BOOKLET SERIES
A

MADE EASY

Simulate the Real **ESE Prelims Exam** by

ANUBHAV
OPEN MOCK TEST

ESE 2026 Preliminary Exam
ELECTRICAL ENGINEERING

FULL SYLLABUS TEST • PAPER-II

Answer Key

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

DETAILED EXPLANATIONS

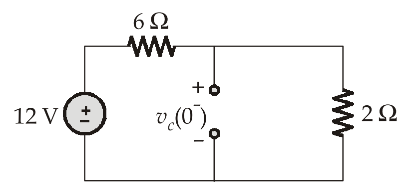
1. (c)

For maximum power transfer,

$$R_L = \sqrt{R_s^2 + X_s^2} = \sqrt{3^2 + 4^2} = \sqrt{9+16} = \sqrt{25} = 5\,\Omega$$

2. (a)

Just before t = 0, the circuit is in steady state and therefore, the capacitor will act like an open circuit.



Here, by voltage division rule:

$$v_c(0^-) = \frac{12 \times 2}{6+2} = 3\text{ V}$$

3. (c)

Taking Laplace transform of the given equation, we get,

$$15s\,V(s) + 3V(s) = 45$$

$$V(s)[15s + 3] = 45$$

or $$V(s) = \frac{45}{(15s+3)} = \frac{15}{(1+5s)} = \frac{K}{(1+s\tau)}$$

∴ The time constant, τ = 5 sec

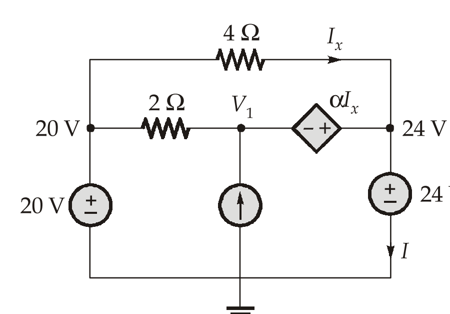
4. (c)

Since 1 Ω resistance connected to a node a, R_{eq} must be greater than 1 Ω. Now there is 1 Ω. First shunt resistance which is connected with other resistance across it on right, this 1 Ω resistance in parallel with rest of the network, so one ohm and other resistance make equivalent resistance less then 1 Ω.

Thus, R_{eq} must be less than 2 Ω.

5. (b)

Applying KCL at super node,



$$\frac{24-20}{4} + \frac{V_1 - 20}{2} + I = 1$$

$$1 + \frac{28-20}{2} + I = 1$$

$$I = -4\text{ A}$$

$$I_x = \frac{20-24}{4} = -1\text{ A}$$

$$\alpha Ix = 24 - V_1 = 24 - 28 = -4$$
$$(-1)\alpha = -4$$
$$\alpha = 4$$

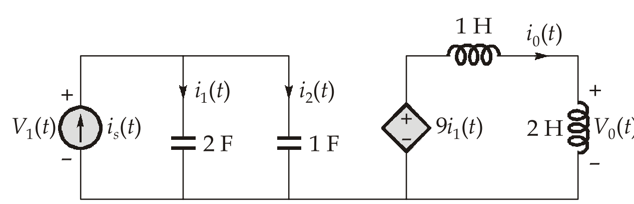
6. (c)

For, $R_L = 10\ \text{k}\Omega,\quad V_{ab1} = \sqrt{10\text{k} \times 3.6\text{m}} = 6\ \text{V}$

For, $R_L = 30\ \text{k}\Omega,\quad V_{ab2} = \sqrt{30\text{k} \times 4.8\text{m}} = 12\ \text{V}$

$$V_{ab1} = \frac{10}{10 + R_{\text{th}}} V_{\text{th}} = 6$$
$$V_{ab2} = \frac{30}{30 + R_{\text{th}}} V_{\text{th}} = 12$$
$$R_L = R_{\text{th}} = 30\ \text{k}\Omega$$

7. (a)



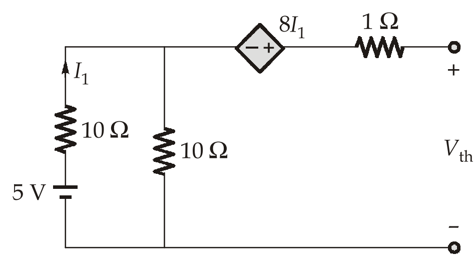
$$i_s(t) = i_1(t) + i_2(t)$$
$$i_1(t) = \frac{2dV_1(t)}{dt},$$
$$i_2(t) = \frac{1dV_1(t)}{dt}$$

So, $$i_s(t) = \frac{2dV_1(t)}{dt} + 1\frac{dV_1(t)}{dt} = \frac{3dV_1(t)}{dt}$$
$$i_1(t) = \frac{2}{3} i_s(t)$$
$$9i_1(t) = \frac{3di_0(t)}{dt}$$
$$V_0(t) = 6i_1(t)$$
$$= 6 \times \frac{2}{3} i_s(t) = 80 \sin(2t)\ \text{V}$$

8. (c)

Applying KVL to the Mesh, we can write

$$-5 + 20I_1 = 0$$
$$I_1 = 0.25\ \text{A}$$



We have,

$$V_{th} = 10I_1 + 8I_1$$
$$V_{th} = 18 \times 0.25 = 4.5 \text{ V}$$

9. (a)

We know that,
$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T V^2(t)dt} = \sqrt{\frac{1}{2}\left[\int_0^1 t^2 dt + \int_1^2 (1)^2 dt\right]}$$

$$V_{rms} = \sqrt{\frac{1}{2}\left[\frac{t^3}{3}\Big|_0^1 + t\Big|_1^2\right]} = \sqrt{\frac{1}{2}\left[\frac{1}{3}+1\right]} = \sqrt{\frac{4}{6}} = \sqrt{\frac{2}{3}}$$

10. (d)

Conversion for Dual Electrical circuits

Loop basis		Node basis
Current		Voltage
Resistance		Conductance
Inductance		Capacitance
Branch current		Branch voltage
Mesh	$\longleftrightarrow$	Node
Short circuit		Open circuit
Parallel path		Series path

Thus, option (d) is incorrect.

11. (a)

In series *R-L-C* circuit under resonance,

$$X_L = X_C$$

So, impedance is minimum, i.e.

$$Z = R + j(X_L - X_C) = R$$

Therefore, the current is maximum at resonance and is also in phase with applied voltage

Also, $$|V_L| = |V_C| = QV$$

Where Q = Quality factor and V = applied voltage

Thus, Statement 4 is not correct.

12. (d)

We have,

$$I_1 = \frac{V}{R + j\omega L} = \frac{V}{\sqrt{R^2 + (\omega L)^2}} \angle \tan^{-1}\left(-\frac{\omega L}{R}\right) = |I_1| \angle \theta_1$$

$$I_2 = \frac{V}{R + j\omega C} = \frac{V}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}} \angle \tan^{-1}\left(\frac{1}{\omega RC}\right) = |I_2| \angle \theta_2$$

For $R = \sqrt{\frac{L}{C}}$,

$$\theta_1 = \tan^{-1}(-\omega\sqrt{LC}) = -\tan^{-1}(\omega\sqrt{LC})$$

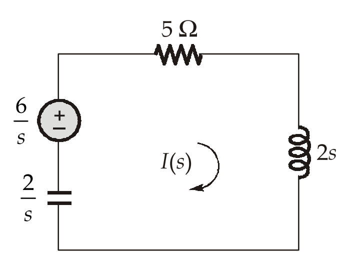
We know that, $\tan^{-1} x + \tan^{-1}\frac{1}{x} = \frac{\pi}{2}$

$$\theta_1 = -\left[\frac{\pi}{2} - \tan^{-1}\left(\frac{1}{\omega\sqrt{LC}}\right)\right]$$

$$\theta_2 - \theta_1 = \frac{\pi}{2}$$

If $R = \sqrt{\frac{L}{C}}$, the two branch currents are in quadrature and not in phase. Hence, statement 3 is incorrect and therefore, option (d) is correct.

13. (b)



$$I(s) = \frac{6/s}{2s + 5 + 2/s} = \frac{6}{2s^2 + 5s + 2} = \frac{3}{s^2 + 2.5s + 1}$$

Comparing with the standard second order equation,

$$s^2 + 2\xi\omega_n s + \omega_n^2 = s^2 + 2.5s + 1$$

We get,

$$\omega_n = 1$$

$$2\xi\omega_n = 2.5$$

$$\xi = \frac{2.5}{2} = 1.25$$

$\because \xi > 1 \Rightarrow$ Overdamped response

14. (a)

$$\text{Direction of magnetic field} = -\hat{a}_z \times \hat{a}_y = \hat{a}_x$$

Magnetic field due to current carrying conductor at distance ρ,

$$\vec{H} = \frac{I}{2\pi\rho}\hat{a}_x = \frac{20\pi}{2\pi \times 5}\hat{a}_x = 2\hat{a}_x \text{ A/m}$$

15. (b)

Considering a spherical Gaussian surface just on the inner shell, electric field is due to the charge $+Q$ alone at a distance R from the centre.

$$\oint \varepsilon_0 \vec{E} \cdot ds = Q_{\text{enclosed}}$$

$$\varepsilon_0 \vec{E} \oint ds = Q_{\text{enclosed}}$$

$$\varepsilon_0 \vec{E} \cdot 4\pi R^2 = Q_{\text{enclosed}}$$

Here, $$\vec{E} = \frac{Q}{4\pi\varepsilon_0 R^2}$$

16. (a)

Since, from boundary conditions,

$$|\vec{D}_{n1}| - |\vec{D}_{n2}| = \rho_s \quad \text{...(i)}$$

Here E_{n1} and E_{n2} are normal components of electric field intensity,

Now, $$\varepsilon_1 |\vec{E}_1| - \varepsilon_2 |\vec{E}_2| = \rho_s$$

$$3 \times \varepsilon_0 \times 2 - 2\,\varepsilon_0 \times 1 = \rho_s$$

or, $$\rho_s = 6\,\varepsilon_0 - 2\,\varepsilon_0$$

$$\rho_s = 4\varepsilon_0$$

17. (d)

$$\text{Flux through coil, } \phi = \frac{LI}{N} = \frac{5 \times 10^{-3} \times 2 \times 10^{-3}}{150} = 6.66 \times 10^{-8} \text{ Wb}$$

18. (c)

The step response of the first system

$$C_1(t) = 0.5\,(1 + e^{-2t})$$

or, $$C_1(s) = \frac{1}{2}\left(\frac{1}{s} + \frac{1}{s+2}\right) = \frac{(s+1)}{s(s+2)}$$

Now transfer function;

Impulse response of first system,

$$H_1(s) = \frac{C_1(s)}{R_1(s)} = \frac{(s+1)}{s(s+2)} \times s = \frac{(s+1)}{(s+2)}$$

The impulse response of the another function,

$$H_2(s) = \frac{1}{(s+1)}$$

Now, the transfer function of the cascaded system,

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

19. (d)

Since at ω = 2 rad/sec, slope changes from –20dB/decade to zero, then these would be zero at ω = 2.

At ω = 20 rad/sec, slope changes from 0 dB/decade to –20dB/decade, then there would be pole at ω = 20.

The slope will cut vertical axis at 40 dB.

Then,
$$20\log\frac{k}{0.2} = 40$$

$$\log\frac{k}{0.2} = 2$$

or,
$$\frac{k}{0.2} = 100$$

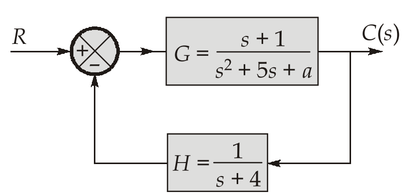
$$k = 20$$

Hence, transfer function
$$T(s) = \frac{20\left(\frac{s}{2}+1\right)}{s\left(\frac{s}{20}+1\right)} = \frac{200(s+2)}{s(s+20)}$$

20. (a)

$$E(s) = R(s) - C(s)\,H(s)$$

$$= R(s) - \frac{G}{1+GH}H(s).R(s) = \frac{1}{1+GH}.R(s)$$



Hence,
$$E(s) = \frac{R(s)}{(1+GH)} = \frac{1}{s}\left[\frac{1}{1+\frac{s+1}{(s+4)(s^2+5s+a)}}\right]$$

The steady state error e_{ss} is

$$e_{ss} = \lim_{t\to\infty} e(t) = \lim_{s\to 0} sE(s)$$

$$= \lim_{s\to 0}\left[\frac{1}{1+\frac{s+1}{(s+4)(s^2+5s+a)}}\right] = \frac{1}{1+\frac{1}{4a}} = \frac{4a}{4a+1} = 0$$

$$a = 0$$

21. (c)

For the stable system,

Closed loop poles in RHS, $Z = 0$

Given that, open loop poles in RHS, $P = 0$

For stable system no. of encirclements of $(-1 + j0)$ must be,

$$N = P - Z = 0 - 0 = 0$$

Therefore, the point $(-1 + j0)$ should not be encircled.

So, $$\frac{2K}{3} < 1$$

or, $$K < \frac{3}{2}$$

or, $$K < 1.5$$

22. (b)

Closed loop transfer function,

$$\frac{C(s)}{R(s)} = \frac{K}{s(s+1)+K(1+K_t s)}$$

Characteristic equation,

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

$$K = \omega_n^2 = (4)^2 = 16$$

and $$1 + KK_t = 2 \times \xi \times \omega_n$$

$$1 + 16 \times K_t = 2 \times 0.5 \times 4 = 4$$

$$K_t = \frac{3}{16} = 0.1875$$

23. (b)

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

Number of open loop poles $= P = 3$

and number of open loop zeros $= Z = 1$

Poles are at: $s = -1 \pm j, 0$ and zero is at $s = -2$

$$\therefore \quad \text{Centroid} = \frac{\Sigma(\text{real part of OL poles}) - \Sigma(\text{real part of OL zeros})}{(P-Z)}$$

$$= \frac{(-1-1-0)-(-2)}{3-1} = \frac{-2+2}{2} = 0$$

Here, $P - Z = 2$

So, angle of asymptotes are given by

$$\theta = \left(\frac{2q+1}{P-Z}\right)\times 180^\circ \; ; \quad (q = 0, 1)$$

Here, $\theta_1 = \frac{180^\circ}{2} = 90^\circ$

and $\theta_2 = \frac{3}{2}\times 180^\circ = 270^\circ \text{ (or) } -90^\circ$

24. (a)

Transfer function from given figure,

$$H(s) = \frac{(s+2)}{(s^2+4)}$$

For unit step excitation, $C(s) = \frac{(s+2)}{s(s^2+4)}$

or $c(t) = L^{-1}[C(s)]$

$$= L^{-1}\left[\frac{1}{2s} + \frac{1}{2}\left\{-\frac{s}{s^2+4} + \frac{2}{s^2+4}\right\}\right]$$

Unit step response, $c(t) = \frac{1}{2}[1 + \sin 2t - \cos 2t]u(t)$

25. (d)

- PD controller increases the value of 'ξ'. As a result, peak overshoot will be decreased.
- PD controller does not change e_{ss} .
- P, I, PI, D controllers change e_{ss} .

26. (b)

$$A = \begin{bmatrix} -6 & K \\ -2 & 0 \end{bmatrix}; \qquad B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

Using Kalman's test for controllability,

$$Q_c = [B \,\vdots\, AB]$$

$$[AB] = \begin{bmatrix} -6 & K \\ -2 & 0 \end{bmatrix}\begin{bmatrix} 1 \\ 1 \end{bmatrix} = \begin{bmatrix} K-6 \\ -2 \end{bmatrix}$$

$$Q_c = \begin{bmatrix} 1 & K-6 \\ 1 & -2 \end{bmatrix}$$

for controllability $\Rightarrow |Q_c| \neq 0$

as the system is uncontrollable $\Rightarrow |Q_c| = -2 - (K-6) = 0$

Hence, $K = 4$

27. (b)

Writing the given equations in Laplace form

$$2\,sC(s) + C(s) = \frac{R(s)}{s^2} - \frac{2R(s)}{s}$$

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

$$\therefore \quad \frac{C(s)}{R(s)} = \frac{1-2s}{s^2(1+2s)}$$

28. (c)

$$G(s)H(s) = \frac{50}{s^2(s+2)(s+5)}$$

$$1 + G(s)H(s) = \frac{s^2(s+2)(s+5)}{s^4+7s^3+10s^2+50}$$

$$\text{Steady state error} = \lim_{s\to 0}\frac{sR(s)}{1+G(s)H(s)}$$

But $$R(s) = \frac{1}{s}$$

Therefore, $$\text{steady state error} = \lim_{s\to 0}\frac{s^2(s+2)(s+5)}{s^4+7s^3+10s^2+50} = 0$$

29. (c)

The characteristic equation is

$$1 + G(s) = 1 + \frac{K}{s(1+0.4s)(1+0.25s)} = 0$$

$$s(1 + 0.4s)\,(1 + 0.25s) + K = 0$$

$$s^3 + 6.5s^2 + 10s + 10K = 0$$

The Routh's array is

s^3	1	10
s^2	6.5	$10K$
s^1	$\frac{65-10K}{6.5}$	
s^0	$10K$	

For absolute stability

$$10\,K > 0$$

or $$K > 0$$

and $$65 - 10K > 0$$

$$K < 6.5$$

Therefore, the system will be absolutely stable if the range of K is $0 < K < 6.5$.

30. (a)

Corner frequencies are 2.5 and 40 rad/sec

$$20 \log K = 40 + 20 \log 2.5 = 47.95$$

$$K = 250$$

At $\omega = 2.5$ rad/sec slope changes from –20 dB/dec to –40 dB/dec due to a factor $\dfrac{1}{\left(1+\dfrac{s}{2.5}\right)}$. At $\omega = 40$ rad/sec, slope changes from –40 dB/dec to –60 dB/dec to a factor.

Since initial slope is –20 dB/dec, it is due to factor $\dfrac{1}{s}$. Therefore open-loop transfer function is

$$G(s) = \frac{250}{s\left(1+\dfrac{s}{2.5}\right)\left(1+\dfrac{s}{40}\right)}$$

$$= \frac{250}{s(1+0.4s)(1+0.025s)}$$

31. (a)

$$\text{No. of turns, } N = 800$$

$$\text{Circumference, } l = 2\pi r = 10 \text{ cm} = 0.1 \text{ m}$$

$$I = 10 \text{ A}$$

Now, $$H = \frac{NI}{2\pi r} = \frac{800 \times 10}{0.1} = 8 \times 10^4 \text{ A/m}$$

$\because$ $$\phi = BA,$$

$$B = \frac{\phi}{A}$$

$$\phi = 1 \times 10^{-3} \text{ Weber}$$

$$A = 20 \text{ cm}^2 = 20 \times 10^{-4} \text{ m}^2$$

$$B = \frac{1 \times 10^{-3}}{20 \times 10^{-4}} = 0.5 \text{ Wb/m}^2$$

$\because$ $$B = \mu_0 \mu_r H$$

$\Rightarrow$ $$\mu_r = \frac{B}{\mu_0 H} = \frac{0.5}{4\pi \times 10^{-7} \times 8 \times 10^4} = 4.97$$

32. (a)

Quartz : used for high frequency oscillation.

Si : used in integrated circuit because of two reasons.

(i) at high temperature it reacts with oxygen and form SiO_2 which is a very good dielectric.

(ii) high power handling capacity.

GaAs : is a direct band gap material having larger carrier life time so suitable for designing of laser.

Nichrome : used as heating element.

33. (b)

As temperature increases, the width of the forbidden energy gap decreases.

$$E_g(T) = Eg_0 - \beta T$$

$E_{g0} \rightarrow$ forbidden energy gap at 0 K

$\beta \rightarrow$ material constant

$T \rightarrow$ temperature in Kelvin

$E_g(T) \rightarrow$ forbidden energy gap at temperature T.

34. (c)

Statements (1) and (3) are correct.

Carrier life time is shorter when compared to indirect band gap semiconductors.

35. (a)

$$\text{Voltage, } V = gtp$$
$$= 6 \times 10^{-3} \times 1 \times 10^{-3} \times 0.5 \times 10^{6}$$
$$V = 3 \text{ V}$$

36. (a)

Ferromagnetic materials remains ferromagnetic upto a critical temperature called as Curie's temperature.

37. (a)

Minimum thickness of insulation required,

$$= \frac{\text{Applied voltage}}{\text{Dielectric strength}} = \frac{11 \times 10^3}{30000} = 0.366 \text{ mm}$$

38. (b)

- Plastic deformation leads to formation of dislocations in the material which leads to increased number of electron scattering by dislocation. Hence plastic deformation increases electrical resistivity of the material.
- The strain hardening leads to localized strain interfaces (defect centers) which impedes the movement of electrons.

  ∴ Resistivity of metal increases.

39. (b)

Length of wire, $l = 1 \text{ m} = 100 \text{ cm}$

Diameter of wire, $d = 0.08 \text{ mm} = 0.008 \text{ cm}$

Resistance of wire, $R = 95.5\ \Omega$

Resistivity of the wire material, $\rho = \dfrac{95.5 \times \frac{\pi}{4} \times (0.008)^2}{100} \times 10^{-2}$

$= 4.8 \times 10^{-5}\ \Omega \text{ m}$

40. (c)

$$\text{Starting torque, } T_{st} = x^2 \left(\frac{I_{sc}}{I_{fl}}\right)^2 s_{fl} T_{fl}$$

$$0.4\ T_{fl} = x^2\ (5)^2 \times 0.04\ T_{fl}$$

$$x^2 = \frac{0.4}{(5)^2 \times 0.04} = 0.4$$

$$x = 0.632$$

$$\text{Current drawn from the supply} = x^2\ I_{sc} = 0.4 \times 5 \times I_{fl} = 2\ I_{fl}$$

41. (d)

In a slip-ring induction motor the external resistance introduced in each phase of the rotor circuit reduces the starting current, increases the starting torque and improve power factor.

42. (a)

$$E_a = V_t - I_a R \quad \text{...(i)}$$

and,

$$\omega = \frac{E_a}{K_a\phi} = \frac{V_t}{K_a\phi} - \frac{I_a R}{K_a\phi}$$

$$\omega = \frac{V_t}{K_a\phi} - \frac{TR}{K_a^2\phi^2} \qquad \left[\because I_a = \frac{T}{K_a\phi}\right]$$

For ω to decrease with ϕ, $\dfrac{d\omega}{d\phi}$ should be negative

$$\frac{d\omega}{d\phi} = \frac{-V_t}{K_a\phi^2} + \frac{2TR}{K_a^2\phi^3} < 0 \qquad [\because T = K_a\phi I_a]$$

$$-V_t + 2I_a R < 0$$

$$V_t - 2I_a R > 0$$

from equation (i),

$$I_a R = V_t - E_a$$

$$V_t - 2V_t + 2E_a > 0$$

$$E_a > 0.5\ V_t$$

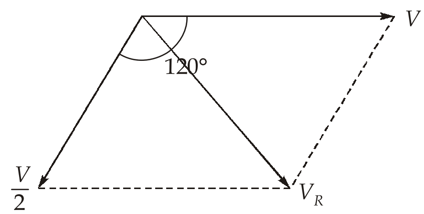
43. (c)

An auto transformer has lower value of leakage impedance than a two winding transformer of the same output.

44. (c)

The phasor representation is

$$\overrightarrow{V_{bd}} = \overrightarrow{V_{bc}} + \overrightarrow{V_{cd}}$$



$$|V_R| = \sqrt{V_1^2 + V_2^2 + 2V_1V_2\cos\theta}$$

$$= \sqrt{V^2 + \frac{V^2}{4} + \left(2\frac{V \times V}{2} \times \left(-\frac{1}{2}\right)\right)}$$

$$= \sqrt{V^2 + \frac{V^2}{4} - \frac{V^2}{2}} = \frac{V}{2}\sqrt{3}$$

$$|V_R| = 115\sqrt{3}\text{ V}$$

45. (b)

Motor input current, $I_1 = 25$ A

Back emf, $E_{b1} = V - I_1(R_a + R_{se})$

$= 200 - 25(0.5 + 0.3) = 180$ V

Speed, $N_1 = 500$ rpm

Let the resistance R be connected in series with the motor to reduce the speed to

$N_2 = 250$ rpm

Motor input current, $I_2 = I_1 = 25$ A

Back emf, $E_{b2} = V - I_2(R + R_a + R_{sc})$

$= 200 - 25(R + 0.5 + 0.3) = 180 - 25R$

Since, $N \propto \dfrac{E_b}{\phi}$

$$\frac{N_2}{N_1} = \frac{E_{b1}}{E_{b1}} \times \frac{\phi_1}{\phi_2} = \frac{E_{b2}}{E_{b1}}$$

$\because$ $\phi_2 = \phi_1$ as field current remains the same

or $$\frac{250}{500} = \frac{180 - 25R}{180}$$

$R = 3.6\ \Omega$

46. (c)

Supply frequency, $f = 50$ Hz

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

Full-load slip, $s = \frac{\text{Frequency of rotor emf}}{\text{Supply frequency}} = \frac{2}{50} = 0.04$ or 4%

Full load, $N = N_s(1 - s)$

$= 1000(1 - 0.04) = 960$ rpm

47. (b)

When power factor, $\cos\phi = 0.8$ leading

$\sin\phi = -0.6$

Percentage voltage regulation $= [0.01 \times 0.8 + 0.05 \times (-0.6)] \times 100$

$= -2.2\%$

48. (b)

Back emf on full-load, $E_{bf} = V - I_{af} R_a$ – Brush contact drop

$= 500 - 60 \times 0.2 - 2 \times 1 = 486$ V

$N_f = \frac{E_b}{\phi} \times \frac{60}{z} \times \frac{A}{P} = \frac{486}{0.03} \times \frac{60}{720} \times \frac{2}{4} = 675$ rpm

49. (b)

Given, Active power, $P = 8$ MW

Reactive power, $Q = 6$ MVAR

$\tan\phi = \frac{\text{Reactive power}}{\text{Active power}} = \frac{6}{8} = \frac{3}{4} = 0.75$

Phase angle, $\phi = \tan^{-1}(0.75) = 36.87°$ (lagging)

(Here 'Q' is +ve so p.f. is lagging)

50. (b)

Armature wave mmf is triangular and airgap mmf is flat topped in nature.

51. (b)

% regulation $= \frac{IR\cos\phi + IX\sin\phi \times 100}{I} = (R\cos\phi + X\sin\phi) \times 100$

As the load is resistive $= (2\cos 0° + 4\sin 0°) = 2\%$

$\frac{2 \times 220}{100} = 4.4$ V

Hence terminal voltage,

$220 - 4.4 = 215.6$ V

52. (c)

Given,

short circuit current, $I_{sc} = 8I_f$

Full load slip, $s_f = 4\%$ or 0.04

Assuming transformation ratio of auto transformer, K

$$I_{st} = K^2 I_{sc}$$

$$K = \sqrt{\frac{I_{st}}{I_{sc}}} = \sqrt{\frac{3I_f}{8I_f}} = \sqrt{\frac{3}{8}}$$

$\therefore$ Starting torque, $$T_{st} = K^2\left(\frac{I_{sc}}{I_f}\right)^2 \cdot S_f T_f = \frac{3}{8}\times(8)^2\times 0.04\cdot T_f$$

$$T_{st} = 0.96T_f$$

$\therefore$ $$\frac{T_{st}}{T_f} = 0.96$$

53. (a)

In round robin scheduling algorithm, the processes run for a fixed time quantum in the same schedule in which they have arrived and are then preempted after the time quantum expires. Later, they are inserted in the job queue and again get CPU for the fixed time quantum is required. So, it can be said that it's the pre-emptive version of FIFO.

54. (b)

Priority scheduling algorithm suffers from the problem of starvation. There might be the case that some low priority process does not get CPU, because of high priority processes. A solution to this problem is ***Aging***. Aging refers to gradually increasing the priority of jobs that wait in the system for a long time to remedy infinite blocking.

55. (c)

$f(1) \rightarrow n = 2,\ i = 2$

$f(2) \rightarrow n = 4,\ i = 3$

$f(4) \rightarrow n = 7,\ i = 4$

$f(7) \rightarrow$ return 7

The value returned by $f(1)$ is 7.

56. (b)

More than one word are put in one cache block to exploit the spatial locality of reference in a program. Spatial locality refers to the use of data element with in relatively close storage locations.

57. (d)

Index addressing mode:

Effective address = [Base address + Displacement]

58. (b)

Array is a collection of items of same type either character, integer, float or anything and storage class that share common name and occupy consecutive memory locations.

59. (b)

Minimum time required without simultaneous occurrence is = Execution time of I_3 + Response time

$$= 4.5 + 20 = 24.5\ \mu\text{sec}$$

Maximum time require when all work simultaneously.

$$= I_1 + I_2 + I_3 \text{ [Since } I_1 \text{ and } I_2 \text{ have high priority]}$$

$$= (4.5 + 25) + (4.5 + 35) + (4.5 + 20)$$

$$= 93.5\ \mu\text{sec}$$

60. (d)

All given algorithms are example of static page replacement algorithm.

61. (b)

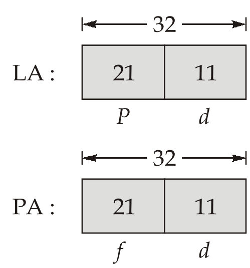
Loading the operating system into the memory of the PC is called booting. Spooling is a specialized form of multiprogramming for the purpose of copying data between different devices.

62. (d)

$$\text{Page size} = 2\text{ KB} = 2^{11}\text{ B}$$

$$\text{LA} = 32\text{ bit},$$

$$\text{PA} = 32\text{ bit}$$



$$\text{Page table size} = \text{No. of pages} \times \text{Pages table entry size}$$

$$= 2^P \times (f + 3) = 2^{21} \times (21 + 3)$$

$$= 2^{21} \times 24\text{ bits} = 2^{21} \times 3\text{ B}$$

$$= 3 \times 2 \times 2^{20}\text{ B} = 6\text{ MB}$$

63. (c)

$$\text{p.u. short circuit current} = I_{\text{s.c. (p.u.)}} = \frac{1}{X_{\text{p.u.}}} = \frac{1}{0.10} = 10\text{ p.u.}$$

$$\text{Rated base current} = \frac{10000}{400} = 25\text{ A}$$

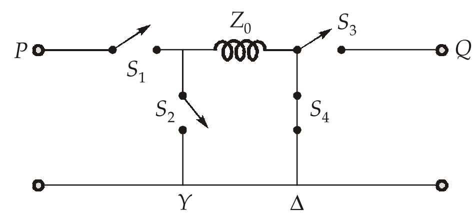
$$\therefore \quad \text{Steady short circuit current} = 25 \times 10 = 250\text{ A}$$

65. (d)

All the given are main objectives of fault analysis.

66. (c)

According to switching diagram for zero sequence component



Since in the primary side it is Y-connected without grounding so S_1 and S_2 are open and in secondary side it is Δ-connected so S_3 is open and S_4 is closed.

67. (a)

- When $\left(\frac{\partial P_e}{\partial \delta}\right)$ is negative, the torque angle increases unboundedly upon occurrence of a small power increment and the synchronism is soon lost.
- For transient stability analysis, as long as equal area criterion is satisfied, the maximum angle to which rotor angle can oscillate is greater than 90°.

68. (b)

$$\text{Surge impedance} = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.22\times10^{-3}}{0.202\times10^{-6}}} = 33\ \Omega$$

69. (c)

$$E_g\angle\delta = V_a\angle 0° + I_a\angle 30°\ X_d\angle 90°$$
$$E_g\angle\delta = 1.0\angle 0° + 1.65\angle 120°$$
$$= 1.44\angle 83°\ \text{p.u.}$$

71. (b)

Impedance of line P, $Z_P = 3 + j4 = 5\angle 53.13°\ \Omega$

Impedance of line Q, $Z_Q = 4 + j3 = 5\angle 36.86°\ \Omega$

$$Z_P + Z_Q = 7 + j7 = 7\sqrt{2}\angle 45°\Omega$$

Total load supplied in kVA, $S^* = \frac{10000}{0.8}\angle -36.86°$

$$S_P = 12500\angle -36.86° \times \frac{5\angle 36.86°}{7\sqrt{2}\ /\ 45°} = 6313.45\ \text{kVA}$$

Power supplied by line P,

$$P = 6313.45 \times 0.707$$
$$= 4463.6\ \text{kV}$$

72. (b)

In power system study, for a transmission line, characteristic impedance also referred to surge impedance.

73. (c)

Gauss-Seidal method is easier but it is less accurate and has a slow convergence rate compare to NR method. So, Gauss-Seidal method is not preferred over NR method.

74. (c)

- Mho relay has inherent directional property.
- Reactance relay are preferred for protection against earth fault conditions.

75. (a)

Let reactive power absorbed,

$$Q_{\text{absorbed}} = \frac{V^2}{X_{\text{rated}}} = \frac{(320)^2}{(400)^2/80} = 51.2 \text{ MVAR}$$

76. (b)

For given generator, $X_1 = X_2 = 0.20$

$$X_0 = \frac{0.20}{3} = 0.066 \text{ p.u.}$$

Three phase fault, $I_{f\,3\text{-}\phi} = \dfrac{V_{\text{Th}}}{X_1}$

Line to ground fault, $I_{f\,\text{L-G}} = \dfrac{3V_{\text{th}}}{X_1 + X_2 + X_0}$

$$\frac{I_{f\,3\text{-}\phi}}{I_{f\,\text{LG}}} = \frac{X_1 + X_2 + X_0}{3X_1} = \frac{0.2 + 0.2 + 0.066}{3 \times 0.2}$$

$$= \frac{0.4 + 0.066}{0.6} = 0.776 \approx 0.78$$

78. (b)

Given, forward current of diode, $I_f = 13$ mA

Carrier life time, $\tau = 40$ psec

Thermal voltage, $V_T = 26$ mV

Diffusion capacitance, $C_D = \dfrac{\tau I_f}{\eta V_T} = \dfrac{40 \times 10^{-12} \times 13 \times 10^{-3}}{1 \times 26 \times 10^{-3}}$ F = 20 pF

79. (d)

When two terminals of a transistor are shorted, it acts as a diode, thus

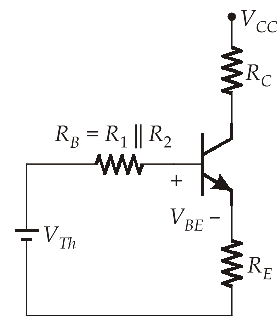
$$I = I_o\left[e^{\frac{V_o}{\eta V_T}} - 1\right] = 1.5 \times 10^{-13}\left[e^{\frac{0.7}{26 \times 10^{-3}}} - 1\right] = 73.898 \text{ mA}$$

80. (a)

In voltage divider bias configuration for a bipolar junction transistor (BJT), the stability factor (S) indicates how much the collector current (I_C) changes with changes in the current gain (β). The stability factor is given by

$$S = \frac{1+\beta}{1-\beta\frac{\partial I_B}{\partial I_C}}$$

Applying KVL in input loop,



$$V_{Th} = R_B I_B + V_{BE} + (I_C + I_B)R_E$$

Differentiating w.r.t. I_C,

$$0 = (R_B + R_E)\frac{\partial I_B}{\partial I_C} + R_E$$

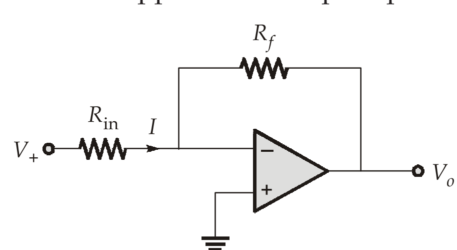
⇒ $$\frac{\partial I_B}{\partial I_C} = \frac{-R_E}{R_E + R_B}$$

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

81. (a)

The op-map circuit in which output voltage or current is directly proportional to either input voltage or current are the linear applications of op-amp. Eg: Inverting amplifiers, Non-inverting amplifiers, etc.

Current-to voltage converter is a linear application of op-amp



$$V_o = -IR_f$$

Some non-linear applications are:

- Comparator
- Peak detector
- Limiter
- Log amplifier
- Rectifier

82. (d)

In the given circuit, three capacitors and one inductor are there, so it is clapp oscillator and frequency of oscillation is

$$f = \frac{1}{2\pi\sqrt{C_{eq}L}}$$

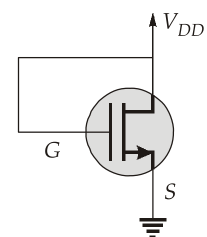
where,
$$C_{eq} = \frac{1}{\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C}} = \frac{1}{\frac{1}{4}+\frac{1}{4}+\frac{1}{3}} = \frac{1}{\frac{1}{2}+\frac{1}{3}} = \frac{6}{5}\text{ pF}$$

∴
$$f = \frac{1}{2\pi\sqrt{\frac{6}{5}\times 10\times 10^{-18}}} = 45.944\times 10^{6}\text{ Hz}$$

$$f \simeq 46\text{ MHz}$$

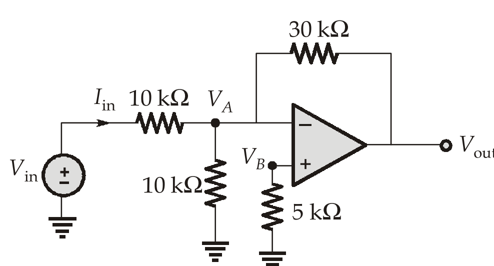
83. (d)

A gate to drain connected enhancement mode MOSFET is an example of an active load.



It work as an active load with resistance as $\left(r_{ds} \,||\, \frac{1}{g_m}\right)$.

84. (b)



∵
$$V_B = 0\text{ V}$$

Thus,
$$V_A = 0\text{ V}$$

Thus,
$$I_{in} = \frac{V_{in}}{10\text{ k}\Omega}$$

∴
$$\frac{V_{in}}{I_{in}} = R_{in} = 10\text{ k}\Omega$$

85. (b)

$$\eta_{\text{Halfwave}} = \frac{4}{\pi^2}\times\frac{1}{\left[1+\dfrac{R_f}{R_L}\right]}\times 100$$

$$= 0.405\times\frac{1}{\left[1+\dfrac{20}{1000}\right]}\times 100 = 0.3971\times 100 = 39.71\%$$

86. (c)

For a common source transistor the voltage gain is given as,

$$A_v = -g_m(R_D \,||\, r_d)$$

Thus, $A_v = -2 \times 10^{-3}$ (50 kΩ || 5 kΩ)

$$= -2\times 10^{-3}\times\left[\frac{250}{55}\right]\times 10^3 = -\frac{100}{11} = -9.09$$

87. (b)

$$I_L + I_Z = \frac{12-V_Z}{R}$$

$\Rightarrow$ $$R = \frac{12-V_Z}{I_L+I_Z}$$

For R_L = 12.5 Ω, $$I_L = \frac{V_Z}{R_L} = \frac{5}{12.5}\text{ A} = 400\text{ mA}$$

$$R \le \frac{12-5}{I_{Z(\min)}+I_L} = \frac{7}{0+400}\text{ k}\Omega = 17.5\ \Omega \quad ...(i)$$

For R_L = 50 Ω, $$I_L = \frac{V_Z}{R_L} = \frac{5}{50}\text{ A} = 100\text{ mA}$$

$$R \le \frac{12-5}{I_{Z(\min)}+I_L} = \frac{7}{0+100}\text{ k}\Omega = 70\ \Omega \quad ...(ii)$$

From equations (i) and (ii), $R \le 17.5\ \Omega$

$$R_{(\max)} = 17.5\ \Omega$$

88. (b)

Applying KVL, we get,

$$-11.8 + 10\text{ k}(I_C + I_B) + 100\text{ k}(I_B) + V_{BE} = 0$$

$$\frac{11.8-0.7}{10\text{ k}+\dfrac{1}{100}(10+100)\text{ k}} = I_C$$

$\therefore$ $$I_C = \frac{11.1}{11.1}\times 10^{-3} = 1\text{ mA}$$

Now,

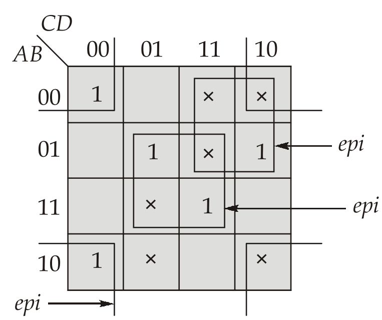
$$V_{CE} = V_{CC} - (I_B + I_C)10\ \text{k}\Omega$$

$$= V_{CC} - \left(1 + \frac{1}{\beta}\right) I_C \times 10\ \text{k}\Omega$$

$$= V_{CC} - \frac{101}{100} \times 1 \times 10^{-3} \times 10 \times 10^{3}$$

$$= 11.8 - \frac{101}{100} \times 10 = 1.7\ \text{V}$$

90. (c)



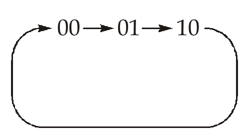
$$f = BD + \bar{A}C + \bar{B}\bar{D}$$

91. (c)

$$T_A = Q_A + Q_B$$

$$T_B = \bar{Q}_A + Q_B$$

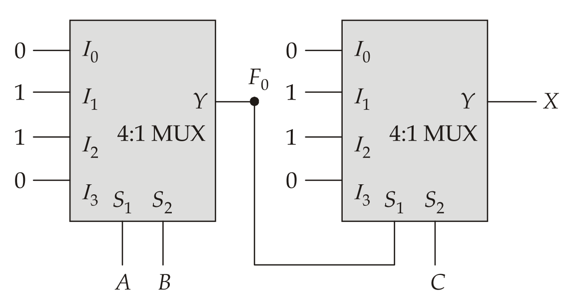
∴ counter counts the sequence of



Present State		FF Input		Next State	
Q_A	Q_B	T_A	T_B	Q_A^+	Q_B^+
0	0	0	1	0	1
0	1	1	1	1	0
1	0	1	0	0	0
0	0	0	1	0	1

Thus, MOD 3 counter.

92. (c)



$$F_0 = \bar{A}B + A\bar{B}$$

$$X = (\bar{A}B + A\bar{B})\bar{C} + (AB + \bar{A}\bar{B})C$$

$$= \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC + \bar{A}\bar{B}C$$

$$X = (A \oplus B \oplus C)$$

95. (b)

$$\begin{aligned} \text{XTHL requires} &\Rightarrow 16 \text{ T-states} \\ \text{CALL 2018 H requires} &\Rightarrow 18 \text{ T-states} \\ \text{STAX D requires} &\Rightarrow 7 \text{ T-states} \\ \text{DAD H requires} &\Rightarrow 10 \text{ T-states} \end{aligned}$$

96. (a)

Modulation index, $\mu = \frac{8-4}{8+4} = \frac{4}{12} = \frac{1}{3}$

97. (d)

The modulation index of an FM signal can be given as,

$$\beta_{FM} = \frac{(\Delta f)_{max}}{f_m} = \frac{A_m k_f}{f_m} \quad ...(i)$$

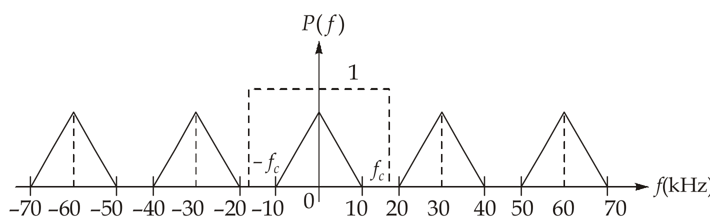
The modulation index of a PM signal can be given as,

$$\beta_{PM} = (\Delta\phi)_{max} = A_m k_p \quad ...(ii)$$

From equations (i) and (ii), option (d) can be selected as the correct one.

98. (c)

The spectrum of the sampled signal can be visualized as,



For proper reconstruction, $f_c \le 20$ kHz

$$f_{c\,(max)} = 20 \text{ kHz}$$

99. (b)

$$\begin{aligned} \text{Total RF power} &= 60 \text{ W} \\ \text{Modulator loss} &= 12 \text{ W} \end{aligned}$$

Useful transmitted AM power:

$$P_{AM} = 60 - 12 = 48 \text{ W}$$

For AM at 100% modulation, $P_{AM} = P_C\left(1 + \frac{m^2}{2}\right)$

$$\begin{aligned} m &= 1 \\ P_{AM} &= 1.5P_C \\ 1.5P_C &= 48 \\ P_C &= \frac{48}{1.5} = 32 \text{ W} \end{aligned}$$

100. (c)

Using Carson's rule for FM bandwidth:

$$\text{BW} = 2(\Delta f + f_m)$$

$$\text{BW} = 2(60 + 12) = 144 \text{ kHz}$$

101. (b)

For a noiseless channel, the maximum bit rate is given by Nyquist formula,

$$R_{\max} = 2B \log_2 \text{M}$$

$$= 2 \times 2000 \times \log_2 4$$

$$= 8000 \text{ bps}$$

103. (b)

$$\text{Maximum fundamental current} = I_{\max,\,1} = \frac{4V_S}{\pi\sqrt{R^2 + X^2}} = \frac{4 \times 200}{\pi\sqrt{2}} = 180 \text{ A}$$

∴ The fundamental component of load current is,

$$I_{01} = 180 \sin(\omega t - 45°)$$

$$\phi = \tan^{-1}\left(\frac{X}{R}\right) = 45° \text{ lagging because } (X_L > X_C)$$

104. (a)

$$\text{Average power} = \frac{V_m I_m}{2}\cos\phi_1 + \frac{V_m I_m}{2}\cos\phi_2$$

$$= \left[0.5 \times \frac{1}{\sqrt{3}} \times 1 \times \frac{\sqrt{3}}{2}\right] + [0.5 \times 1 \times 1 \times \cos 0°]$$

$$= \frac{1}{4} + \frac{1}{2}$$

$$\text{Average power} = 0.75 \text{ p.u.}$$

106. (c)

$$\text{Input power factor} = \frac{V_{0,\text{rms}}}{V_{s,\text{rms}}} = \frac{\frac{V_m}{2}}{\frac{V_m}{\sqrt{2}}}$$

$$= \frac{1}{\sqrt{2}} = 0.707$$

107. (d)

- Increasing load inductance slows down current rise (di/dt), so the rise time of thyristor current increases.
- In GTO, both latching current and holding current are higher than in SCR.
- Turn-on gain of GTO is lower than SCR because GTO needs a larger gate current for turn-on.

108. (c)

- Load is resistive input current is non-sinusoidal. Hence distortion factor < 1, so P.F. < 1.
- Full-wave rectification does not change rms value.
- Output current is unidirectional supply current is alternating.
- Freewheeling diode reduces average output voltage.

109. (b)

Current through main thyristor is $\frac{V_s}{R} + V_s\sqrt{\frac{C}{L}}$

$$= 10 + 200\sqrt{\frac{0.1\times10^{-6}}{1\times10^{-3}}} = 12 \text{ A}$$

Current through auxiliary thyristor is $V_s\sqrt{\frac{C}{L}}$

$$= 200\sqrt{\frac{0.1\times10^{-6}}{1\times10^{-3}}} = 2 \text{ A}$$

110. (a)

Fundamental output current, $i_0 = \frac{230}{2} = 115 \text{ A}$

$$I_{\text{sw 1, rms}} = \frac{I_P}{2} = \frac{115\sqrt{2}}{2} = 81.33 \text{ A}$$

No diode action.

111. (b)

t_{rr} is defined as the time between the instant forward diode current becomes zero and the instant the reverse recovery current decays to 25% of its reverse peak value.

112. (b)

Average output voltage,

$$V_0 = E + I_0R = 143.33 + 20 \times 1 = 163.33 \text{ V}$$

Now, $$V_0 = \frac{2V_m}{\pi}\cos\alpha - 4fL_sI_0$$

$$163.33 = \frac{2\times\sqrt{2}\times230}{\pi}\cos\alpha - 4\times50\times4\times10^{-3}\times20$$

$$163.33 = \frac{460\sqrt{2}}{\pi}\cos\alpha - 16$$

$$\cos\alpha = \frac{(163.33+16)\pi}{460\sqrt{2}} = 0.866$$

$\Rightarrow$ $\alpha = 30°$

113. (a)

Required deflection in radian, θ_d = 1 radian

Current in the coil = 40 mA = 40×10^{-3} A

Control spring constant, K_c = 20×10^{-6} N-m/rad

Steady state deflection, $\theta = \dfrac{Gi}{K_c}$

Where G is displacement constant,

$$\therefore \quad G = \frac{K_c\theta}{i} = \frac{20\times10^{-6}\times1}{40\times10^{-3}}$$

$$= 0.5 \times 10^{-3} \text{ N-m/A}$$

Displacement constant can be written as,

$$G = NBld$$

$$\therefore \quad N = \frac{G}{Bld} = \frac{0.5\times10^{-3}}{0.05\times50\times10^{-3}\times50\times10^{-3}}$$

$$= 4 \text{ turns}$$

114. (d)

$$\text{Ammeter current, } I_m = \frac{0.8\,\text{V}}{2\,\text{k}\Omega} = 0.0004 \text{ A}$$

When total current is 10 A

The allowed current in ammeter = 0.0004 A

The shunt current, I_{sh} = 10 – 0.0004

= 9.9996

$$I_{sh}R_{sh} = 0.8 \text{ V}$$

$$R_{sh} = \frac{0.8}{9.9996} = 0.08\ \Omega$$

Alternate Method:

$$R_{sh} = \frac{R_m}{m-1}$$

Where, $m = \dfrac{I}{I_m}$

$$\therefore \quad m = \frac{10}{0.0004} = 2.5\times10^4$$

$$\therefore \quad R_s = \frac{2\,\text{k}\Omega}{25000-1} \approx 0.08\Omega$$

115. (b)

$$1 \text{ scale division} = \frac{50}{200} = 0.25 \text{ A}$$

$$\text{Resolution} = \frac{1}{5} \text{ of the 1 scale division}$$

$$= \frac{1}{5} \times 0.25 = 0.05 \text{ A}$$

116. (b)

$$L = 40 + 20\theta - \theta^2 \ \mu\text{H}$$

$$T_d = \frac{I^2}{2}\frac{dL}{d\theta}$$

$$= \frac{I^2}{2} \times 10^{-6}[20 - 2\theta]$$

$$= I^2 \times 10^{-6} [10 - \theta]$$

$$T_c = K\theta$$

$$= 20 \times 10^{-6} \text{ N-m/rad} \times \theta$$

$$20 \times 10^{-6} \times \theta = \left[10I^2 - \theta I^2\right] \times 10^{-6}$$

$$20\,\theta = [10 - \theta]\,4$$

$$20\,\theta = 40 - 4\,\theta$$

$$24\,\theta = 40$$

Deflection, $$\theta = \frac{40}{24} = \frac{5}{3} = 1.667 \text{ rad}$$

117. (b)

Power consumption by load in an hour = 2 kW

No. of revolutions by disc in one hour,

$$= 2000 \times \frac{600}{1000} = 1200 \text{ revolution}$$

$\therefore$ No. of revolution in one sec $= \dfrac{1200}{60 \times 60} = 0.33$ rev

Meter should show no. of revolution in 90 sec = 30 rev.

But meter shows 40 revolution in 90 sec.

$\therefore$ Disc is showing 10 extra revolutions.

118. (a)

$$\text{Deflection, } D = \frac{L l_d E_d}{2 d E_a}$$

Where, E_d is the input voltage,

$$E_d = \frac{2d \times E_a \times D}{L l_d} = \frac{2 \times 4 \times 10^{-3} \times 2000 \times 4 \times 10^{-2}}{0.4 \times 3 \times 10^{-2}}$$

$$= \frac{64 \times 10^{-2}}{1.2 \times 10^{-2}} = \frac{64}{1.2}$$

$$= \frac{320}{6} = \frac{160}{3} = 53.33 \text{ V}$$

119. (d)

All given statements are correct.

120. (d)

Drift is an undesired gradual change of instrument output over a period of time which is unrelated to change in input, operating conditions or load.

- Dead zone is defined as the range with in which the variable can vary without being detected.
- Accuracy and linearity is related with each other, so it is better to keep non-linearity as small as possible.
- Static errors are also undesired.

121. (d)

We have,

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

$$= 2500 \times 10^{-6} \times \frac{d}{d\theta}[(-6\cos(\theta + 30°))] \times 10^{-3}$$

$$= 25 \times 6 \sin(\theta + 30°) \times 10^{-7}$$

$$= 15\ \mu\text{N-m}$$

122. (c)

Measurement through an bridge is depend on sensitivity of detector and applied voltage.

123. (b)

$$y(t) = (t^3 + 2)\ \delta(t - 2)$$

$$\text{Area} = \int_{-\infty}^{\infty} y(t)\, dt = \int_{-\infty}^{\infty} (t^3 + 2)\delta(t-2)\, dt$$

$$= 10 \int_{-\infty}^{\infty} \delta(t-2)\, dt = 10$$

124. (a)

For N point DFT,

No. of complex additions $\rightarrow N(N-1)$

No. of complex multiplications $\rightarrow N^2$

125. (a)

Given,
$$x(n) = \{-2,5,1,-3\}$$
$$\uparrow$$
$$x(-n) = \{-3,1,5,-2\}$$
$$\uparrow$$

$\therefore$
$$x_e(n) = \frac{1}{2}[x(n)+x(-n)]$$
$$= \frac{1}{2}[-2+0,5-3,1+1,-3+5,0-2]$$
$$= \{-1,1,1,1,-1\}$$
$$\uparrow$$

126. (b)

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

From z-transform definition

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

$$\begin{array}{r|l} & 1 + z^{-3} + \cdots \\ \hline 1 - z^{-3} & 1 \\ & 1 - z^{-3} \\ \hline & z^{-3} \\ & z^{-3} - z^{-6} \end{array}$$

$$= x(0) + x(1)z^{-1} + x(2)\,z^{-2} + x(3)\,z^{-3} \cdots$$

$$X(z) = \frac{1}{1-z^{-3}} = 1 + 0\cdot z^{-1} + 0\cdot z^{-2} + 1\cdot z^{-3} \cdots$$

By comparison $x(2) = 0$

127. (b)

Only complex exponential are periodic.

$$x_2(t) = e^{-jt} \cdot e^{t}$$

(because of this term $x_2(t)$ is non-periodic)

128. (b)

$$H(e^{j\omega}) = \frac{1}{1-0.8e^{-j\omega}}$$

$$H(e^{j\omega})\Big|_{\omega=0} = \frac{1}{1-0.8} = 5$$

Steady state response, $y_{ss}(n) = (5)\ (4) = 20$

129. (a)

$$x(t) = u(t+1)\ u(1-t) \text{ is an energy signal } \text{rec}\left(\frac{t}{2}\right),$$

So, statement (3) is false.

130. (c)

$$x(t) \text{ energy, } E = 8 \text{ J}$$

$$(4+j3)\ x(t) = |4+j3|^2 \cdot E = 200 \text{ J}$$

$$x\left(\frac{t}{5}+4\right) \to \frac{E}{1/5} = 5E = 40 \text{ J}$$

$$x(5t-3) \to \frac{E}{5} = \frac{8}{5} \text{ J}$$

$$5x(t) \to |5|^2 \cdot E = 200 \text{ J}$$

131. (a)

$$H(e^{j\omega}) = \sum_{n=-\infty}^{\infty} h(n)e^{-j\omega n}$$

$$H(e^{j0}) = \sum_{n=-\infty}^{\infty} h(n)$$

$$= 1+4+2-3+0+5-1 = 8$$

$$H(e^{j\pi}) = \sum_{n=-\infty}^{\infty} h(n)(-1)^n$$

$$= 1-4+2+3+0-5-1 = -4$$

$$|H(e^{j\pi})| = 4$$

Since, $|H(e^{j0})| > |H(e^{j\pi})|$

Filter is LPF.

132. (a)

$$H(z) = H_1(z)\cdot H_2(z)$$
$$= (1 - Az^{-1})\cdot(1 + Bz^{-1})$$
$$= 1 + Bz^{-1} - Az^{-1} - ABz^{-2}$$
$$= 1 + (B - A)z^{-1} - ABz^{-2}$$

$\Rightarrow$ $$h[n] = \{\underset{\uparrow}{1}, (B-A), -AB\}$$

$\therefore$ On comparing, $$-AB = -1$$

$\Rightarrow$ $$AB = 1$$

133. (c)

We know, $$X(k) = \sum_{n=0}^{N-1} x[n]e^{-j\frac{2\pi nk}{N}}$$

$\Rightarrow$ $$X(0) = \sum_{n=0}^{N-1} x[n]e^{-j0} = \sum_{n=0}^{N-1} x[n]$$

$\Rightarrow$ $$X(0) = \sum_{n=0}^{8-1}\left[\frac{3+\cos\left(\frac{8\pi n}{N}\right)}{2}\right] = \sum_{n=0}^{7}\left[\frac{3+\cos\left(\frac{8\pi n}{N}\right)}{2}\right]$$

$$= \sum_{n=0}^{7}\left(\frac{3}{2}+\frac{1}{2}(-1)^n\right)$$

$$= \left[8\times\frac{3}{2}\right]+\frac{1}{2}-\frac{1}{2}+\frac{1}{2}-\frac{1}{2}+\frac{1}{2}-\frac{1}{2}+\frac{1}{2}-\frac{1}{2}$$

$$= \frac{24}{2} = 12$$

134. (a)

Using Parseval's theorem,

$$P = \sum_{n=0}^{N-1}|x[n]|^2 = \frac{1}{N}\sum_{k=0}^{N-1}|X(k)|^2$$

$$14 = \frac{1}{4}\sum_{k=0}^{3}|X(k)|^2$$

$$56 = (6)^2 + (X^2 + Y^2) + (-2)^2 + (X^2 + Y^2)$$

$\Rightarrow$ $$2(X^2 + Y^2) = 56 - 36 - 4$$

$\Rightarrow$ $$X^2 + Y^2 = \frac{16}{2} = 8$$

135. (b)

Eigen values of given matrix A are 1, –1, 3

$$\text{Eigen values of } A^4 = 1, 1, 81$$

$$\text{Eigen values of } 4A^3 = 4, -4, 108$$

$$\text{Eigen values of } A^4 - 4A^3 = -3, 5, -27$$

$$\therefore \quad \text{Trace of } A^4 - 4A^3 = -3 + 5 - 27 = -25$$

136. (b)

$$(D^2 + 2D + 1) = 0$$

$$D = -1, -1$$

C.F. is, $y(t) = (C_1 + C_2 t)e^{-t}$

$$y'(t) = C_2\, e^{-t} + (C_1 + C_2 t)\,(-e^{-t})$$

$$y(0) = y'(0) = 1$$

From here, $C_1 = 1,$

$$C_2 = 2$$

Solution is, $y(t) = (1 + 2t)e^{-t}$

137. (a)

$$(D^2 + 6D + 9)y = 9\, e^{3x}$$

Auxiliary equation is

$$D^2 + 6D + 9 = 0$$

or $D = -3, -3$

$$\text{C.F.} = (C_1 + C_2 x)\, e^{-3x}$$

$$\text{P.I.} = \frac{1}{D^2 + 6D + 9}\cdot 9e^{3x} = \frac{9\cdot e^{3x}}{(3)^2 + 6(3) + 9} = \frac{9e^{3x}}{36}$$

$$= \frac{e^{3x}}{4}$$

The complete solution is,

$$y = (C_1 + C_2 x)e^{-3x} + \frac{e^{3x}}{4}$$

138. (b)

$$I = \oint_c \frac{8z+6}{(z^2+4z+5)}dz$$

$$= 2\pi i \qquad \text{(sum of residues)}$$

Poles of $\dfrac{8z+6}{z^2+4z+5}$ are given by:

$$z^2 + 4z + 5 = 0$$

$$z = \frac{-4 \pm \sqrt{16-20}}{2} = -\frac{4 \pm 2i}{2}$$

$$= -2 \pm i$$

Since the poles lie outside the circle $|z| = 1$.

So, $f(z)$ is analytic inside the circle $|z| = 1$.

Hence, $$\oint_c f(z)dz = 2\pi i\ (0) = 0$$

139. (c)

$$\lim_{t\to\infty} f(t) = \lim_{s\to 0} sF(s)$$

Given that, $$F(s) = \left[\frac{3s+1}{s^3+4s^2+(K-2)s}\right]$$

$$\lim_{t\to\infty} f(t) = 1$$

$$\Rightarrow \quad \lim_{s\to 0} s\left[\frac{3s+1}{s^3+4s^2+(K-2)s}\right] = 1$$

$$\Rightarrow \quad \lim_{s\to 0}\left[\frac{3s+1}{s^2+4s+K-2}\right] = 1$$

$$\frac{1}{K-2} = 1$$

$$\Rightarrow \quad K-2 = 1$$

$$\Rightarrow \quad K = 3$$

140. (c)

Since A is upper triangular matrix the eigen values are same as the diagonal elements of A.

$\therefore$ Eigen values are $\lambda = 1, 1, 1$

The eigen vectors for $\lambda = 1$ are given by

$$[A - \lambda I] = 0$$

$$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

Here rank of $[A - \lambda I] = K = 1$

Number of variables $= n = 3$

Number of linearly independent eigen vectors

$$= n - K = 2$$

141. (d)

$$\frac{\partial z}{\partial x} = 2x \cdot f'(x^2+y^2) \quad \text{...(i)}$$

and
$$\frac{\partial z}{\partial y} = 2y \cdot f'(x^2+y^2) \quad \text{...(ii)}$$

Dividing equation (i) by (ii),

$$\frac{\frac{\partial z}{\partial x}}{\frac{\partial z}{\partial y}} = \frac{2x \cdot f'(x^2+y^2)}{2y \cdot f'(x^2+y^2)}$$

$$\Rightarrow \quad \frac{\partial z}{\partial x} = \frac{x}{y}\frac{\partial z}{\partial y}$$

$$\Rightarrow \quad y\frac{\partial z}{\partial x} - x\frac{\partial z}{\partial y} = 0$$

142. (a)

$$\nabla \cdot \bar{A} = \left(\frac{\partial}{\partial x}\hat{a}_x + \frac{\partial}{\partial y}\hat{a}_y + \frac{\partial}{\partial z}\hat{a}_z\right)\cdot\left(x^2y\,\hat{a}_x - 2xz\,\hat{a}_y + 2yz\,\hat{a}_z\right)$$

$$= 2xy + 2y$$

At (2, –1, 3)

$$\nabla \cdot \bar{A} = -4 - 2 = -6$$

143. (b)

The probability density function of X is

$$f(x) = \begin{bmatrix} \frac{1}{30}, & 0 < x < 30 \\ 0, & \text{otherwise} \end{bmatrix}$$

$$P(5 < x < 10) = \int_5^{10} f(x)\,dx = \int_5^{10} \frac{1}{30}dx = \frac{1}{6}$$

144. (c)

$$\text{P.I.} = \left(\frac{1}{D^4+1}\right)x^5 = (1+D^4)^{-1}x^5$$

$$= (1 - D^4 + D^8 .....)x^5$$

$$= x^5 - D^4x^4$$

$$= x^5 - 120x$$

145. (c)

For the given network, $Z_{11} = 2\ \Omega$

$Z_{22} = 3\ \Omega$

$Z_{11} \neq Z_{22} \Rightarrow$ Not a symmetrical network

For a symmetrical network, $A = D$

So, Statement (I) is correct and Statement (II) is wrong.

146. (d)

Routh-Hurwitz criterion tests whether any roots of the characteristic equation lie in the right-half s-plane as well as the number of roots that lie on the $j\omega$-axis. Therefore, statement (I) is false.

147. (d)

Hard magnetic materials are used for making permanent magnets.

150. (b)

Both statements are correct but statement-II is not the correct explanation of statement-I.

■■■■

