DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

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

Note : (*) Indicates marks to all.

DETAILED EXPLANATIONS

1. (a)

At node, using KCL, we have,

$$10 + i_2 = i_1 + i_3$$

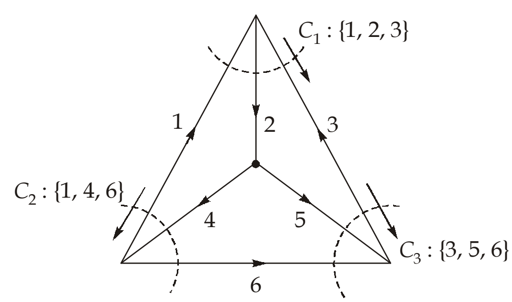
$$10 + \frac{30}{6} = \frac{20}{10} + i_3$$

$$15 - 2 = i_3$$

$$i_3 = 13 \text{ A}$$

$$\therefore \quad R_3 = \frac{65}{13} = 5\,\Omega$$

2. (d)



3. (b)

For series *RLC* circuit,

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} \quad \text{...(i)}$$

and

$$f_2 - f_1 = \text{BW} = \frac{1}{2\pi}\frac{R}{L} \quad \text{...(ii)}$$

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

$$\frac{\text{BW}}{f_0^2} = \frac{\frac{1}{2\pi}\times\frac{R}{L}\times\left(\sqrt{(LC)}\right)^2}{1/4\pi^2} = 2\pi RC$$

or,

$$R = \frac{9\times10^3}{2\pi\times3\times3\times10^{12}\times70\times10^{-12}}$$

$$R = \frac{10^3}{2\times\pi\times70} = \frac{10^3}{440}\,\Omega$$

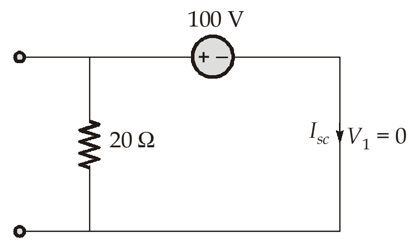
$$R = 2.27\,\Omega$$

4. (c)

In order to determine V_{Th} let $V_1 = V_{oc}$

$$\frac{-V_{oc}}{100} + \frac{100 + V_{oc}}{20} = 0$$

$$V_{oc} = -125 \text{ V}$$



when $V_1 = 0$, the dependent source is open circuited.

$$\therefore \quad I_{sc} = -5 \text{ A}$$

$$\therefore \quad R_{Th} = \frac{V_{oc}}{I_{sc}} = 25\ \Omega$$

5. (c)

Conversion from [h] parameter to [T] parameter.

We get,
$$T = \begin{bmatrix} \frac{-\Delta h}{h_{21}} & \frac{-h_{11}}{h_{21}} \\ \frac{-h_{22}}{h_{21}} & \frac{-1}{h_{21}} \end{bmatrix} = \begin{bmatrix} -10^{-4} & -20 \\ -10^{-7} & -10^{-2} \end{bmatrix}$$

$$\therefore \quad Z_{in} \text{ across } AB = \frac{AR_L + B}{CR_L + D} = 1.67\ \text{k}\Omega$$

6. (d)

$$Y_{in} = \frac{1}{R + j10} + \frac{1}{4 - j5} = \frac{R - j10}{R^2 + 100} + \frac{4 + j5}{16 + 25}$$

For resonance, imaginary part in Y_{in} should be equal to zero,

$$\frac{-j10}{R^2 + 100} + \frac{j5}{41} = 0$$

$$R^2 = -18$$

$$R = \text{some imaginary value}$$

7. (d)

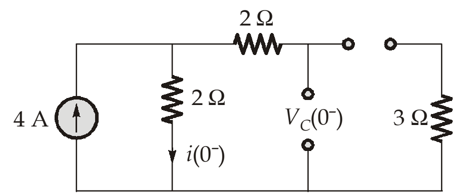
The angle between voltage and current is 30°.

$$\therefore \quad \text{Power factor } \phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$

$$R = \frac{X_L}{\tan\phi} = \frac{\sqrt{3}}{\tan 30^\circ} = \sqrt{3} \times \sqrt{3} = 3\ \Omega$$

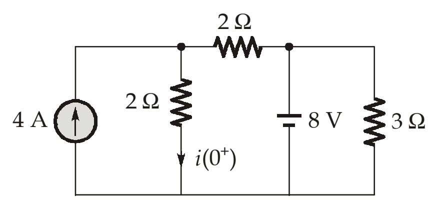
8. (d)

At $t = 0^-$,



$$V_C(0^-) = V_C(0^+) = 8 \text{ V}$$

At $t = 0^+$,



Using superposition theorem,

$$i(0^+) = \frac{4\times 2}{2+2} + \frac{8}{2+2} = 4 \text{ A}$$

9. (b)

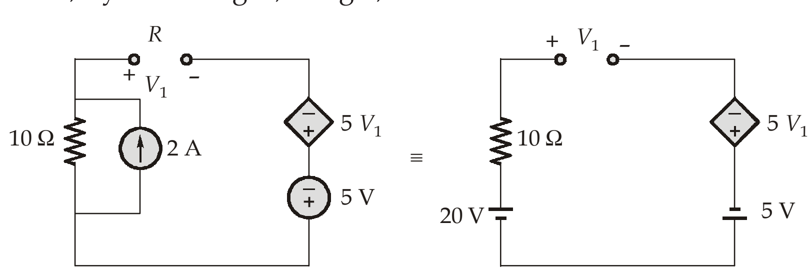
$$v = M\frac{di}{dt}$$

$$400 = 10\times\frac{2}{t_0}\times 10^{-3}$$

$$t_0 = \frac{10\times 2}{400}\times 10^{-3} = \frac{1}{20}\times 10^{-3} = 50\ \mu\text{s}$$

10. (d)

Redrawing the circuit, by removing R, we get,



using KCL,

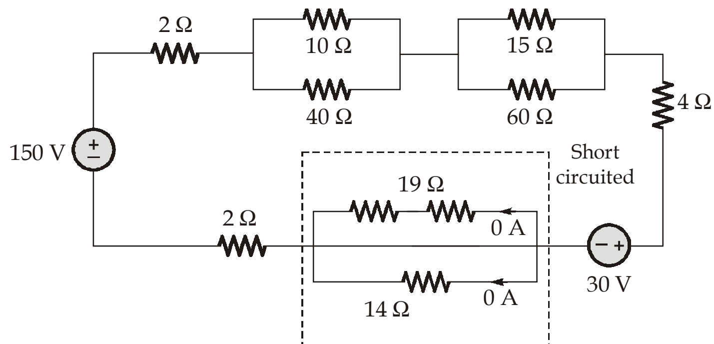
$$V_1 = 20 + 5 + 5V_1$$

$$-4\,V_1 = 25 \text{ V}$$

$$V_1 = -6.25 \text{ V}$$

11. (a)

The circuit can be simplified as



$\because$ The current through 13 Ω resistance is zero hence power absorbed by it will also be zero.

12. (b)

$$\frac{\sin\theta_t}{\sin\theta_i} = \sqrt{\frac{1}{\varepsilon_r}}$$

$$\varepsilon_r = \left(\frac{\sin\theta_i}{\sin\theta_t}\right)^2 = \left(\frac{\sin 45°}{\sin 30°}\right)^2 = \left(\frac{1/\sqrt{2}}{1/2}\right)^2 = 2$$

13. (c)

According to Gauss law, the volume charge density in a certain region is equal to the divergence of electric flux density in that region.

$\therefore$
$$\rho_v = \nabla\cdot\vec{D}$$

$$= \frac{\partial}{\partial x}(3y^2+4z)+\frac{\partial}{\partial y}(2xy)+\frac{\partial}{\partial z}(4x) = 2x$$

$\therefore$ Total charge,
$$Q = \int \rho_v dv = \int_0^2\int_0^1\int_{-1}^1 2x\, dxdydz$$

$$= \left(x^2\right)_0^2 \times 1\times 2 = 4\times 1\times 2 = 8\text{ C}$$

14. (a)

The given field equation can be modified as,

$$\vec{E} = 20\cos(\omega t-\beta z+45°)\hat{a}_x + 20\cos(\omega t-\beta z-45°+90°)\hat{a}_y$$

$$= 20\cos(\omega t-\beta z+45°)\hat{a}_x + 20\cos(\omega t-\beta z+45°)\hat{a}_y$$

$\because$ $E_x = E_y$

and $\phi_x = \phi_y$

$\therefore$ linearly polarized.

15. (c)

$$\left|\frac{J_C}{J_D}\right| = \frac{\sigma}{\omega\varepsilon} = 1$$

$\therefore$
$$\omega = \frac{\sigma}{\varepsilon}$$

$$\omega = \frac{4}{16\varepsilon_0} = \frac{1}{4\varepsilon_0}$$

$\therefore$
$$2\pi f = \frac{1}{4\varepsilon_0} = \frac{1}{4\times\frac{1}{36\pi}\times 10^{-9}}$$

or
$$f = \frac{1}{8\pi\times\frac{1}{36\pi}\times 10^{-9}} = \frac{9}{2}\times 10^9 = 4.5\text{ GHz}$$

16. (c)

$$f_c = \frac{c}{2a} = \frac{3\times 10^{10}}{6} = \frac{1}{2}\times 10^{10} = 5\text{ GHz}$$

$\therefore$
$$\lambda_g = \frac{\lambda_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{3\times 10^{10}/10^{10}}{\sqrt{1-\left(\frac{5}{10}\right)^2}} = \frac{3}{\sqrt{1-\frac{1}{4}}} = \frac{3\times 2}{\sqrt{3}}$$

$$= 2\sqrt{3}\text{ cm} = 2\times 1.732 = 3.464\text{ cm}$$

17. (c)

$$\text{Directive gain} = \frac{\text{Power gain}}{\text{Efficiency}}$$

$$\eta = \frac{3}{4} = \frac{R_{rad}}{R_{rad}+R_{loss}}$$

$$4R_{rad} = 3R_{rad} + 30$$

$$R_{rad} = 30\ \Omega$$

18. (b)

Since Z_0 and Z_L are real and $Z_L < Z_0$, voltage minima occurs at the load end.

So, the distance of first voltage maxima from the load end is equal to,

$$\frac{\lambda}{4} = 5\text{ cm}$$

$$\lambda = 20\text{ cm}$$

$\therefore$
$$\beta = \frac{2\pi}{\lambda} = \frac{\pi}{10}\text{ rad/cm}$$

19. (c)

$$\delta \propto \frac{1}{\sqrt{f}}$$

$$\therefore \quad \frac{\delta_1}{\delta_2} = \sqrt{\frac{f_2}{f_1}}$$

or
$$f_2 = f_1 \times \left(\frac{\delta_1}{\delta_2}\right)^2 = 1 \times 10^6 \left(\frac{20}{5}\right)^2 = 16 \text{ MHz}$$

20. (b)

$$\gamma_g = \alpha_g + j\beta_g$$

$$\because \quad f = 2f_c$$

$$\gamma_g = j\beta_g$$

and
$$\alpha_g = 0$$

$\because$ Operating frequency > cut-off frequency, propagation constant is imaginary.

21. (d)

$$H^2\eta = \frac{P_{\text{rad}} G_d}{4\pi R^2}$$

$$H^2 = \frac{30 \times 10^3 \times 10}{4\pi (1600)^2 \times 120\pi}$$

$$H = \sqrt{\frac{30 \times 10^4}{120 \times 4 \times \pi^2 \times (1600)^2}}$$

$$= \sqrt{\frac{10^4}{4 \times 4 \times (1600)^2 \times \pi^2}} = \frac{100}{2 \times 2 \times 1600 \times \pi} = \frac{1}{64\pi} \text{ A/m}$$

22. (b)

$$\nabla^2 V = -\frac{\rho}{\varepsilon} = -\frac{\rho}{\varepsilon_0}$$

$$\frac{\partial^2}{\partial x^2}(5x^3 + 2y^4) + \frac{\partial^2}{\partial y^2}(5x^3 + 2y^4) = -\frac{\rho}{\varepsilon_0}$$

$$\frac{\partial}{\partial x} 15x^2 + \frac{\partial}{\partial y} 8y^3 = -\frac{\rho}{\varepsilon_0}$$

$$30x + 24y^2 = \frac{-\rho}{\varepsilon_0}$$

at point (1, 0, 0),
$$30 = -\frac{\rho}{\varepsilon_0}$$

$$\rho = -30\varepsilon_0 = \frac{-30}{36\pi} \times 10^{-9} = \frac{-5}{6\pi} \text{ nC/m}^3$$

23. (d)

24. (a)

25. (b)

26. (b)

$$\mu_r = 1+\frac{M}{H} = 1+\frac{19.8\times 1000}{200} = 100$$

27. (c)

28. (d)
Dichroism is a phenomenon in which the optical absorption in a material depends on the direction of propagation and the state of polarization of the light beam.

29. (b)
The reciprocal of the intercept of the plane.

30. (c)

$$H = H_0\left[1-\left(\frac{T}{T_c}\right)^2\right]$$

$$9\times 10^3 = 25\times 10^3\left[1-\left(\frac{T}{7.5}\right)^2\right]$$

$$\frac{9}{25} = 1-\left(\frac{T}{7.5}\right)^2$$

$$\frac{T}{7.5} = \sqrt{1-\frac{9}{25}} = \sqrt{\frac{16}{25}} = \frac{4}{5}$$

$$T = \frac{4}{5}\times 7.5 = 6\text{ K}$$

31. (a)

32. (c)

33. (c)

34. (c)

35. (a)
Given, transfer function of PI controller,

$$T(s) = 2+\frac{0.2}{s}$$

$$T(s) = 2\left[1+\frac{0.1}{s}\right]$$

PI controller transfer function, $T(s) = K_P\left[1+\frac{1}{T_r s}\right]$

$\therefore$ Gain $= 2 = K_P$

We know that, proportional band $= \frac{100}{\text{Gain}} = \frac{100}{2} = 50\%$

Reset time, $T_r = \frac{1}{0.1} = 10$ minutes

36. (c)

The step response, $c(t) = (1 - 5e^{-t})\, u(t)$

Taking the Laplace transform of the above equation, we get,

$$C(s) = \frac{1}{s} - \frac{5}{(s+1)} = \frac{(1-4s)}{s(s+1)}$$

Therefore the transfer function can be obtained as,

$$\frac{C(s)}{R(s)} = \frac{(1-4s)}{s(s+1)} \times s = \frac{(1-4s)}{(s+1)}$$

37. (d)

For type-II system,

- Acceleration error constant, $K_a = \lim_{s \to 0} s^2 G(s) H(s)$

  $\therefore$ $K_a = \text{Constant}$

- Positional error constant, $K_p = \lim_{s \to 0} G(s) H(s) = \infty$

- The steady state error for unit step displacement is zero,

  i.e. $e_{ss} = \frac{A}{1+K_p} = \frac{A}{1+\infty} = 0$

38. (b)

$$G(s) = \frac{e^{-\tau_D s}}{s}$$

$$G(j\omega) = \frac{e^{-j\omega\tau_D}}{j\omega}$$

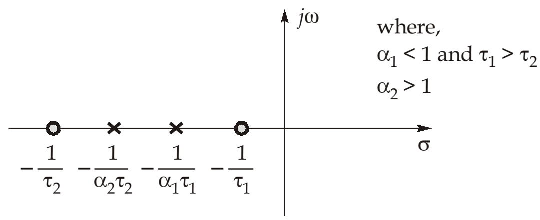
At $\omega = \frac{\pi}{2\tau_D}$, $|G(j\omega)| = \frac{1}{\omega} = \frac{1}{\pi/2\tau_D} = \frac{2\tau_D}{\pi}$

and $\angle G(j\omega) = -\frac{\pi}{2} - (\tau_D \omega)$

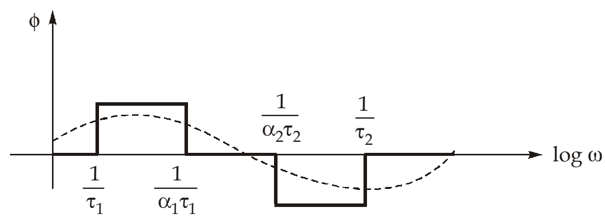
$$= -\frac{\pi}{2} - \left(\tau_D \times \frac{\pi}{2\tau_D}\right) = -\frac{\pi}{2} - \frac{\pi}{2} = -\pi \text{ or } \pm 180^\circ$$

39. (b)

The pole zero plot of lead-lag network is



The phase plot can be drawn as,



40. (a)

Given poles are $s = -1 \pm j2$ and zero at $s = -3$, transfer function can be written as,

$$\frac{C(s)}{R(s)} = \frac{K(s+3)}{(s+1-2j)(s+1+2j)}$$

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

given $$r(t) = u(t) \Rightarrow R(s) = \frac{1}{s}$$

applying final value theorem to find steady state value

$$C_{ss} = \underset{s\to 0}{lt}\ sC(s)$$

where $$C(s) = \frac{K(s+3)}{s\left[(s+1)^2+2^2\right]}$$

∴ $$C_{ss} = \underset{s\to 0}{lt}\ s\cdot\frac{K(s+3)}{s\left[(s+1)^2+2^2\right]} = 2$$

$$\frac{3K}{5} = 2 \Rightarrow K = \frac{10}{3}$$

∴ $$\frac{C(s)}{R(s)} = \frac{10}{3}\frac{(s+3)}{s^2+2s+5}$$

41. (a)

Given $$[A] = \begin{bmatrix} 0 & 2 \\ 8 & 0 \end{bmatrix}$$

The poles or the eigen values of the system can be obtained by solving the following equation:

$$|sI - A| = 0$$

where, $$[sI - A] = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 2 \\ 8 & 0 \end{bmatrix} = \begin{bmatrix} s & -2 \\ -8 & s \end{bmatrix}$$

∴ $$|sI - A| = \begin{vmatrix} s & -2 \\ -8 & s \end{vmatrix} = s^2 - 16 = 0$$

or $$s = \sqrt{16} = \pm 4$$

42. (c)

The given figure represents the phase lead compensator having lead constant 'α' given by,

$$\alpha = \frac{R_2}{R_1 + R_2}$$

Here, R_2 = 2 kΩ and R_1 = 3 kΩ

∴ $$\alpha = \left(\frac{2}{2+3}\right) = \frac{2}{5} = 0.4$$

43. (b)

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

Here, P = 3 and Z = 0.

Number of root locus branches terminate at infinite,

∴ $$P - Z = 3$$

(i) $$\text{Centroid} = \frac{\Sigma P - \Sigma Z}{P - Z} = \frac{-2-4}{3} = -2$$

(ii) $$\text{Angle of asymptotes} = \frac{(2q+1)}{P-Z} \times 180° \ ; \ q = 0, 1, 2$$

$$= 60°, 180° \text{ and } 300°$$

Only in the Root locus plot given in option (b), the angle of asymptotes are 60°, 180° and 300°. So, option (b) is correct.

44. (a)

The transfer function, $$\frac{C(s)}{R(s)} = \frac{1}{s^2 + 1.5s + 4}$$

The Laplace transform of output of the system,

$$C(s) = \frac{R(s)}{s^2 + 1.5s + 4}$$

Given, $$R(s) = \mathcal{L}\,(2\,u(t)) = \frac{2}{s}$$

∴ $$C(s) = \frac{2/s}{s^2 + 1.5s + 4}$$

The steady value of the output is,

$$c(\infty) = \lim_{s \to 0} sC(s) = \lim_{s \to 0} \frac{s \times 2/s}{s^2 + 1.5s + 4} = \frac{2}{4} = \frac{1}{2} = 0.5$$

45. (d)

The characteristic equation is,

$$s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$$

The Routh array is,

s^5	1	2	3
s^4	1	2	5
s^3	$\in$	–2	0
s^2	$\frac{2\in +2}{\in}$	5	0
s^1	x	0	0
s^0	5	0	0

Where, $x = \frac{-4\in -4 - 5\in^2}{2\in +2}$

Thus, for $\in \to 0$, $x \to -2$.

Hence, the total number of sign changes in the first column of Routh array is 2. Therefore the number of roots lie on the left half of the s-plane is 3.

46. (b)

From the given frequency response graph,

$$\text{Resonant peak} = 1.35$$

i.e.,

$$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}} = 1.25$$

$$4\xi^2(1 - \xi^2) = \frac{1}{(1.25)^2} = 0.64$$

$$\xi^4 - \xi^2 + 0.16 = 0$$

$$\xi^2 = 0.2,\ 0.8$$

$$\xi \simeq 0.45,\ 0.90$$

But ξ should be less than 0.707. Hence, option (b) can be chosen.

47. (b)

48. (a)

In mobile communication using IP protocol, mobile nodes use agent advertisement to determine their current point of attachment to the internet or to an organisation's network.

It is an Internet Control Message Protocol (ICMP).

In the absense of agent advertisements, a mobile node can solicit advertisements. This is known as agent solicitation.

49. **(b)**

In circuit switching, all the packets travel through the same route.

In packet switching, different packets travel through different routes and their by they experience different delays. Hence, packets switching offers more variations in delay than circuit switching.

50. **(c)**

FTP has control and data connection it requires authorizaton. HTTP is stateless protocol. TCP is not application layer but it is statefull. POP3 is application protocol and it gets state with help of TCP.

51. **(a)**

Since

$$t_r = \text{Transit time} = \frac{\text{Depletion layer width } (W_d)}{\text{Carrier velocity}}$$

$$= \frac{28 \times 10^{-6}}{3.5 \times 10^4} = 8 \times 10^{-10} \text{ sec}$$

$$\text{Maximum 3 dB bandwidth} = \frac{0.35}{t_r} = \frac{0.35}{8 \times 10^{-10}} = 4.375 \times 10^8 \text{ Hz}$$

$$= 437.5 \text{ MHz}$$

52. **(d)**

$$L = \frac{10}{\alpha} \log_{10}\left(\frac{P_{in}}{P_{out}}\right) \text{km}$$

$$L_{max} = \frac{10}{0.5} \log_{10}\left(\frac{10^{-3}}{50 \times 10^{-6}}\right) \text{km}$$

$$= \frac{10}{0.5} \log_{10} 20 \text{ km} \approx \frac{10}{0.5} \times 1.30 = 26 \text{ km}$$

53. **(d)**

$$\text{Number of modes } (M) = \left(\frac{\alpha}{\alpha + 2}\right)\frac{V^2}{2}$$

$\alpha = 1$ for triangular profile

$$\therefore \quad M = \frac{V^2}{6} = \frac{30^2}{6} = \frac{900}{6} = 150$$

54. **(b)**

$$r_e + h_a = a(1 + e) = \text{apogee}$$

$$r_e + h_p = a(1 - e) = \text{perigee}$$

$$\Rightarrow \quad \frac{1 - e}{1 + e} = \frac{6400 + 1000}{6400 + 4000} = \frac{74}{104} = \frac{37}{52}$$

$$e = \frac{52 - 37}{52 + 37} = \frac{15}{89} \simeq 0.17$$

55. (a)

For given 8-PSK system

$$\text{Transmission Rate} = R_b = 60 \text{ Mbps}$$

$$\text{Bandwidth (B)} = \frac{R_b}{\log_2 M} = 20 \text{ Mbps}$$

since

$$\frac{C}{N} = \frac{E_b f_b}{N_0 B}$$

$$\frac{C}{N}(dB) = \frac{E_b}{N_0}(dB) + \frac{f_b}{B}(dB) = 15 + 10 \log 3$$

$$= 15 + 4.77 = 19.77 \text{ dB}$$

56. (a)

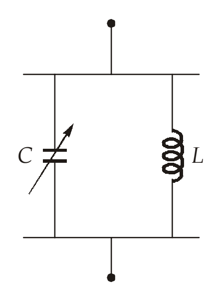
For geostationary satellites, the transmitted power required is more as the distance between the earth station and satellite is more as compared to MEO satellites.

57. (d)

58. (d)

While producing sustained oscillations, the imaginary part of β will be zero and hence $|\beta| = \frac{1}{3}$.

59. (d)



Since

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where

$$C \propto \frac{1}{\sqrt{V_0 + V_r}}$$

So, as the Vr increases from 0 to 2V.

$$C' = \sqrt{\frac{0.7}{2.7}}\,C = \frac{C}{\sqrt{3.85}}$$

and

$$f' = \sqrt{\frac{C}{C'}}\,f$$

So, freq. increases but less than 2 times the initial frequency.

60. (d)

$$A = 1 + \frac{R_1}{R_2} = 4 \quad \Rightarrow \frac{R_1}{R_2} = 3$$

when op-amp is non ideal

then

$$\frac{V_{out}}{V_{in}} = \frac{A_{OL}}{1 + \frac{R_2}{R_1 + R_2}A_{OL}} = \frac{1000}{1 + \frac{1}{4} \times 1000} = \frac{1000}{251} = 3.984$$

61. (b)

at $t = 0$, $V_{in} = 0$; $V_{out} = 0$

at $t > 0$ $$I_{in} = C_1 \frac{dV_{in}}{dt} = C_1 V_1 \delta(t)$$

The current flows through R_1, generating an output given by

$$V_{out} = -I_{in} R_1$$
$$= -V_1 R_1 C_1 \delta(t)$$
$$= -5 \times 10^{-6} \times 10^{3}\, \delta(t)$$
$$V_{out} = -5 \times 10^{-3}\, \delta(t) \quad \text{at } t = 0^+$$

and $$V_{out} = 5 \times 10^{-3}\, \delta(t - T_b) \quad \text{at } t = T_b$$

62. (b)

Since $$I_{in} = I_{D1} + I_{D2}$$

and $$V_{D1} = V_{D2}$$

$$\Rightarrow \quad V_T \ln \frac{I_{D1}}{I_{S1}} = V_T \ln \frac{I_{D2}}{I_{S2}}$$

$$\Rightarrow \quad \frac{I_{D1}}{I_{S1}} = \frac{I_{D2}}{I_{S2}}$$

$$\Rightarrow \quad I_{D2} = \frac{I_{in}}{1 + \dfrac{I_{S1}}{I_{S2}}}$$

63. (a)

$$\text{Corner frequency } (\omega_0) = \frac{1}{R_1 C_1}$$

$$\frac{d\omega_0}{dR_1} = -\frac{1}{R_1^2 C_1}$$

$$\frac{\delta\omega_0}{\omega_0} = \frac{-\delta R_1}{\omega_0 \cdot R_1^2 C_1} = \frac{-\delta R_1}{R_1} \cdot \frac{1}{\omega_0 R_1 C_1} = -\frac{\delta R_1}{R_1}$$

So, for +5% change in R_1, ω_0 changes by –5%.

64. (c)

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12 - 0.7}{100} = \frac{11.3}{100}\,\text{mA}$$

$$\beta I_B = \frac{11.3}{100} \times 100 = 11.3\,\text{mA}$$

$$I_{C(sat)} = \frac{V_{CC} - V_{CE(Sat)}}{R_C} = \frac{12 - 0.2}{4} = 2.95\,\text{mA}$$

$$\beta I_B >> I_{C(sat)} \quad \Rightarrow \quad \text{Saturation region}$$

65. (c)

66. (a)

DC current carried by each diode in bridge rectifier is $\frac{I_L}{2}$.

67. (a)

68. (c)

69. (c)

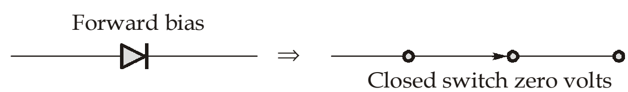
$$g_m = \sqrt{2\mu_n C_{ox} \times \frac{W}{L} I_D} = \sqrt{2 \times 0.1 \times 10 \times 0.5} \text{ m℧}$$

$$g_m = 1 \text{ m℧}$$

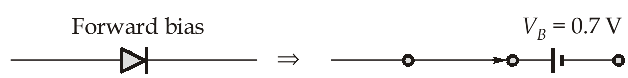
$$r_0 = \frac{1}{\lambda I_D} = 20 \text{ k}\Omega$$

70. (b)

According to first approximation



According to second approximation



71. (c)

72. (b)

73. (a)

Auger Recombination: This mechanism involves an additional electron. Here energy released during e-h recombination is used to promote the other electron onto higher energy level from which it then falls down releasing energy as heat.

74. (a)

Condition to be satisfied for saturation mode of operation is,

$$V_{DS} \geq V_{GS} - V_T$$

$$V_D - V_S \geq V_{GS} - V_T$$

$$V_D \geq V_{GS} - V_T + V_S$$

So, $$V_{D(\text{min})} = (V_{GS} - V_T + V_S) = (4 - 2 + 1) = 3 \text{ V}$$

75. (a)

- Data logger is an electric device that records data over time, these are based on digital processors. They are generally small battery powered, portable and equipped with microprocessor.
- Generally data acquisition system have printers, digital displays, magnetic tape recorder or computer processors as their output stage.

76. (a)

A standard for the voltage is : A Josephson junction cooled to nearly absolute zero and irradiated with microwave energy.

The voltage developed across the junction which is a function of irradiating frequency

$$V = \frac{hf}{2e};\ h = \text{Planck's constant}$$

$$V = \frac{6.63\times10^{-34}\times10.25\times10^{9}}{2\times1.6\times10^{-19}}$$

$$= \frac{6.63\times10.25}{3.2}\times10^{6} = 21.23\times10^{-6}\text{ V}$$

$$V = 21.23\ \mu\text{V}$$

77. (a)

78. (d)

The rms value of the square-wave voltage is

$$E_{\text{rms}} = E_m$$

$$E_{\text{avg}} = E_m$$

so that the form factor $K = \frac{E_{\text{rms}}}{E_{\text{avg}}} = 1$

Since meter scale is calibrated in terms of rms value of sine wave voltage, where,

$$E_{\text{rms}} = 1.11\,E_{\text{avg}}$$

therefore the meter indication for the square wave voltage is high by a factor 1.11.

The percentage error equals

$$\frac{1.11-1}{1}\times100\% = 11\%$$

79. (a)

Effective Q of coil, $Q_c = \frac{1}{\omega CR}$

the indicated Q of coil, $Q_i = \frac{1}{\omega C(R+0.02)}$

then, Percentage error $= \frac{\frac{1}{\omega CR}-\frac{1}{\omega C(R+0.02)}}{\frac{1}{\omega CR}}\times100\%$

$$= \frac{0.02}{10.02}\times100 \simeq 0.2\% \qquad [\because R = 10\ \Omega]$$

80. (b)

81. (a)

Traceability: This gives the comparison between various standards to demonstrate an unbroken chain of comparisons or trace back the accuracy value of primary standard. Each level of ladder in comparison should necessarily be with higher accuracy than lower level.

Calibration: The set of operations which establish under specified conditions, the relationship between values indicates by measuring instruments or measuring system and corresponding standard or known value derived from the standard.

82. (c)

Thermocouple type instrument reads rms value,

Given, $$I = 1+3\sqrt{2}\sin(314t+30°)+2\cos(942t+45°)$$

$\therefore$ $$I_{rms} = \sqrt{(1)^2+\left(\frac{3\sqrt{2}}{\sqrt{2}}\right)^2+\left(\frac{2}{\sqrt{2}}\right)^2}\text{ A} = \sqrt{1+9+2}\text{ A} = \sqrt{12}$$

$$= 2\sqrt{3} = 3.46\text{ A}$$

83. (d)

Differential head type flow meters:

- Orifice Plate
- Venturimeter

Difference in pressure exists between the upstream and downstream sides of restriction in a confined fluid stream, which is related to square of fluid velocity.

Venturimeter is differential head type and can be used at temperature extremes.

Differential area type:

Rotameter.

For measurement: A free moving float is balanced inside a vertical tapered tube.

As flow is in upward direction the float remains steady when the dynamic forces acting on it are zero.

These are simple and rugged, but can be only used in vertical installation only.

84. (a)

In Pirani gauge or hot wire meter resistance of the heating element is varied by conversion cooling of a stream of gas.

Reluctance pickup is used to measure vibration and position measurement.

Dielectric gauge is based on variation in capacitance by changes in the dielectric and used for liquid level measurement.

Eddy current gauge is used for displacement and thickness measurement.

85. (a)

Sampling oscilloscope is used at very high frequencies, and has provision for post deflection acceleration. It has one extra post acceleration anode and phosphor coating which has short persistence.

Dual trace CRO has 1 electron gun, 1 horizontal plate and 2 vertical plates and one output is taken at a time. Alt-chop switch is used for switching.

Dual beam CRO has two separate beams, two pairs of vertical deflection plates and one pair of horizontal deflection plates.

86. (b)

$$f_{in} = 1.28 \text{ MHz}$$

for Binary counter MOD $= M_1 = 2^n = 2^5 = 32$

Johnson counter MOD $= M_2 = 2n = 2 \times 4 = 8$

Ripple counter MOD $= M_3 = 5$

$$M = M_1 \times M_2 \times M_3$$

$$= 32 \times (2 \times 4) \times 5 = 1280$$

$$\therefore \quad f_{out} = \frac{f_{in}}{M} = \frac{1.28 \times 10^6}{1280} = 1 \text{ kHz}$$

87. (a)

Analog voltage $V_a = R \times$ Decimal equivalent

Where, R is the resolution,

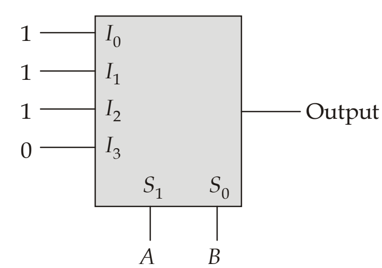
Decimal equivalent of 1010 = 10

Decimal equivalent of 1001 = 9

$$R = \frac{6.5}{10} = 0.65$$

$$\therefore \quad V_a' = R \times (1001)_B = 0.65 \times 9 = 5.85 \text{ V}$$

88. (a)

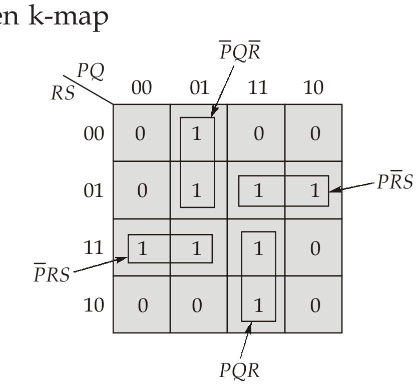


$$\text{Output} = \bar{A}\bar{B} + A\bar{B} + \bar{A}B = \bar{A} + \bar{B} = \overline{AB} \Rightarrow \text{NAND gate}$$

89. (b)

90. (c)

By properly arranging the given k-map



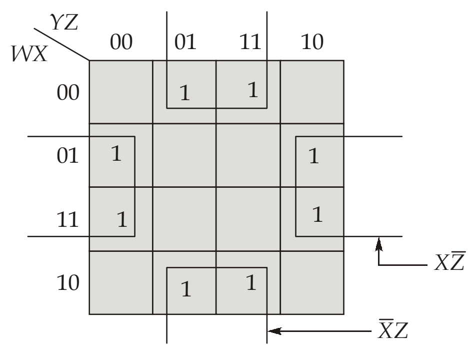
$$\therefore \quad f(P, Q, R, S) = P\bar{R}S + PQR + \bar{P}RS + \bar{P}Q\bar{R}$$

91. (d)

Number of self dual functions possible with n variables is $2^{2^{(n-1)}}$
where, $n = 4$

$$= 2^{2^{(4-1)}} = 2^{2^3} = 2^8 = 256$$

92. (b)



$$f = X\bar{Z} + \bar{X}Z \Rightarrow \text{It is independent of two variables } (W, Y)$$

93. (b)

$$y[n] = \sum_{k=-\infty}^{\infty} u(k+3)\, u[n-k-3]$$

$$u(k + 3) = 1, \quad \text{for } k + 3 \geq 0 \text{ or } k \geq -3$$
$$u[n - k - 3] = 1, \quad \text{for } n - k - 3 \geq 0 \text{ or } k \leq n - 3$$

So, $$y[n] = \sum_{k=-3}^{n-3} 1 = n+1$$

∴ $$y[n] = (n + 1)\, u(n)$$

Given, $$y[n] = (n + k)\, u[n + k - 1]$$

By comparing $k = 1$.

94. (a)

95. (a)

96. (a)

For the given block diagram, $$H(z) = \frac{1}{1+\frac{3}{4}z^{-1}+\frac{1}{8}z^{-2}} = \frac{1}{\left(1+\frac{1}{2}z^{-1}\right)\left(1+\frac{1}{4}z^{-1}\right)}$$

doing partial fraction, $$H(z) = \frac{2}{\left(1+\frac{1}{2}z^{-1}\right)} - \frac{1}{\left(1+\frac{1}{4}z^{-1}\right)}$$

⇒ $$h(n) = 2\left(\frac{1}{2}\right)^n u(n) - \left(\frac{1}{4}\right)^n u(n)$$

97. (d)

According to Deal Grove method of thermal oxidation:

$$\frac{dt_{ox}}{dt} = \frac{B}{A + 2t_{ox}}$$

So, as oxide layer thickness grown on the substrate increases growth rate decreases.

When thicker oxide layer is needed, wet oxidation is preferred.

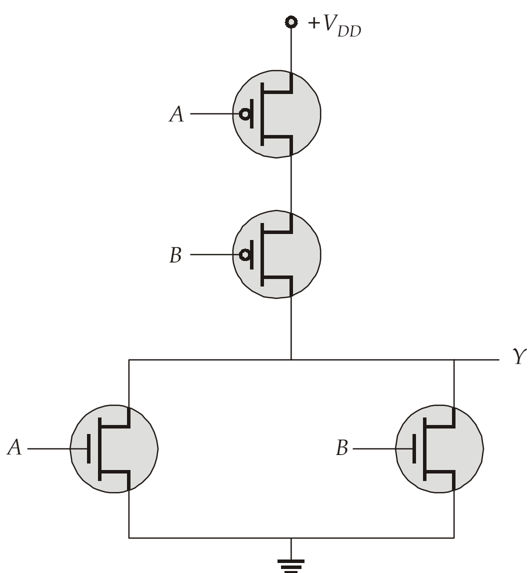
When better quality oxide is needed, dry oxidation is preferred.

98. (d)

$$\text{Swithcing time} \propto \frac{1}{K_n} \Rightarrow \text{for NMOS}$$

$$\text{Swithcing time} \propto \frac{1}{K_p} \Rightarrow \text{for PMOS}$$

NOR gate:



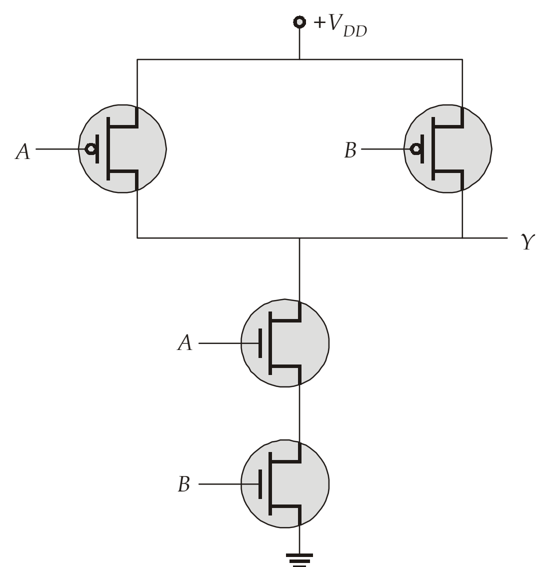
$$t_{PLH} \propto \frac{2}{K_p}$$

$$t_{PHL} \propto \frac{1}{K_n}$$

$$K_n = 2K_p$$

So, $t_{PLH} = 4t_{PHL}$

NAND gate:



$$t_{PLH} \propto \frac{1}{K_p}$$

$$t_{PHL} \propto \frac{2}{K_n}$$

$$K_n = 2K_p$$

So, $t_{PLH} = t_{PHL}$

99. (c)

For a Moore type sequence detector,

Number of states = (Number of bits in the sequence to be detected) + 1

So, for the required sequence detector,

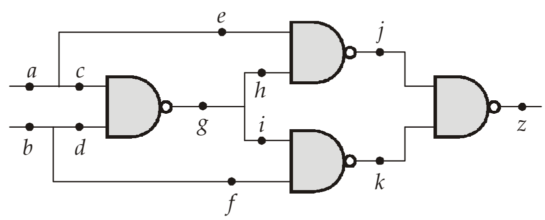
Number of states = 4 + 1 = 5

$2^n \geq 5$; n = number of flip-flops

$n \geq 3$ $\because$ n can be only integer

So, $n_{min} = 3$

100. (b)



Total fault sites = 12

101. (c)

RPE ⇒ Return if parity flag is one

LXI H, 1000H ⇒ Load HL pair with immediate data 1000H

JPO 1000H ⇒ Jump to 1000H if parity flag is zero.

LDAX H ⇒ It is an invalid instruction in 8085 microprocessor.

Only BC and DE register pairs are allowed with LDAX.

102. (b)

8051 microcontroller has four register banks and each bank has eight 8-bit registers.

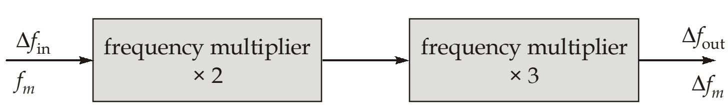
103. (d)

104. (d)

Thermal noise power is independent of the value of resistor which is causing the noise.

105. (d)

106. (c)



$$\beta_{out} = \frac{\Delta f_{out}}{f_m} = \frac{2 \times 3 \times \Delta f_{in}}{f_m}$$

$$= \frac{2 \times 3 \times 10 \text{ kHz}}{5 \text{ kHz}} = 12$$

107. (c)

Entropy, $$H = \frac{1}{2}\log_2(2) + \frac{1}{4}\log_2(4) + \frac{1}{8}\log_2(8) + \frac{2}{16}\log_2(16)$$

$$= \frac{1}{2} + \frac{2}{4} + \frac{3}{8} + \frac{8}{16} = \frac{30}{16} = \frac{15}{8} = 1.875 \text{ bits/symbol}$$

Information rate, $$R = r_s H$$

$$r_s = \frac{1 \text{ symbol}}{1 \text{ millisecond}} = 1000 \text{ symbols/sec}$$

So, $$R = Hr_s = 1.875 \times 1000 = 1875 \text{ bits/sec}$$

108. (b)

$$f_{\max} = \frac{1000\pi + 4000\pi}{2\pi} = 2500 \text{ Hz}$$

Nyquist sampling interval, $$T_{s(\min)} = \frac{1}{2f_{\max}} = \frac{1}{5000}\text{sec} = \frac{10^6}{5000} = 200\ \mu\text{s}$$

109. (b)

For sinusoidal message signal,

$$[\text{SQNR}] = 1.76 + 6.02 \text{ n dB}$$

$$1.76 + 6.02\, n \le 40$$

$$n \ge \left\lceil \frac{40 - 1.76}{6.02} \right\rceil = \lceil 6.35 \rceil$$

$$n_{\min} = 7 \quad [\because n \text{ can be integer only}]$$

110. (c)

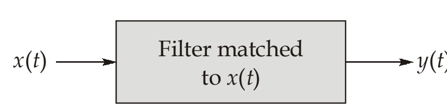
$$\frac{R_b}{2}(1+\alpha) \le BW$$

$$\frac{5}{2}(1+\alpha) \le 4$$

$$\alpha \le \left(\frac{2\times 4}{5} - 1\right) = \left(\frac{8}{5} - 1\right)$$

$$\alpha_{\max} = 0.60$$

111. (b)



$$y_{\max} = \int_{<T>} x^2(t)dt = \int_0^1 4\sin^2(8\pi t)dt \text{ V}$$

$$= 2\int_0^1 [1 - \cos(16\pi t)]dt = 2 \text{ V}$$

112. (c)

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

$$\int_0^1 Kx(1-x)dx = 1$$

$$K\int_0^1 (x-x^2)dx = 1$$

$$K\left[\frac{x^2}{2}-\frac{x^3}{3}\right]_0^1 = 1$$

$$K\left[\frac{1}{2}-\frac{1}{3}\right] = 1$$

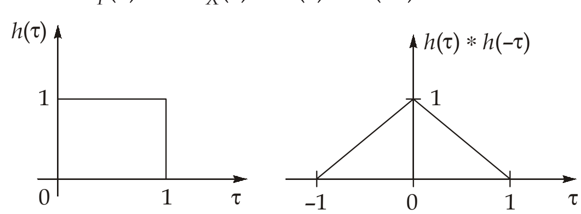
$$K\left(\frac{1}{6}\right) = 1$$

$$K = 6$$

113. (d)

$$R_X(\tau) = \frac{N_0}{2}\delta(\tau)$$

$$R_Y(\tau) = R_X(\tau) * h(\tau) * h(-\tau)$$



$$R_Y(\tau) = \frac{N_0}{2}\delta(\tau) * h(\tau) * h(-\tau) = \frac{N_0}{2}\left[h(\tau) * h(-\tau)\right]$$

Since $[h(\tau) * h(-\tau)]$ does not contain any impulses, $R_Y(\tau)$ also will not contain any impulses. So, statement-1 is incorrect.

$$S_Y(f) = S_X(f)|H(f)|^2 = \frac{N_0}{2}\text{sin}c^2(f)$$

Since $S_Y(f)$ exists from $(-\infty$ to $\infty)$, $Y(t)$ is not a band-limited process. So, statement-2 is also incorrect.

114. (b)

For an AWGN channel with infinite bandwidth,

$$C_\infty = \frac{1}{\ln(2)}\frac{S}{N_0} \Rightarrow \text{finite for finite } E_b$$

So, statement-1 is wrong.

$$C_\infty \propto \frac{1}{N_0}$$

So, statement-2 is correct.

115. (d)

116. (b)

Maintenance and generation costs are negligible for electrical energy generation from wind mills.

117. (a)

$$\text{Rotor emf/phase at stand still} = \frac{78}{\sqrt{3}} = 45\text{ V}$$

$$\text{Rotor impedance/phase} = \sqrt{3^2+4^2} = 5\,\Omega$$

$$\text{Rotor current/phase} = \frac{45}{5} = 9\text{ A}$$

118. (c)

Space harmonic fields are developed by the windings, slotting, magnetic saturation, gap-length irregularity. These harmonic fields induce emfs and circulate harmonic currents in the rotor windings and develope harmonic torque, vibration and noise. 5^{th} and 7^{th} space harmonics are of more concern as their amplitude is considerable. Time harmonics are of little significance because the torques developed by such harmonics are usually very small throughout the operating range of motor. The time harmonics voltages are usually small in proportion to fundamental voltage, the motor reactance to the time harmonics is high and consequently harmonic currents and therefore harmonic torque developed are very small, responsible for crawling.

119. (b)

As the reactive power demand of load decreases the voltage on secondary side increases.

120. (*)

Adding silicon increases the resistivity of the core thus reduces the eddy current loss in transformer. Silicon steel also reduces the hyteresis loss.

121. (d)

If the armature reaction is ignored then,

$$E_a \approx \text{Constant} \approx V$$

Now, $E_a \propto \phi\ N$

Since saturation is neglected,

therefore $\phi \propto I_a$

and $E_a = \text{Constant}$

$\therefore$ $N_2 I_{a2} = N_1 I_{a1}$

or, $N_2 = N_1 \times \dfrac{I_{a1}}{2I_{a1}} = \dfrac{N_1}{2}$

Hence, speed becomes half, i.e decreases by 50%.

122. (a)

No. of coils = 30

Each coil has 5 turns

Total no. of turns = 30 × 5 = 150

Each turn has 2 conductors

So total no. of conductors = Z = 150 × 2 = 300

For wave wound armature no. of parallel paths = A = 2

Expression of induced emf,

$$E = \frac{PZ\phi N}{60\,A}$$

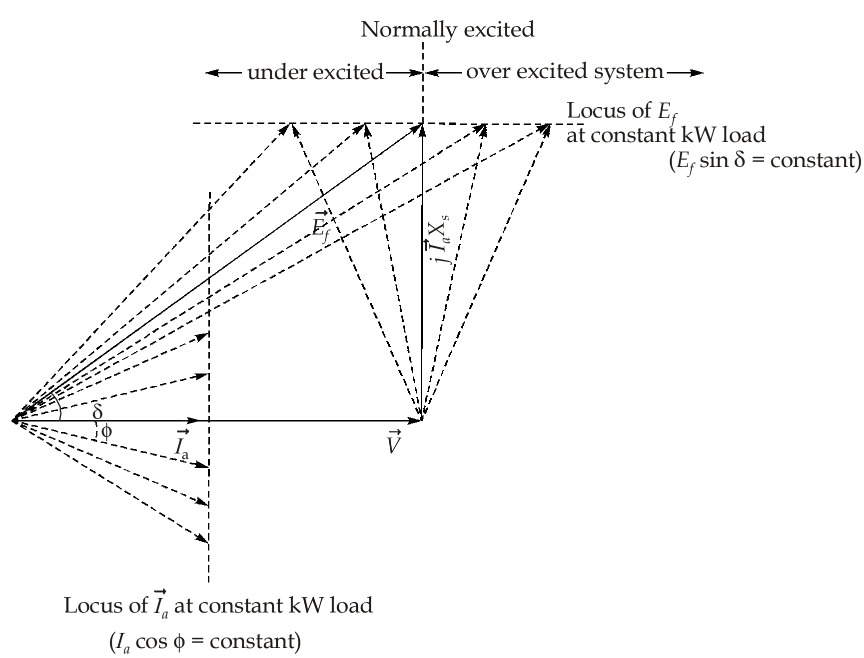
$$= \frac{6 \times 300 \times 0.08 \times 300}{60 \times 2} = 360 \text{ V}$$

123. (d)

Windage loss is a rotational loss (mechanical loss) and is due to air friction. It is directly proportional to square of speed (N).

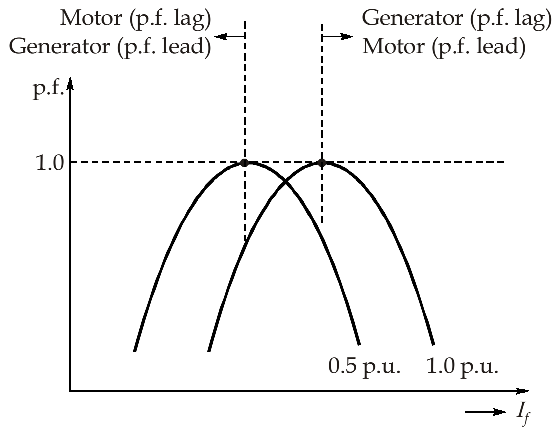
124. (a)

Case I : Power angle



For constant steam input, E_f sin δ and I_a cos ϕ remains constant. So if I_f increases then E_f increases but sin δ decreases and δ decreases.

Case II : Inverted V curve



From the diagram above shown if I_f increases than power factor decreases when generator operates on lagging power factor.

125. (c)

Let, starting current in induction motor 'I_{st}'

Full load current ('I_f')

Given; $I_{st} = 5(I_f)$

Full load slip, $s_f = 0.04$

Ratio of starting torque to full load torque.

$$\frac{T_{st}}{T_f} = \left(\frac{I_{st}}{I_f}\right)^2 \cdot s_f$$

$$\frac{T_{st}}{T_f} = (5)^2\,(0.04) = 1$$

126. (c)

$$\frac{V}{f} = \frac{400}{50} = \frac{200}{25} = \text{constant}$$

so, $P_h \propto f$

and $P_e \propto f^2$

$$P_{\text{Total}} = Af + Bf^2$$

$$A(50) + B(50)^2 = 2500 \quad ...(1)$$

$$A(25) + B(25)^2 = 850 \quad ...(2)$$

Solving (1) and (2),

$$B = 0.64$$

so, $(P_e)_1 = 2500 \times 0.64 = 1600$ W

127. (c)

128. (c)

Cache uses direct mapping and cache size is 1K words.

So, Index field contains $= \log_2(1K) = \log_2(1024) = 10$ bits

129. (d)

Pipelining improves CPU performance due to efficient utilization of the processor hardware.

130. (d)

131. (c)

132. (b)

133. (d)

134. (b)

Using Gantt chart,

A	*B*	*D*	*A*	*C*
0 – 1	1 – 5	5 – 10	10 – 17	17 – 26

$$\text{Average waiting time} = \frac{(17-8-0)+(5-4-1)+(26-9-2)+(10-5-3)}{4}\text{ ms}$$

$$= \frac{9+0+15+2}{4} = \frac{26}{4} = 6.50 \text{ ms}$$

135. (c)

(a) (0, 99) $\Rightarrow$ (offset = 99) < (length of segment – 0 = 124) $\Rightarrow$ No fault

(b) (2, 78) $\Rightarrow$ (offset = 78) < (length of segment – 2 = 99) $\Rightarrow$ No fault

(c) (1, 265) $\Rightarrow$ (offset = 265) > (length of segment – 1 = 211) $\Rightarrow$ Fault occurs

(d) (3, 222) $\Rightarrow$ (offset = 222) < (length of segment – 3 = 302) $\Rightarrow$ No fault

So, the logical address given in option (c) generates a segment fault.

136. (a)

Virtual memory size does not depend on the size of main memory.

137. (d)

There is not always a decomposition into BCNF that is lossless and dependency preserving. So, 3NF is considered adequate for normal relational database design.

138. (a)

```
1. int m = 10;    // m = 10
2. int n, n1;
3. n = ++m;       // n = 11
4. n1 = m++;      // n1 = 11, m = 12
5. n – –;         // n = 10
6. – – n1;        // n1 = 10
7. n – = n1;      // n = 0
8. printf("%d", n);
```

The output will be 0.

139. (c)

The electromotive force of an energy source is always active.
The potential difference across an energy source can be either active or passive.

140. (a)

Distortionless transmission is a situation where the attenuation constant and phase velocity of the transmission line will not change with frequency.
It is not necessary in power transmission lines, as they operate at single frequency.

141. (c)

When a magnetic field is applied, the superconducting materials repel back all the flux lines. This is the perfectly diamagnetic behaviour of a superconducting material and is known as "Meissner effect". It is helpful in protecting devices from the undesired magnetic fields.
The critical current density in a superconductor is determined by Silsbee's rule.

142. (a)

In distribution transformers to maintain the low voltage regulation, leakage reactance is kept low.

143. (c)

SQL statements are not case-sensitive.

144. (d)

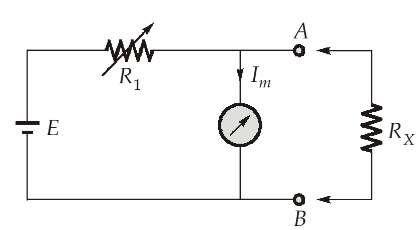
Skew rays follow a helical path through the fiber, helical path traced through the fiber gives a change in direction of 2γ at each reflection; where γ is the angle between the projection of the ray in two dimensions and the radius of the fiber core at the point of reflection. Hence point of emergence of skew rays from the fiber in air will depend upon the number of reflections they undergo rather than the input conditions of the fiber.

145. (d)

At low electric field: Mobility in independent of E and velocity rises linearly with $E(v = \mu E)$.
For sufficiently large electric fields, carriers collide with lattice so frequently and they cannot accelerate much, as a result μ decreases with E, and velocity varies sublinearly and eventually saturates.

146. (c)

For a shunt type ohmmeter,



when $R_X = 0\ \Omega$; meter current is zero.
and when $R = \infty\ \Omega$; meter current is maximum which can be made to read full scale current.

147. (d)

Vector impedance meter can be used for impedance calculation for wide range of frequencies even above 100 MHz.

148. (d)

Image-frequency problem is also present in double conversion receivers.

149. (b)

150. (a)

Phosphorus has a large diffusion coefficient compared to Arsenic and can diffuse faster than Arsenic into the substrate. Hence, Phosphorus is preferred to Arsenic for deep *n*-well diffusions.

❍❍❍❍