}$$

$$= \frac{1}{r^2 \sin\theta}\left[-\frac{\partial}{\partial\phi}(10\,r\sin\theta)\right]\hat{a}_r - \frac{r}{r^2\sin\theta}\left[\frac{\partial}{\partial r}(0)\right]\hat{a}_\theta + \frac{10\,r\sin^2\theta}{r^2\sin\theta}\left[\frac{\partial}{\partial r}(r)\right]\hat{a}_\phi$$

$$= \frac{10\sin\theta}{r}\,\hat{a}_\phi$$

$$\vec{B}\left(2, \frac{\pi}{2}, 0\right) = \frac{10\sin\pi/2}{2}\hat{a}_\phi = 5\,\hat{a}_\phi \text{ Wb/m}^2$$

17. (b)

There are six forward paths,

Forward path-1, $R - x_1 - x_2 - x_3 - x_6 - C$

Forward path-2, $R - x_1 - x_2 - x_5 - x_6 - C$

Forward path-3, $R - x_1 - x_2 - x_5 - x_4 - x_3 - x_6 - C$

Forward path-4, $R - x_1 - x_4 - x_5 - x_6 - C$

Forward path-5, $R - x_1 - x_4 - x_3 - x_6 - C$

Forward path-6, $R - x_1 - x_4 - x_3 - x_2 - x_5 - x_6 - C$

18. (b)

The closed-loop transfer function of the given unity feedback system is

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)} = \frac{\frac{K}{s(s+10)}}{1+\frac{K}{s(s+10)}} = \frac{K}{s^2+10s+K}$$

Comparing it with the standard form of the transfer function of a second-order system. We have

$$\frac{C(s)}{R(s)} = \frac{K}{s^2+10s+K} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$$

$$\omega_n^2 = K$$

$$\omega_n = \sqrt{K}$$

$$2\xi\omega_n = 10$$

$$2 \times 0.5 \times \omega_n = 10$$

$$\omega_n = 10$$

$$\therefore \quad K = \omega_n^2 = 10^2 = 100$$

For damping ratio of 0.5 gain $K = 100$.

19. (d)

The characteristic equation of the system is

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

$$1+\frac{K(1-s)}{s(s^2+5s+9)} = 0$$

$$s^3 + 5s^2 + (9 - K)s + K = 0$$

Forming the Routh array, we have

s^3	1	$9-K$
s^2	5	K
s^1	$\frac{5(9-K)-1\times K}{5}$	0
s^0	K	

For the system to be stable, all the elements in the first column of the routh array must be positive.

From the s^0 row, $K > 0$

From the s^1 row,

$$5(9 - K) - 1 \times K > 0$$

$$45 - 6K > 0$$

i.e. $K < \frac{45}{6} = 7.5$

The maximum value of K for the closed loop system to be stable is $K = 7.5$

20. (d)

All statements are correct.

21. (b)

The number of states required to describe a network is equal to the number of energy storing elements in the network. Here there are two energy storage elements L and C thus the number of states required are two.

22. (d)

Slope changes from +20 dB/decade to –60 dB/decade hence number of poles are 4.

23. (b)

$$-3\tan^{-1}\omega = -180°$$

$\therefore$ $\tan^{-1}\omega = 60°$

$\therefore$ $\omega = \sqrt{3}$ rad/sec (phase crossover frequency)

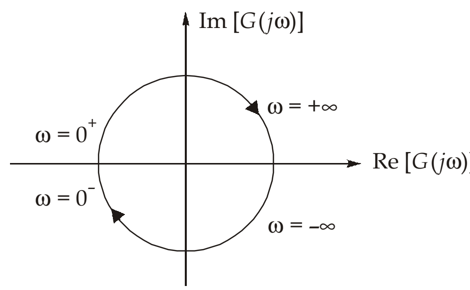
24. (b)

$$G(s) = \frac{s-1}{s+1};$$

$$G(j\omega) = \frac{j\omega-1}{j\omega+1} = 1\angle(180° - 2\tan^{-1}\omega)$$

$$\text{on varying, } \omega = 0^+ \text{ to } +\infty$$
$$\text{Now on varying } \omega = -\infty \text{ to } 0^-$$
$$G(j\omega)\big|_{\omega=0} = 1\angle 180°$$
$$G(j\omega)\big|_{\omega=0^-} = 1\angle 180°$$
$$G(j\omega)\big|_{\omega=1} = 1\angle 90°$$
$$G(j\omega)\big|_{\omega=-1} = 1\angle 270°$$
$$G(j\omega)\big|_{\omega=\infty} = 1\angle 0°$$
$$G(j\omega)\big|_{\omega=-\infty} = 1\angle 360°$$

On plotting



∴ No of times the Nyquist plot encircle the origin clockwise = 1.

25. (c)

$$\text{Centroid 'S'} = \frac{0+0-(-1)}{2-1} = 1$$

26. (a)

The Hall coefficient is

$$R_H = \frac{1}{ne} = \frac{E_y}{J_x B}$$

$$R_H = \frac{V_y}{bJ_x B}$$

$$E_y = \frac{V_y}{b}$$

The current density, $$J_x = \frac{I_x}{bt} = \frac{\text{current}}{\text{area of cross section}}$$

$$R_H = \frac{V_y}{bB} \times \frac{bt}{I_x} = \frac{V_y t}{BI_x}$$

$$= \frac{40\times10^{-6}\times1\times10^{-3}}{1\times10\times10^{-3}} = 4 \times 10^{-6}\ \text{m}^3/\text{C}$$

27. (b)

The directions of angular momentum and dipole moment are opposite to each other.

28. (c)

Given that, $\lambda = 2 \times 10^{-10}$ m,

$\theta = 60°$,

$n = 1$

Bragg's equation, $2d \sin\theta = n\lambda$

$$d = \frac{n\lambda}{2\sin\theta} = \frac{1 \times 2}{2 \times \sin 60°} \times 10^{-10}$$

$$d = \frac{2}{\sqrt{3}} = 1.15 \times 10^{-10}\,\text{m}$$

29. (a)

When a dielectric is subjected to ac fields, the polarization decreases with increasing frequency. This is because the ionic polarization and the dipolar polarization, which are slower processes cannot follow the rapidly varying electric fields. So, at higher frequencies, the contribution to polarization is only from the electronic polarization.

30. (a)

Critical value of the magnetic field,

$$H_C = 7900 \text{ A/m}$$

Radius of conductor, $r = 2 \times 10^{-3}$ m

According to Silsbee's rule,

Critical current, $I_C = 2\pi r H_c$

$= 2\pi \times 2 \times 10^{-3} \times 7900$

$I_C = 99.27$ A

31. (b)

Superconductor is a diamagnetic material, which repel the external magnetic field.

33. (d)

Antiferro magnetic property is observed only below a certain temperature known as Neel temperature, which is due to ordered antiparallel alignment of spin magnetic moments. Above Neel temperature, antiferro magnetic materials become paramagnetic.

34. (a)

Dielectric susceptibility, $\chi_e = \varepsilon_r - 1$

$= 1.000074 - 1$

$= 0.000074$

35. (a)

The value of new torque of motor by reduction of armature current to 60% of rated value, the torque of the motor is reduced to 36% of rated value.

36. (d)

For given magnetic circuit,

The reluctance of core, $\Re = \frac{1}{\mu_0 \mu_r}\frac{l}{A}$

$$\Re = \frac{1}{4\pi \times 10^{-7} \times 3200} \times \frac{2.56}{32 \times 10^{-4}}$$

$$= \frac{1.6 \times 1.6}{4\pi \times 10^{-7} \times 32 \times 32 \times 10^{-2}} = \frac{1 \times 10^{7}}{16\pi}$$

Flux in core, $\phi = \frac{MMF}{\Re} = \frac{200 \times 2 \times 16\pi}{10^{7}} = 64\pi \times 10^{-5}$ Wb

Energy stored $= \frac{1}{2}LI^2$

and $L = \frac{N\phi}{I}$

Magnetic energy stored $= \frac{1}{2} \times \frac{N\phi}{I} \times I^2 = \frac{1}{2} \times N\phi I$

$$= \frac{1}{2} \times 200 \times 64 \times \pi \times 10^{-5} \times 2$$

$$= 12800\pi \times 10^{-5} = 128\pi \text{ mJ}$$

37. (b)

- In a dc generator, the ripples in emf generated are reduced by employing commutator with large number of segments.
- In dc machine, the number of commutator segments is equal to number of armature coil. If there are x coil sides, number of commutator segment is $x/2$.

38. (b)

Core of the transformer should have high permeability and low reluctance.

39. (b)

Given, Number of phase = 3,

Number of poles, $P = 8$,

$f = 50$ Hz

coil span = 12 slots,

Total number of slots in stator = 120

Number of conductor per slot = 10

∴ Total number of conductors = 120 × 10 = 1200

Number of turns per phase, $N_{ph} = \frac{1200}{2 \times 3} = 200$

Angular slot pitch, $\gamma = \frac{180° \times P}{\text{Total number of slots}} = \frac{180 \times 8}{120} = 12°$

$$\text{Slot/pole/phase} = \frac{120}{8 \times 3} = 5$$

$$\text{Coil span angle} = 12\,\gamma = 12 \times 12° = 144°$$

$$\text{Chording angle } (\in) = 180° - 144° = 36°$$

$$\text{Pitch factor, } K_p = \cos\frac{36°}{2} = \cos 18°$$

$$\text{Distribution factor, } K_d = \frac{\sin\dfrac{5\times 12°}{2}}{5\sin\dfrac{12°}{2}} = \frac{\sin 30°}{5\sin 6°} = \frac{1}{10\sin 6°}$$

40. (b)

Given, Number of poles, $P = 6$

frequency, $f = 50$ Hz

$N_{max} = 875$ rpm

$T_{max} = 160$ N-m

Slip at full load, $s_{fL} = 0.04$

$r_2 = 0.2\ \Omega$/phase

$$\text{Synchronous speed } (N_s) = \frac{120f}{P} = \frac{120\times 50}{6} = 1000 \text{ rpm}$$

$$s_{\max,T} = \frac{N_S - N_{\max}}{N_S} = \frac{1000-875}{1000} = \frac{125}{1000}$$

$$\text{Using relation, } \frac{T_{fl}}{T_{\max}} = \frac{2}{\dfrac{s_{fl}}{s_{\max,T}} + \dfrac{s_{\max,T}}{s_{fl}}}$$

$$T_{fl} = \left(\frac{2}{\dfrac{s_{fl}}{s_{\max,T}} + \dfrac{s_{\max,T}}{s_{fl}}}\right)\times T_{\max} = \left(\frac{2}{\dfrac{0.04}{0.125}+\dfrac{0.125}{0.04}}\right)\times 160$$

$$= \left(\frac{2}{0.32+3.125}\right)\times 160 = 92.89 \text{ N-m}$$

41. (d)

From open circuit test, $P_{oc} = P_i = 200$ W

From short circuit test, $P_{cu} = 240$ W

$$P_{cu} \text{ at half load } P_{cu\,(half)} = \left(\frac{1}{2}\right)^2 \times 240\,\text{W} = 60 \text{ W}$$

$$\text{Efficiency at half load } (\eta_{1/2}) = \frac{40000\times\dfrac{1}{2}}{40000\times\dfrac{1}{2}+60+200} = \frac{20000}{20000+260} \simeq 0.9872 \text{ or } 98.72\%$$

42. (c)

Both statements are correct.

43. (d)

$$\text{Total copper loss} = I_a^2 r_a + I_f^2 R_f$$

$$\text{Field current, } I_f = \frac{V_t}{R_f} = \frac{200}{50} = 4 \text{ A}$$

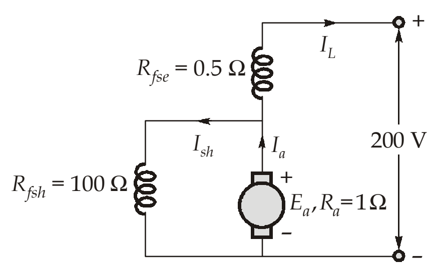
$$\text{Armature current, } I_a = I_L - I_f = 10 - 4 = 6 \text{ A}$$

$$\text{Total copper loss at no load} = (6)^2 \times 1 + (4)^2 \times 50$$

$$= 36 + 800 = 836 \text{ W}$$

44. (b)

The equivalent circuit for short shunt configuration



$$\text{Load current} = \frac{\text{Load power}}{\text{Terminal voltage}} = \frac{4000}{200} = 20 \text{ A}$$

Voltage drop across series field resistance,

$$= I_{se} \times R_{se}$$

$$= 0.5 \times 20 = 10 \text{ V}$$

Voltage drop across shunt field resistance,

$$= V_t - V_{se}$$

$$= 200 - 10 = 190 \text{ V}$$

$$\text{Shunt field current } (I_{sh}) = \frac{190}{100} = 1.9 \text{ A}$$

$$\text{Series field current} = \text{Load current} = 20 \text{ A}$$

$$\text{Armature current, } I_a = 20 + 1.9 = 21.9 \text{ A}$$

Total voltage drop across brushes

$$= 1 \times 2 = 2 \text{ V}$$

$$E_g = V_b + I_a r_a + I_{se} \times R_{fse} + V_t$$

$$\text{rated emf} = (2) + (21.9 \times 1) + (20 \times 0.5) + 200$$

$$= 233.9 \text{ V}$$

45. (c)

We know, $V_t = 20 - 0.5\, I_L$ ...(i)

Power delivered to load = 200 W

$V_t \times I_L = 200$ ...(ii)

Using equation (i) and (ii),

$$(20 - 0.5I_L)I_L = 200$$

$$20I_L - 0.5I_L^2 = 200$$

$$40I_L - I_L^2 = 400$$

$$I_L^2 - 40I_L + 400 = 0$$

$$I_L = 20 \text{ A}$$

Terminal voltage, $V_t = 20 - 20 \times 0.5 = 10$ V

Load resistance, $R_L = \dfrac{V_t}{I_L} = \dfrac{10}{20} = 0.5\ \Omega$

46. (c)

Given,

Full load shaft power = 14500 W

Mechanical power developed = Shaft power + windage and friction loss
= 14500 + 500
= 15000 W

$$\text{Synchronous speed} = \frac{120 \times 60}{4} = 1800 \text{ rpm}$$

$$\text{Slip, } s = \frac{1800 - 1728}{1800} = \frac{72}{1800} = 0.04$$

$$\text{Airgap power, } P_{ag} = \frac{15000}{1 - 0.04} = 15625 \text{ W}$$

Rotor copper loss, $P_2 = 0.04 \times 15625 = 625$ W

47. (d)

Medium-term scheduler can transit a job from 'ready' to 'suspended ready'.

If event occurs for suspend blocked job then it can move to 'suspend ready'.

Medium term scheduler can transit a job from 'suspend ready' to 'ready'.

∴ All given statements are correct.

48. (c)

Here structure creates the memory for array and union, but union creates the memory for only 'long z' which is maximum among all data types in union

u = max (2, 4, 8) = 8

∴ t = 20 + 8 = 28

49. (d)

RISC processor has hardwired control unit. In hardwired control unit, the control units use fixed logic circuits to interpret instructions and generate control signals from them.

50. (d)

	P_1	P_2	P_3	P_4	P_3	P_4	P_3	P_4	P_2	P_3	P_4	P_2	P_3	P_4	P_1	P_2	P_3	P_4

0 1 2 3 4 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Process	Arrival Time	Burst Time	C.T.	TAT
P_1	1	2	18	17
P_2	2	4	19	17
P_3	3	6	20	17
P_4	4	8	21	17
				Average TAT = 68/4 = 17

51. (c)

From at

1 bit	8 bit	23 bit
Sign	Exponent	Mantissa

← 32 →

1	10000011	11110000 . . . 0

$= (-1)^s\ (1.E) \times 2^{E-127}$

$= (-1)^1\ (1.1111) \times 2^{131-127}$

$= -(1.1111) \times 2^4$

$= -[2^0 \times 1 + 2^{-1} \times 1 + 2^{-2} \times 1 + 2^{-3} \times 1 + 2^{-4} \times 1] \times 2^4$

$= -[2^4 + 2^3 + 2^2 + 2^1 + 2^0]$

$= -(31)_{10}$

52. (a)

$$\text{CPI} = \frac{\sum (J_i \times CP_i)}{I_C} = \frac{[45000 \times 1 + 32000 \times 2 + 15000 \times 2 + 8000 \times 2]}{10^5}$$

$$= \frac{155000}{10^5} = \frac{155}{10^2} = 1.55$$

$$\text{Execution time} = \frac{I_C \times CPI}{f} = \frac{10^5 \times 1.55}{40 \times 10^6} = 3.87 \text{ msec.}$$

53. (c)

Execution time for pipeline = (k + n – 1) × *tp*

where k = Number of stages

n = Number of instruction

tp = Execution time = Max (all stages)

P_1 = [8 + 500 – 1] × 8 = 4056

P_2 = [5 + 500 – 1] × 5 = 2520

Time saved using P_2 = 4056 – 2520 = 1536 nsec = 1.536 μsec

54. (b)

$$ET_{\text{non-pipe}} = 6 \times 0.25 \text{ ns}$$
$$ET_{\text{pipe}} = 1 \times 0.5 \text{ ns}$$
$$S = \frac{ET_{\text{non-pipe}}}{ET_{\text{pipe}}} = \frac{1.5}{0.5} = 3$$

55. (b)

Reserve capacity = plant capacity – maximum demand. Since plant runs with maximum demand equal to its capacity and hence its reserve capacity is zero.

Also,

$$\text{Plant utilization factor} = \frac{\text{Maximum demand}}{\text{Plant capacity}} \times 100\%$$

56. (b)

$$\text{Reactive power} \propto \frac{Q^2}{f}$$
$$Q_1 \propto \frac{V_1^2}{f}$$

and

$$Q_2 \propto \frac{(1.1V_1)^2}{1.1f}$$

$\Rightarrow$
$$\frac{Q_2}{Q_1} = 1.1$$

$\Rightarrow$
$$Q_2 = 1.1\ Q_1$$

Hence reactive power increased by 10%.

57. (a)

$$\text{Wavelength} = \lambda,$$
$$\text{Propagation constant} = \beta$$
$$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{0.00112} = 5609.986 \text{ km}$$

$\therefore$
$$\frac{\text{line length}}{\text{wavelength}} = \frac{400 \text{ km}}{5609.986 \text{ km}} \times 100 = 7.130\%$$

58. (b)

Since, surge travels from overhead line to cable, we consider characteristic impedance of cable as load impedance,

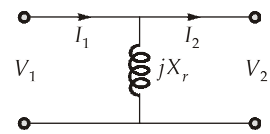
$$V_{\text{transmitted}} = \left(\frac{2Z_{\text{cable}}}{Z_{0H} + Z_{\text{cable}}}\right)V_s$$

$\therefore$
$$V_{\text{transmitted}} = 50 \times \frac{2 \times 50}{400 + 50} = 11.11 \text{ kV}$$

59. (c)

Due to delta connected reactor a single reactor will be connected between two lines,

The *ABCD* parameters can be determined as



$$V_1 = V_2$$

$$I_1 = \frac{V_2}{jX_r} + I_2$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \frac{1}{jX_r} & 1 \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$$

The entire network can be assumed to be cascading of two networks so equivalent parameters are

$$\begin{bmatrix} A_{eq} & B_{eq} \\ C_{eq} & D_{eq} \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} 1 & 0 \\ \frac{1}{jX_r} & 1 \end{bmatrix}$$

$$A_{eq} = |A| + \frac{|B|}{X_r} = 1$$

$$\Rightarrow \qquad X_r = \frac{|B|}{1-|A|}$$

For 3-phase delta reactor,

$$X_{r(\Delta)} = \frac{3|B|}{1-|A|}$$

60. (a)

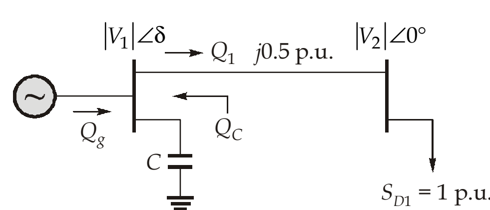
If shunt admittance is assumed to be zero as well as series resistance is neglected then,

$$A = 1\angle 0°,$$

$$X = |B|\sin\beta = 82.5 \sin 76° = 80\ \Omega$$

$$P_{max} = SSSL = \frac{|V_S||V_R|}{X} = \frac{110 \times 110}{80} = 151.25 \text{ MW}$$

61. (a)



$$P = \frac{|V_S| \cdot |V_R|}{X} \sin\delta$$

$$\Rightarrow \qquad 1 = \frac{1 \times 1}{0.5} \sin\delta$$

$$\Rightarrow \quad \sin\delta = 0.5$$

$$\Rightarrow \quad \delta = 30°$$

$$Q_g + Q_C = Q_1$$

$$\Rightarrow \quad Q_C = Q_1 - Q_g$$

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

$$= \frac{1}{0.5}[1 - \cos 30°] = 0.268 \text{ p.u.}$$

$$\text{Capacitor, } Q_C = 0.268 - 0.1 = 0.168 \text{ p.u.}$$

62. (a)

Capacitance of single core cable is,

$$C = \frac{2\pi\varepsilon_0\varepsilon_r l}{\ln\left(\frac{R}{r}\right)}$$

for most economic radius of core,

$$\ln\left(\frac{R}{r}\right) = 1 \text{ i.e. } \frac{R}{r} = e$$

$$\therefore \quad C = \frac{2\pi\varepsilon_0\varepsilon_r l}{1} = 2 \times \pi \times 8.854 \times 10^{-12} \times 3 \times 10 \times 10^3 = 1.668\ \mu\text{F}$$

63. (b)

$$X_S = 0.25 \times \left(\frac{\text{MVA}_{\text{new}}}{\text{MVA}_{\text{old}}}\right) \times \left(\frac{\text{kV}_{\text{old}}}{\text{kV}_{\text{new}}}\right)^2$$

$$= 0.25 \times \left(\frac{100}{500}\right) \times \left(\frac{18}{20}\right)^2 = 0.0405 \text{ p.u.}$$

64. (b)

$$X_{\text{new (p.u.)}} = 0.5,$$

$$X_m = 0.1 \text{ p.u.}$$

$$X_1 = X_s - X_m = (0.5 - 0.1) = 0.4 \text{ p.u.}$$

$$V_{a1} = 1.5\angle 30° \text{ p.u.}$$

$$I_{a1} = \frac{1.5\angle 30°}{0.4\angle 90°} = 3.75\angle -60° \text{ p.u.}$$

$$I_{b1} = \alpha^2 I_{a1} = 3.75\angle(-60 + 240°)$$

$$= 3.75\angle 180° \text{ p.u.}$$

65. (c)

By increasing the cross arm length, the value of k can be reduced upto 0.1 so that string efficiency is improved. Guard ring is used for improving string efficiency.

66. (b)

$$\text{Base impedance of circuit, } A = \frac{(13.8)^2 \times 1000}{10000} = 19.044\ \Omega$$

Impedance of load referred to circuit A,

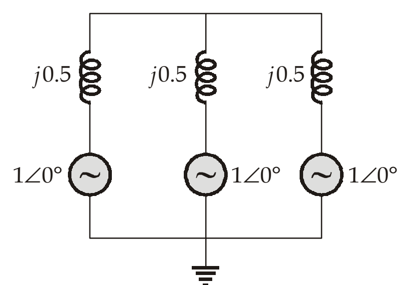
$$= 300 \times 2^2 \times 0.1^2 = 12\ \Omega$$

Per unit impedance of load referred to A,

$$= \frac{12}{19.044} = 0.63 \text{ p.u.}$$

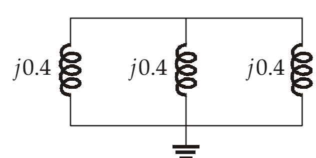
67. (a)

Positive sequence reactance diagram:



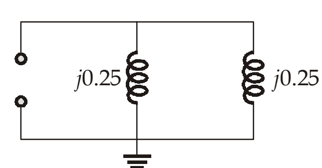
$$\Rightarrow \quad Z_{01} = j\frac{0.5}{3}$$

Negative sequence reactance diagram:



$$\Rightarrow \quad Z_{02} = j\frac{0.4}{3}$$

Zero sequence reactance diagram:



$$\Rightarrow \quad Z_{00} = j\frac{0.25}{2}$$

$$I_f = 3\left(\frac{E}{Z_{01} + Z_{02} + Z_{00}}\right) = 3\left(\frac{1}{j0.425}\right)$$

$$I_f = -j7.058 \text{ p.u.}$$

$$\Rightarrow \quad |I_f| = 7.058 \text{ p.u.}$$

68. (c)

Since, $n_i^2 = N_c N_v e^{-E_g/KT}$

Also N_c and N_v are temperature dependent.

$$N_c \propto T^{3/2}$$

69. (b)

$$S = \frac{1+\beta}{1+\beta\dfrac{R_C}{R_B+R_C}} = \frac{1+99}{1+99\times\dfrac{1\text{ k}\Omega}{100\text{ k}\Omega}}$$

$$= \frac{100}{1+99\times 0.01} = 50.25$$

70. (b)

The zener diode current varies from 5 mA to 40 mA. The current through resistor R should not exceed the maximum current rating of zener diode, $I_R \le 40$ mA

Also, $I_{L\text{ max}} = I_{R\text{ max}} - I_{\text{zener min}}$

$\Rightarrow$ $I_{L\text{ max}} = 40 - 5 = 35$ mA

71. (a)

Given, $I_c = 1$ mA

$$r_e = \frac{V_T}{I_C} = 26\ \Omega$$

in CE configuration, $Z_i = (1+\beta)r_e = (1+200)\times 26$

$= 5226\ \Omega = 5.2\text{ k}\Omega$

72. (a)

$$\beta = \frac{I_C}{I_B} = \frac{\alpha}{1-\alpha}$$

When base width increases recombination in base region increases and α hence β decreases.

It doping in base region increases, then recombination in base region increases and α decreases there by decreasing β.

73. (a)

$$I_B = \frac{V_i - 0.7}{100\text{k}}$$

$$I_{C\text{ (sat)}} = \frac{4-0.2}{2\text{k}} = 1.9\text{ mA}$$

The condition for saturation is,

$$I_B \ge \frac{I_{C\text{sat}}}{\beta} = \frac{V_i - 0.7}{10^5} \ge \frac{1.9\times 10^{-3}}{100}$$

$\Rightarrow$ $V_i - 0.7 \ge 1.9$

$\Rightarrow$ $V_i \ge 2.6$ V

74. (a)

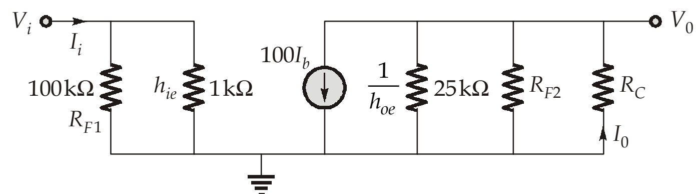
For output impedance, $V_i = 0$

$\Rightarrow$ $i_b = 0$

$z_0 = r_0 = 2.1\ \text{k}\Omega$

75. (a)

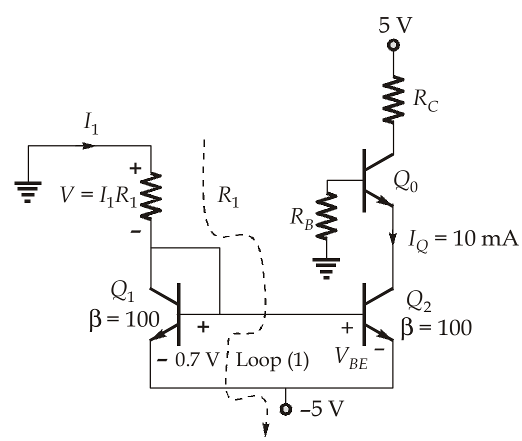
The AC equivalent circuit for the amplifier is,



$$R_i = (R_{F1} \parallel h_{ie}) = \frac{100 \times 10^3 \times 1 \times 10^3}{(100+1) \times 10^3}$$

$$= 0.99\ \text{k}\Omega$$

76. (b)



For current mirror circuit formed by transistors Q_1 and Q_2, we can directly write

$$I_Q = \frac{I_1}{\left(1 + \frac{2}{\beta}\right)}$$

When β is very large, $I_1 \approx I_Q = 10\ \text{mA}$

Applying KVL we get in loop (1), we get

$$I_1R_1 + V_{BE} = 5\ \text{V}$$

$$(10\ \text{mA})\ R_1 + 0.7\ \text{V} = 5\ \text{V}$$

$$R_1 = \frac{4.3}{10} \times 10^3 = 430\ \Omega$$

77. (d)

In a transistor when both the junctions (J_C and J_E) are forward bias and if collector junction voltage is greater than emitter junction voltage then this transistor is in forward saturation mode.

78. (c)

For undamped oscillation,

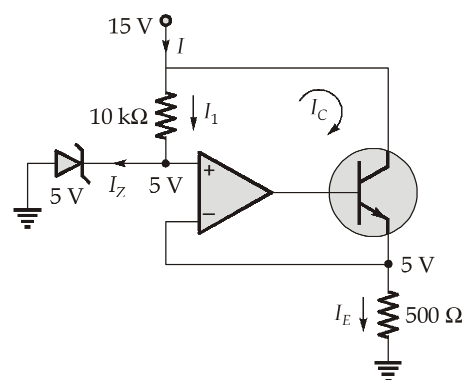
$$A\beta = 1$$

$$\Rightarrow \quad A = 10$$

$$10 = 1 + \frac{R_1}{R_2}$$

$$R_1 = 9R_2$$

79. (a)

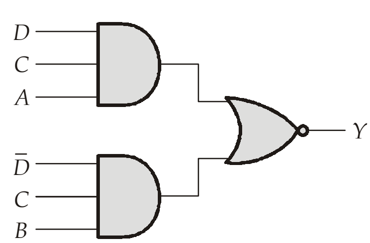


$$I_1 = \frac{15-5}{10\text{k}} = 1 \text{ mA}$$

$$I_E \approx I_C = \frac{5}{500} = 10 \text{ mA}$$

$$I = I_1 + I_C = 11 \text{ mA}$$

81. (a)

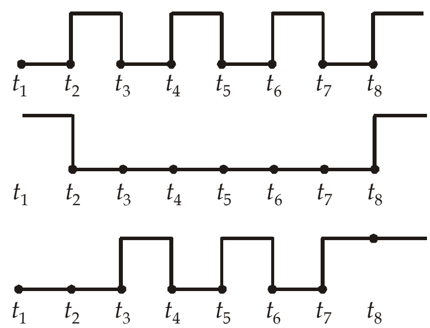


$$Y = \overline{ACD + BC\bar{D}}$$

$$Y = \overline{ACD} \cdot \left(\overline{BC\bar{D}}\right)$$

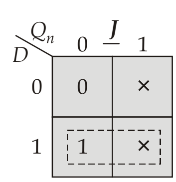
82. (a)

A	B	$A \odot B$
0	0	1
0	1	0
1	0	0
1	1	1

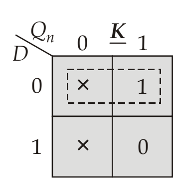


83. (a)

D	Q_n	Q_{n+1}	J	K
0	0	0	0	×
0	1	0	×	1
1	0	1	1	×
1	1	1	×	0



$J = D$



$K = \bar{D}$

84. (b)

$$P \odot Q \odot R = (\bar{P}\bar{Q} + PQ) \odot R$$

$$= \overline{(\bar{P}\bar{Q} + PQ)} \cdot \bar{R} + (\bar{P}\bar{Q} + PQ)R$$

$$= (\overline{\bar{P}\bar{Q}}.\overline{PQ})\bar{R} + (\bar{P}\bar{Q} + PQ)R$$

$$= \left[(P + Q) \cdot (\bar{P} + \bar{Q})\right]\bar{R} + \bar{P}\bar{Q}R + PQR$$

$$= \left[P\bar{Q} + \bar{P}Q\right]\bar{R} + \bar{P}\bar{Q}R + PQR$$

$$= P\bar{Q}\bar{R} + \bar{P}Q\bar{R} + \bar{P}\bar{Q}R + PQR$$

85. **(c)**

(i) LXI H, 01CCH [load register pair immediately]

i.e. [L] ← [CC]

[H] ← [01]

(ii) SHLD 4080H [store HL pair direct]

i.e. [[4080]] ← [L] i.e. CC

[[4080 + 1]] ← [H] i.e. 01

86. **(c)**

INR (Increment register content) is a 1 byte instruction and STA (Store Accumulator direct) is 3-byte instruction.

87. **(c)**

An instruction cycle consists of both fetch cycle and execution cycle.

89. **(c)**

Temporary register is 8-bit register associated with ALU to hold data during arithematic or logical operation.

90. **(a)**

$$L = 2^n$$

$$L \Rightarrow 4 \text{ to } 64$$

$$n \Rightarrow 2 \text{ to } 6$$

$$(\text{BW})_{\text{PCM}} \propto R_b = nf_s$$

$$\frac{(\text{BW})_2}{(\text{BW})_1} = \frac{n_2}{n_1} = \frac{6}{2} = 3$$

91. **(b)**

$$f_{m(\max)} = 15 \text{ kHz}$$

Sampling rate, $f_s = 2f_{m(\max)} = 30$ kHz

Bits/sample, $n = \log_2(256) = 8$ bits/sample

Bit rate, $R_b = nf_s = 240$ kbps

Theoretical minimum channel BW required is,

$$(\text{BW})_{\min} = \frac{R_b}{2} = 120 \text{ kHz}$$

92. **(c)**

Number of message signals, $m = 5$

$$f_{m(\max)} = 10 \text{ kHz}$$

Minimum sampling rate,

$$f_{s(\min)} = 2f_{m(\max)} = 20 \text{ kHz}$$

Bits/sample, $n = \log_2(L) = \log_2(64) = 6$ bits/sample

Minimum sampling rate of multiplexed signal,

$$f_a = mf_{s(\min)} = 5 \times 20 \text{ kHz} = 100 \text{ kHz}$$

Minimum bit rate, $R_{b(\min)} = nf_a = 600$ kbps

93. (b)

When message signal is uniformly distributed with symmetrical swing,

$$[\text{SQNR}] = 6.02n \text{ dB}$$

For $n = 8$, $[\text{SQNR}] = 6.02 \times 8 = 48.16$ dB

Note : [SQNR] = $6.02n + 1.8$ dB for sinusoidal message signal only.

94. (d)

High reverse voltage sucks out the carriers out of the junction J_1, J_3 and the adjacent transition regions at a faster rate.

95. (b)

$$V_d = \frac{2V_m}{\pi} = \frac{2 \times 120\sqrt{2}}{\pi} = 108 \text{ V}$$

$$P_d = V_d I_d = 108 \times 10 = 1080 \text{ W}$$

96. (a)

$$V_S \, \mu = 2 \, \omega L_S \, I_d$$

$$\mu = \frac{2 \times 100\pi \times 0.01 \times 10}{200} = \frac{\pi}{10}$$

$$\mu = \frac{\pi}{10} \times \frac{180°}{\pi} = 18°$$

98. (d)

MOSFET → Unipolar, conduction, while BJT → No reverse voltage withstand capability.

Only TRIAC has both the features required and it is a bidirectional thyristor with three terminals.

99. (d)

$$V = IR$$

$$V = 10 \times 2 = 20 \text{ V}$$

∴ Minimum 20 V is required to turn on the SCR.

100. (c)

Energy in half cycle = Energy in one cycle

$$(3000)^2 \times \frac{1}{2f} = I^2 \times \frac{1}{f}$$

$$I = \left(\frac{3000}{\sqrt{2}}\right) \text{A}$$

101. (b)

Flyback converter is similar to buck boost converter.

102. (a)

Peak current through main thyristor,

$$(I_{TM})_{peak} = i_{load} + V_s\sqrt{\frac{C}{L}}$$

$$= 80 + 220\sqrt{\frac{50\times10^{-6}}{20\times10^{-6}}} = 427.85\text{A}$$

103. (b)

The frequencies at which voltage harmonics occur can be indicated as

$$f_h = (jm_f \pm k)f_1$$

if $j = 1$, $k = 2, 4, 6$ ....

$k = 2$; $f_H = (39 \pm 2) \times 47$

$= 1739$ Hz, 1927 Hz

$j = 2$, $k = 1, 3, 5$

$k = 1$, $f_H = (39 \times 2 \pm 1) \times 47$

$= (78 \pm 1) \times 47$

$= 3619$ Hz, 3713 Hz

104. (c)

Voltage applied, $V = 300$ V

Coil resistance, $R = 12000\ \Omega$

Current flowing through the coil, $i = \frac{V}{R} = \frac{300}{12000} = 0.025$ A

Deflecting torque, $T_d = NBilr$

$= 100 \times 6 \times 10^{-2} \times 0.025 \times 0.04 \times 0.03$

$= 18 \times 10^{-5}$ Nm

Controlling toque, $T_c = 25 \times 10^{-7}\ \theta$ Nm

Where θ is the deflection in degrees produced by 300 V

Since for steady deflection state, $T_c = T_d$

$\therefore$ $25 \times 10^{-7}\ \theta = 18 \times 10^{-5}$

or $\theta = \frac{18\times10^{-5}}{25\times10^{-7}} = 72°$

105. (b)

$$\text{Energy consumed in 30 seconds} = \frac{\text{Number of revolutions made}}{\text{Meter constant in revolution per kWh}}$$

$$= \frac{15}{750} = 0.02 \text{ kWh}$$

$$\text{Load in kW} = \frac{\text{Energy consumed in kWh}}{\text{Time in hours}} = \frac{0.02}{\frac{30}{3600}} = 2.4 \text{ kW}$$

106. (a)

$$G_f = \frac{\Delta R / R}{\varepsilon}$$

$$\varepsilon = \frac{\Delta R / R}{G_f} = \frac{0.30 / 500}{8}$$

$$= 0.75 \times 10^{-4}$$

107. (c)

Measured value of voltage, $$E_m = \frac{E_0}{1+\frac{R_0}{R_m}} = \frac{50}{1+\frac{100\,\text{k}\Omega}{R_m}}$$

Where R_m is the resistance of the voltage measuring device

Measured value with 99% accuracy,

$$E_m = E_0 \times \frac{99}{100} = 50 \times \frac{99}{100} = 49.5\,\text{V}$$

$$49.5 = \frac{50}{1+\frac{100\,\text{k}\Omega}{R_m}}$$

or $$1+\frac{100\,\text{k}\Omega}{R_m} = \frac{50}{49.5}$$

or $$\frac{100\,\text{k}\Omega}{R_m} = \frac{50}{49.5} - 1 = \frac{1}{99}$$

or $$R_m = 9900\ \text{k}\Omega$$

108. (b)

Controlling weight, W = 0.005 kg

Distance of controlling weight from the axis of moving system,

l = 2.4 cm = 0.024 cm

Deflecting torque, T_d = 1.04×10^{-4} kg-m

Let the deflection corresponding to the deflecting torque of 1.04×10^{-4} kg-m be θ°

Since, deflecting torque = controlling torque

$$1.04 \times 10^{-4} = Wl \sin\theta = 0.005 \times 0.024 \times \sin\theta$$

or deflection, $$\theta = \sin^{-1}\left(\frac{1.04 \times 10^{-4}}{0.005 \times 0.024}\right) = 60°$$

109. (c)

Given that, C_1 = 251 pF at f_1 = 3 MHz

C_2 = 50 pF at f_2 = 6 MHz

Self capacitance of coil, $$C_d = \frac{C_1 - 4C_2}{3} = \frac{251 - 4 \times 50}{3} = 17\ \text{pF}$$

110. (a)

Frequency of horizontal input, $f_x = 100$ Hz

Points of tangency of vertical line = 2

Points of tangency of horizontal line = 5

$$\text{Frequency of vertical input, } f_y = f_x \times \frac{\text{Horizontal tangencies}}{\text{Vertical tangencies}}$$

$$= 100 \times \frac{5}{2} = 250 \text{ Hz}$$

111. (d)

$$\text{Percentage relative error} = \left|\frac{A_m - A_t}{A_t}\right| \times 100$$

$$= \left|\frac{200 - 220}{220}\right| \times 100 = 9.09\%$$

112. (b)

If two readings are equal and opposite

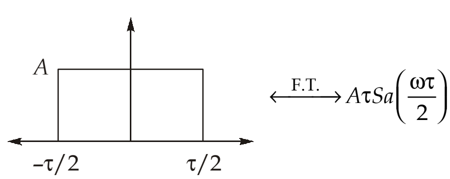
$$W_1 = -W_2$$

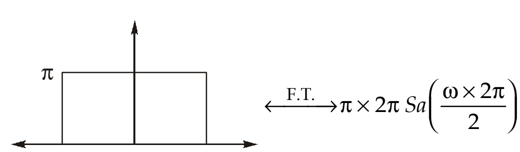
$$\tan\phi = \sqrt{3}\frac{W_1 - W_2}{W_1 + W_2} = \infty$$

$$\phi = 90°$$

$$\text{Power factor} = \cos\phi = \cos(90°) = 0$$

113. (a)

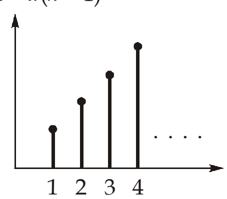




$$2\pi^2 Sa(\omega\pi) = 2\pi^2\frac{\sin(\omega\pi)}{\omega\pi} = \frac{2\pi}{\omega}\sin(\omega\pi)$$

114. (b)

$h(n) = e^{2n}\, u(n-1)$



$$h(n) = 0 \text{ for } n \le 0$$

∴ system is causal

$$\sum_{n=-\infty}^{\infty} |h(n)| = \sum_{n=-\infty}^{\infty} e^{2n} u(n-1) = \sum_{n=1}^{\infty} e^{2n} = \infty$$

∴ System is unstable

$$h(2) = e^4\, u(1)$$

As system depends on past values, system is not memoryless.

115. (a)

$$\left(\frac{1}{2}\right)^n u(n) \xleftrightarrow{\text{Z.T.}} \frac{z}{z-\frac{1}{2}}, |z| > \frac{1}{2}$$

$$\left(\frac{1}{2}\right)^{-n} u(-n) \xleftrightarrow{\text{Z.T.}} \frac{z^{-1}}{z^{-1}-\frac{1}{2}}, |z| < 2$$

$$2^n u(-n) \xleftrightarrow{\text{Z.T.}} \frac{\frac{1}{z}}{\frac{2-z}{2z}}, |z| < 2$$

$$2^n u(-n) \xleftrightarrow{\text{Z.T.}} \frac{-2}{(z-2)}, |z| < 2$$

$$2^{n+3} u(-n-3) \xleftrightarrow{\text{Z.T.}} \frac{-2z^3}{(z-2)}, |z| < 2$$

$$2^n u(-n-3) \xleftrightarrow{\text{Z.T.}} \frac{-z^3}{4(z-2)}, |z| < 2$$

116. (c)

Nyquist rate for signal $x(t)$ is ω_0. The maximum frequency present in the signal is $\frac{\omega_0}{2}$.

∴ Maximum frequency present in the signal $x(t) \cdot \cos \omega_0 t$ is $\frac{\omega_0}{2} + \omega_0 = \frac{3\omega_0}{2}$

∴ Nyquist rate for the signal,

$$x(t) \cdot \cos \omega_0 t = \frac{3\omega_0}{2} \times 2 = 3\,\omega_0$$

117. (c)

N-point DFT requires N^2 complex multiplications.

∴ time taken $= (1024)^2 \times 10^{-6} \approx 1.05$ sec

118. (c)

$$x_0(n) = \frac{x(n) - x(-n)}{2} = \frac{1}{2}\left[\alpha^n u(n) - \alpha^{-n} u(-n)\right]$$

$$x_0(n) = \frac{1}{2}\alpha^{|n|}\,\text{sgn}(n)$$

119. (b)

If S_1 and S_2 are non-linear, it is not necessarily true that the cascade will be non-linear.

For example, with

$$w(n) = S_1\{x(n)\} = e^{x(n)}$$
$$y(n) = S_2\{x(n)\} = \ln(w(n))$$

Although both S_1 and S_2 are non-linear, the cascade is the identity system and therefore is linear.

If S_1 and S_2 are linear, the cascade will be linear.

For example, the response of S_1 to the input $ax_1(n) + bx_2(n)$ will be $aw_1(n) + bw_2(n)$ due to the linearity of S_1. With this as the input to S_2, the response will be, again by linearity, $ay_1(n) + by_2(n)$.

Therefore, if both S_1 and S_2 are linear, the cascade will be linear.

120. (a)

Overall impulse response,

$$\begin{aligned} h(n) &= h_1(n) * [h_2(n) + h_3(n) * h_4(n)] \\ &= 2^n u(n) * [u(n) + u(n) * (-\delta(n-1))] \\ &= 2^n u(n) * [u(n) - u(n-1)] \\ &= 2^n u(n) * \delta(n) \\ &= 2^n \cdot u(n) \end{aligned}$$

121. (c)

Given, Matrix $= \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

Applying $R_3 \to R_3 - R_1 \approx \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 1 \\ 0 & 0 & 0 \end{bmatrix}$

Since one row has all zero element

$$\rho(A) < 3$$

Now, $\begin{vmatrix} 1 & 1 \\ 1 & -1 \end{vmatrix} = -2 \neq 0$

Thus, $\rho(A) = 2$

122. (a)

The system of equation is

$$3x + 3y + 2z = 1$$
$$x + 2y + 0z = 4$$
$$0x + 10y + 3z = -2$$

Therefore, $$D = \begin{vmatrix} 3 & 3 & 2 \\ 1 & 2 & 0 \\ 0 & 10 & 3 \end{vmatrix}$$

$$= 3(6 - 0) - 3(3 - 0) + 2(10 - 0)$$
$$= 18 - 9 + 20$$
$$= 29 \neq 0$$

Since $D \neq 0$, so the system of simultaneous equations is consistent with unique solution.

123. (c)

$$\text{Directional derivative} = \bar{\nabla}\phi$$

$$= \left(\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right)(x^2 - y^2 + 2z^2)$$

$$= 2x\hat{i} - 2y\hat{j} + 4z\hat{k}$$

Directional derivative at the point,

$$P(1, 2, 3) = 2\hat{i} - 4\hat{j} + 12\hat{k}$$

$$\overline{PQ} = \bar{Q} - \bar{P} = (5, 0, 4) - (1, 2, 3) = (4, -2, 1)$$

$$\text{Directional derivative along, } PQ = \left(2\hat{i} - 4\hat{j} + 12\hat{k}\right)\cdot\frac{\left(4\hat{i} - 2\hat{j} + \hat{k}\right)}{\sqrt{16+4+1}}$$

$$= \frac{8+8+12}{\sqrt{21}} = \frac{28}{\sqrt{21}} = 6.11$$

124. (d)

Since, $$\text{R.H.L.} = \lim_{x \to 0^+} \frac{|x|}{x} = \frac{x}{x} = 1$$

and $$\text{L.H.L.} = \lim_{x\to 0^-} \frac{|x|}{x} = \frac{-x}{x} = -1$$

Therefore $\lim_{x\to 0} \frac{|x|}{x}$ does not exists.

125. (d)

In a chess board, there are 64 squares of which 32 are white and 32 are black, since 2 of one colour and 1 of other can be 2 W, 1 B or 1 W, 2 B the number of ways is $2 \times {}^{32}C_2 \times {}^{32}C_1$ and also, the number of ways of choosing any 3 boxes is ${}^{64}C_3$.

$$\text{Hence the required probability} = \frac{{}^{32}C_2 \times {}^{32}C_1 \times 2}{{}^{64}C_3}$$

126. (b)

Since a leap year has 366 days and hence 52 weeks and 2 days

The 2 days can be SM, MT, TW, WTh, ThF, FSt, StS

Therefore, possibilities of getting 53 Sundays or 53 Mondays = {SM, MT, StS}

$$P(\text{53 Sundays or 53 Mondays}) = \frac{3}{7}$$

127. (c)

We have,
$$f(x) = 2x^3 - 15x^2 + 36x + 1$$
$$f'(x) = 6x^2 - 30x + 36$$
$$= 6(x-3)(x-2)$$
$$f'(x) = 0 \text{ gives } x = 2 \text{ and } x = 3$$

We shall now evaluate the value of f at these points and the end points of the interval [1, 5], i.e at $x = 1$, $x = 2$, $x = 3$ and $x = 5$, so

$$f(1) = 2(1)^3 - 15(1)^2 + 36(1) + 1 = 24$$
$$f(2) = 2(2)^3 - 15(2)^2 + 36(2) + 1 = 29$$
$$f(3) = 2(3)^3 - 15(3)^2 + 36(3) + 1 = 28$$
$$f(5) = 2(5)^3 - 15(5)^2 + 36(5) + 1 = 56$$

Thus we conclude that absolute maximum value of f on [1, 5] is 56.

128. (a)

We have,
$$\frac{d^2y}{dx^2} - \frac{8dy}{dx} + 16 = 0$$
$$D^2 - 8D + 16 = 0$$
$$(D-4)(D-4) = 0$$
$$D = 4, 4$$

Hence solution is
$$y = (C_1 + C_2 x)e^{4x}$$

129. (d)

$$f(z) = \frac{z-1}{z^2+1} = \frac{z-1}{z^2-i^2} = \frac{z-1}{(z-i)(z+i)}$$

∴ The singularities are at $z = i$ and $-i$

130. (b)

$$L(f(t)) = \int_0^{\infty} e^{-st} f(t)dt$$

131. (b)

$$\text{Chords} = (b - n + 1)$$

Chords is always fewer than branches.

133. (b)

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

136. (c)

Pyroelectrics are those dielectric that get polarized when heated. All pyroelectrics are piezoelectric, but not all piezoelectric are pyroelectrics.

139. (c)

An important feature of synchronous motor is that it can draw either lagging or leading reactive current from the ac supply.

140. (b)

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

141. (b)

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

143. (c)

Bandwidth of the amplifier is reduced by Miller effect.

145. (a)

Both statements are correct as due to angle modulation we are getting frequency components at output as

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

$f_c \rightarrow$ carrier frequency,

$f_m \rightarrow$ message signal frequency

∴ so it has infinite side bands so B.W. = ∞.

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

146. (a)

The low level gate circuit must be isolated from the high level power circuit through isolation devices such as pulse transformer.

147. (a)

IGBT has the best qualities of both BJT and MOSFET. It possesses high input impedance like a MOSFET and a low on state power loss as in BJT.

148. (b)

- Both the statements are true individually.
- Systematic errors are of three types i.e. instrument error, environmental error or observation error.
- As components are guaranteed to be within a certain percentage of rated value. Hence manufacturer specify the deviations called as limiting errors or guarantee errors.

149. (a)

$$\text{real , even} \xrightarrow{\text{F.T.}} \text{real, even}$$

$$\text{imaginary, odd} \xrightarrow{\text{F.T.}} \text{real, odd}$$

Fourier transform of $\underbrace{e^{-a|t|}}_{\text{real, even}} - \underbrace{j\,\text{sgn}(t)}_{\text{img, odd}}$ is purely real.

150. (a)

$P_{avg} = \frac{1}{T}\int_0^T (10\sin\omega t)(20\cos 2\omega t)\cdot d(\omega t) = 0$ because $\sin\omega t$ and $\cos 2\omega t$ are orthogonal signals to each other.

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