DETAILED SOLUTIONS

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ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 22

ANUBHAV - PAPER-II

Simulate Real ESE Prelims Exam

Full Syllabus Test

Answer Key

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

Note: Answer key has been updated of **Q.78** and In **Q. 137** ('*' indicates) mark to all.

DETAILED EXPLANATIONS

1. (b)

The circuit will act as an ideal current source, if impedance is infinite

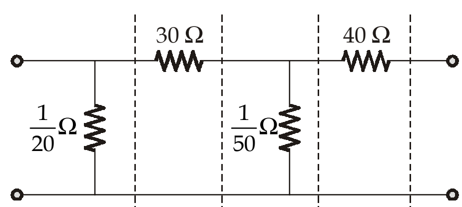
$$Z = \frac{(j\omega L)\left(\frac{1}{j\omega C}\right)}{j\omega L + \frac{1}{j\omega C}} = \frac{j\omega L}{-\omega^2 LC + 1}$$

Now, put $z = \infty$

$$1 - \omega^2 LC = 0$$

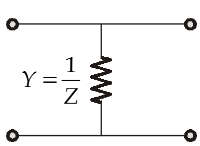
$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5\times10^{-3}\times50\times10^{-6}}} = 2 \text{ Krad/sec}$$

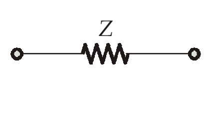
2. (c)



Overall T-parameter of the cascaded elements will be

$$[T] = \begin{bmatrix} 1 & 0 \\ 20 & 1 \end{bmatrix}\begin{bmatrix} 1 & 30 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ 50 & 1 \end{bmatrix}\begin{bmatrix} 1 & 40 \\ 0 & 1 \end{bmatrix}$$

[**Note:** 

$\Rightarrow [T] = \begin{bmatrix} 1 & 0 \\ 4 & 1 \end{bmatrix}$; 

$\Rightarrow [T] = \begin{bmatrix} 1 & 2 \\ 0 & 1 \end{bmatrix}$]

$$\therefore \qquad [T] = \begin{bmatrix} 1 & 30 \\ 20 & 601 \end{bmatrix}\begin{bmatrix} 1 & 40 \\ 50 & 2001 \end{bmatrix}$$

$$= \begin{bmatrix} 1501 & 60070 \\ 30070 & 1203401 \end{bmatrix}$$

3. (c)

Applying KCL to node a, we obtain

$$3 + 0.5i_0 = i_0$$

$$i_0 = 6 \text{ A}$$

For the 5 Ω resistor, ohm's law gives

$$V_0 = 5 \times 6 = 30 \text{ V}$$

4. (a)

$$\begin{aligned} V_1(t) &= V_m \sin(10t - 120°) \\ &= V_m \cos(10t - 120° - 90°) \\ &= V_m \cos(10t - 210°) \\ &= V_m \cos(10t - 210° + 360°) \\ &= V_m \cos(10t + 150°) \\ V_2(t) &= V_m \cos(10t + 20°) \end{aligned}$$

$\therefore$ clearly $V_1(t)$ is leading $V_2(t) = 150° - 20° = 130°$

5. (a)

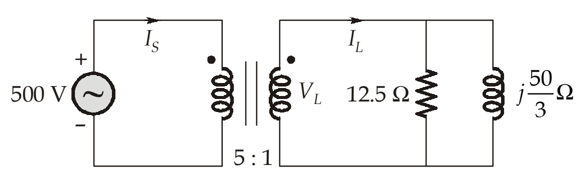
$$\begin{aligned} R &= 100\ \Omega, \\ X_L &= \omega L = 100\ \Omega, \\ X_C &= \frac{1}{\omega C} = 100\ \Omega \\ Z &= 100 + j(100 - 100) = 100\ \Omega \\ I &= \frac{V_{\text{rms}}}{Z} = \frac{200}{100} = 2\text{ A} \end{aligned}$$

6. (d)

$$\frac{L}{C} = \frac{1}{1/16} = 16 = R^2$$

Hence, circuit is under resonance and the net impedance will be purely resistive.

7. (a)



The load voltage, $$V_L = \frac{1}{5}\times 500 = 100\text{ V}$$

The load current, $$I_L = \frac{100}{12.5} + \frac{100}{j50/3} = (8 - j6)\text{ Amp}$$

$$= 10\angle{-36.87°}\text{ Amp}$$

The source current, $$I_S = 10\left(\frac{1}{5}\right) = 2\text{ A}$$

8. (c)

We can find the thevenin resistance between terminals 1 and 2, by short circuiting the battery of 4 V

$$R_{12} = \frac{40\times 60}{100} + \frac{50\times 50}{100} = 24 + 25 = 49\text{ k}\Omega$$

9. (d)

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

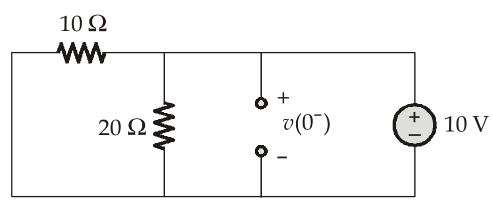
and as R, L and C are halved

$$\therefore \quad Q' = \frac{1}{0.5R}\sqrt{\frac{0.5L}{0.5C}} = 2Q$$

10. (c)

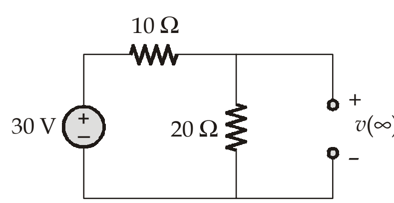
For $t < 0$, the switch is closed and $30\,u(t) = 0$

The circuit becomes like,



$$v(0^-) = 10 \text{ V}$$

For $t > 0$, switch is open



$$v(\infty) = \frac{20}{20+10}(30) = 20 \text{ V}$$

The time constant, $\quad \tau = R_{eq}\,C$

$$R_{eq} = 10 \,\|\, 20 = \frac{20}{3}\,\Omega$$

$$\therefore \quad \tau = \frac{5}{3}\text{ sec}$$

Thus, v for all time $\quad v(t) = v(\infty) + [v(0) - v(\infty)]e^{-t/\tau}$

$$v(t) = 20 + [10 - 20]e^{-3/5t}$$

$$v(t) = 20 - 10e^{-0.6t} \text{ V}$$

11. (c)

Let R_o = Combination of three 12 Ω resistors in parallel.

$$\frac{1}{R_o} = \frac{1}{12}+\frac{1}{12}+\frac{1}{12} \quad \Rightarrow R_o = 4\,\Omega$$

$$R_{eq} = 30 + 60 \,\|\, (10 + R + R_o)$$

$$R_{eq} = 30 + 60 \,\|\, (14 + R)$$

$$50 = 30 + \frac{60(14+R)}{74+R}$$

$$74 + R = 42 + 3R$$

or $$R = 16\ \Omega$$

12. (b)

The capacitor charging current is an exponential decay function. The charging current exponentially approaches zero as the capacitor becomes charged upto the bartery voltage.

14. (d)

Field lines are always from higher potential point to lower potential point. So, at equipment surface, no component of field can be tangential to surface as otherwise potential difference will produced. Hence, electric field lines are orthogonal to equipotential surface.

15. (a)

$$H = \frac{NI}{\pi D}$$

$$B = 1 = \mu_0 \mu_r H$$

$$1 = 4\pi \times 10^{-7} \times 5000 \times \frac{250 \times I}{\pi \times 0.2}$$

$$I = 0.4\ \text{A}$$

16. (b)

$$\begin{aligned} \rho_v &= \nabla \cdot \vec{D} \\ &= 4 - 20y + 2z \\ &= 4 - 20 \times 2 + 2 \times 4 \\ &= 4 - 40 + 8 \\ &= -28\ \text{C/m}^3 \end{aligned}$$

17. (c)

$$\vec{\nabla} \cdot \vec{F} = \frac{\partial}{\partial x}[xe^{-x}] + \frac{\partial}{\partial y}(y) + \frac{\partial}{\partial z}[xze^{-y}]$$

$$= -xe^{-x} + e^{-x} + 1 + xe^{-y}$$

$$\vec{\nabla} \cdot \vec{F} = x[e^{-y} - e^{-x}] + e^{-x} + 1$$

18. (a)

Transfer function of second order band-pass filter is

$$A_V(s) = \frac{\left(\frac{\omega_0}{Q}\right) A_0 s}{s^2 + \left(\frac{\omega_0}{Q}\right) s + \omega_0^2}$$

Given, $Q = 200$, $A_0 = 1$, $\omega_0 = 2000$ rad/sec

We get,

$$A_V = \frac{\left(\frac{2000}{200}\right)\cdot 1\cdot s}{s^2+\left(\frac{2000}{200}\right)s+(2000)^2} = \frac{10s}{s^2+10s+4\times 10^6}$$

19. (c)

Between y_1 and y_2

Forward paths,

$$P_1 = 2$$

and $$P_2 = 3$$

Loop, $$L_1 = 4$$

$$\text{Transfer function} = \frac{P_1\Delta_1 + P_2\Delta_2}{\Delta} = \frac{2(1-0)+3(1-0)}{1-4}$$

$$= \frac{2+3}{-3} = \frac{-5}{3}$$

20. (d)

Let a system is given by

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

$\therefore$ $$\phi = -\tan^{-1}\omega$$

If the system has a dead time of t_d sec, then

$$G'(s) = \frac{e^{-t_d s}}{(s+1)}$$

$$\phi' = -\tan^{-1}\omega - (57.3\times t_d)$$

$$\text{PM} = 180° + \phi$$

and $$\text{PM}' = 180° + \phi'$$

clearly, $$\phi' < \phi$$

$\therefore$ $$PM' < PM$$

So, if a time delay element is introduced in the loop then the phase margin of the system is decreased.

21. (b)

$$\text{Closed loop transfer function} = \frac{16}{s(s+4)+16} = \frac{16}{s^2+4s+16}$$

$\therefore$ $$\omega_n = 4$$

$$2\xi\times\omega_n = 4$$

$$2\xi\times 4 = 4$$

$$\xi = 0.5$$

22. (a)

Now, characteristics equation is

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

$$1+\frac{K}{s(s+1)(s+4)} = 0$$

$$s(s^2 + 5s + 4) + K = 0$$

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

According to R-H array

$$\begin{array}{c|cc} s^3 & 1 & 5 \\ s^2 & 4 & K \\ s^1 & \frac{(20-K)}{4} & 0 \\ s^0 & K & 0 \end{array}$$

The value of K that makes the s' term in the first column equal to zero is

$$\frac{20-K}{4} = 0$$

$$K = 20$$

23. (a)

0 dB/decade $\rightarrow$ is a constant line

+20 dB/decade $\rightarrow$ is a zero.

Again to reach –20 dB/decade, the +20 dB/decade line will go to 0 dB/decade and then –40 dB/decade.

So, there will be one zero and three poles.

24. (a)

Here,
$$A = \begin{bmatrix} -5 & -1 \\ -4 & -1 \end{bmatrix}$$

$$B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

$$D = 0$$

$$T(s) = C[sI - A]^{-1} B + D$$

$$[sI - A] = \begin{bmatrix} (s+5) & 1 \\ 4 & (s+1) \end{bmatrix}$$

$$[sI - A]^{-1} = \begin{bmatrix} (s+1) & -1 \\ -4 & (s+5) \end{bmatrix} \times \frac{1}{s^2+6s+1}$$

$$\therefore \quad T(s) = \frac{\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}(s+1) & -1 \\ -4 & (s+5)\end{bmatrix}\begin{bmatrix}1 \\ 1\end{bmatrix}}{s^2+6s+1}$$

$$= \frac{\begin{bmatrix}(s+1) & -1\end{bmatrix}\begin{bmatrix}1 \\ 1\end{bmatrix}}{s^2+6s+1} = \frac{s}{s^2+6s+1}$$

25. (a)

From the Bode plot, $\omega_{gc} < \omega_{pc}$ so both gain margin and phase margin are positive. Therefore, the closed loop system is stable.

26. (a)

For more than one variable, root locus is not used but we prefer state space analysis.

28. (b)

Shifting of a summing point from a position before a block to a position after the block.

$$C(s) = G(s)\,[R(s) \pm X(s)]$$

$$C(s) = R(s) \cdot G(s) \pm X(s) \cdot G(s)$$

29. (b)

For orthorhombic crystal structure:

$$a \neq b \neq c \text{ and } \alpha = \beta = \gamma = 90°$$

30. (c)

$$M = 1.5 \times 10^{-3} \times 10^{6} = 1500 \text{ A/m}$$

$$B = \mu_o(H + M)$$

$$= 4\pi \times 10^{-7}\,(10^{6} + 1500)$$

$$B = 1.258 \text{ Wb/m}^2$$

31. (c)

$$V_n = E \times d = 10 \times 0.04$$

$$= 0.4 \text{ V}$$

32. (d)

$$V_d = \mu E = \frac{2}{1.54\times10^{-8}\times6\times10^{28}\times1.6\times10^{-19}}$$

$$V_d = 13.53 \times 10^{-3} \text{ m/s}$$

33. (c)

For series connected material, the resultant temperature coefficient is given as

$$\alpha_{res} = \frac{\alpha_1+\alpha_2}{2} = \frac{0.05+0.03}{2} = 0.04$$

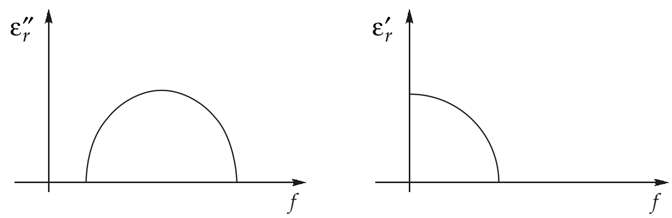
34. (b)

To show the Meissner effect by a superconducting material,

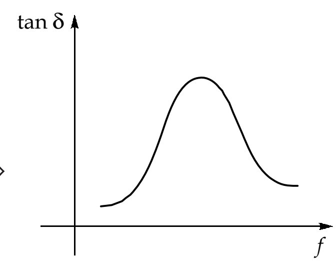
$$B = 0 \text{ at } T \leq T_C \text{ is essential condition.}$$

35. (c)

Relationship between ε_r'' Vs T and between ε_r' Vs T are shown below,



So, $$\tan\delta = \frac{\varepsilon_r''}{\varepsilon'} \Rightarrow$$

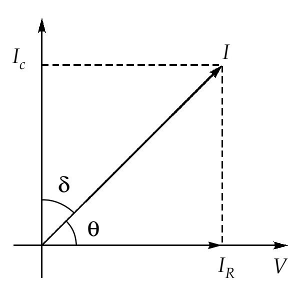


36. (b)

$$a = 2\sqrt{2}r = 2 \times 1.414 \times 1.315 \times 10^{-10} \text{ m}$$
$$= 3.7188 \times 10^{-10} \text{ m}$$
$$\text{Density} = \frac{A_w \cdot N}{N_A V} = \frac{63.54 \times 4}{6.023 \times 10^{23} \times (3.7188 \times 10^{-10})^3}$$
$$= 8205 \text{ kg/m}^3$$

37. (c)

For capacity with lossy dielectric,



$\delta =$ loss angle

38. (c)

For permanent magnetic materials, it is required by materials the residual magnetization and coercive field should be large as it should retain magnetic energy which is not easily demagnetized.

39. (a)

Regulation at 0.8 power factor leading

$$= R_{e2} \cos \phi_2 - X_{e2} \sin \phi_2$$
$$= 2 \times 0.8 - 6 \times 0.6$$
$$= 1.6 - 3.6$$
$$= -2\%$$

40. (a)

$$\frac{P_i}{f} = a + bf$$

$$\frac{100}{40} = a + 40b$$

$$\frac{72}{30} = a + 30b$$

Solution of these equation gives

$$a = 2.1 \text{ and } b = 0.01$$

Therefore,

$$\text{hysteresis loss at 60 Hz} = af = 2.1 \times 60 = 126 \text{ W}$$

Eddy-current loss at 60 Hz

$$= bf^2 = 0.01 \times (60)^2 = 36 \text{ W}$$

41. (d)

All statements are correct.

42. (d)

The functions of pulse transformers are:

1. For changing the amplitude of a voltage pulse.
2. For inverting the polarity of a pulse.
3. For affecting dc isolation between source and load.
4. For coupling different stages of pulse amplifiers.

43. (b)

The slip of motor, $s = 0.05$

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

So, $N_r = N_s(1 - s)$

$$= 1500(1 - 0.05)$$
$$= 1500 \times 0.95$$
$$= 1425 \text{ rpm}$$

44. (a)

From open circuit test:

$$\text{No load power factor} = \cos\phi_0 = \frac{P_{NL}}{V_{NL}I_{NL}}$$

$$\cos\phi_0 = \frac{105}{250\times 1.4} = 0.3$$

So, $$I_m = (I_{NL}\sin\phi_0) = 1.4\times\sqrt{1-0.3^2}$$

$$I_m = 1.336 \text{ Amp}$$

So, magnetizing reactance,

$$X_m = \frac{V_{NL}}{I_m} = \frac{250}{1.336} = 187.19\,\Omega$$

Alternate Solution:

$$R_C = \frac{V_{NL}^2}{P_{NL}} = \frac{250^2}{105} = 595.25\ \Omega$$

$$I_C = \frac{V_{NL}}{R_C} = \frac{250}{595.23} = 0.42\text{ A}$$

$$I_m = \sqrt{I_0^2 - I_C^2} = \sqrt{1.4^2 - 0.42^2} = 1.3355\text{ A}$$

$$X_m = \frac{V_{NL}}{I_m} = 187.1937\ \Omega$$

45. (c)

The secondary current, $I_2 = 4\angle{-45°}$ Amp

So secondary current referred to primary side

$$I_2' = \left(\frac{1}{2}\right)\times 4\angle -45° = 2\angle -45° \text{ Amp}$$

and $I_m = 2\angle{-90°}$ Amp

So, Primary current, $I_1 = I_m + I_2'$

$$I_1 = 2\angle{-90°} + 2\angle{-45°}$$

$$|I_1| = \sqrt{2^2 + 2^2 + 2\times 2\times 2\times\cos(90° - 45°)} = 3.69\text{ Amp}$$

46. (a)

The slip, $$s = \frac{N_s - N_r}{N_s} = \frac{1500-1425}{1500} = 0.05$$

The backward slip, $s_b = 2 - s$

and forward slip, $s_f = s$

So, $$\frac{s_b}{s_f} = \frac{2-s}{s} = \frac{2-0.05}{0.05} = 39$$

47. (b)

The synchronous speed, $N_s = \dfrac{120f}{P} = \dfrac{120\times 50}{4} = 1500\text{ rpm}$

The full load slip, $s = \dfrac{N_s - N_r}{N_s} = \dfrac{1500-1425}{1500} = 0.05$

For linear region, $T \propto s$

So, for half load, $s_2 = \dfrac{s_1}{2} = \dfrac{0.05}{2}$

$s_2 = 0.025$

So, speed, $N_2 = N_s(1 - s_2) = 1500(1 - 0.025)$

$N_2 = 1462.5\text{ rpm}$

48. (c)

Given, $X_d = 1.2\text{ p.u.}$

$X_q = 0.8\text{ p.u.}$

We know, $\tan\psi = \dfrac{V\sin\phi + I_aX_q}{V\cos\phi + I_aR_a} = \dfrac{(1)\times 0.8 + (1)\times 0.8}{(1)\times 0.6 + 0} = 2.67$

$\psi = 69.44°$

For alternator, $\delta = \psi - \phi = 69.44° - \cos^{-1} 0.6$

$\delta = 16.31°$

49. (b)

Only over-excited synchronous motor can work as capacitor.

So Q is false, P is true.

50. (b)

If the air gap of an inductor motor decreases,

- The permeability of the magnetic circuit rotor to stator will increase.
- The magnetizing inductance of the motor thus increases.
- The magnetizing current will decrease, this will cause a better factor at all loads.
- The magnetic flux in the air gap will increase and leakage flux will decrease, this will cause a increase in the maximum (breakdown) available torque.

51. (c)

The absolute conditions for parallel operation of transformer are:

- The same polarity
- The relative phase displacement
- The same phase sequence

52. (a)

$$V = 200 \text{ V},$$
$$r_a = 0.2\ \Omega$$
$$R_f = 100\ \Omega$$
$$\text{No-load rotational loss} = 500 \text{ Watt}$$
$$\text{Shunt field losses} = \frac{V^2}{R_f} = \frac{200^2}{100} = 400 \text{ Watt}$$
$$\therefore \quad \text{Constant losses} = \text{No-load rotational loss + Shunt field losses}$$
$$= 500 + 400 = 900 \text{ Watt}$$

Maximum efficiency occurs when

$$\text{Variable losses} = \text{Constant losses}$$
$$I_a^2 r_a = 900 \text{ Watt}$$
$$0.2 I_a^2 = 900 \text{ Watt}$$
$$I_a = \sqrt{\frac{900}{0.2}} = 67.082 \text{ A}$$

53. (d)

32 bit

opcode	Reg	Reg	Immediate
6 bit	5 bit	5 bit	16 bit

The number of bits for immediate operand field is 16 bits.

54. (b)

In horizontal form signals are present in decoded form. So number of signal bits

$$= 20 + 70 + 2 + 10 + 23$$
$$= 125 \text{ bits}$$

In vertical form signals are present in encoded form. So, number of signal bits:

$$= \log (20) + \log (70) + \log (2) + \log (10) + \log (23)$$
$$= 5 + 7 + 1 + 4 + 5 = 22$$

So, total bits saved using vertical form

$$= 125 - 22 = 103 \text{ bits}$$

55. (b)

40 bit

Tag	Set offset	word offset
21		

$\underbrace{\text{Set offset} \quad \text{word offset}}$ cache index ($\log_2 512$ K = 19 bits)
Block size not given so, cache index is considered

or

Hypothetically, line size considered as cell size.

$$\therefore \quad \text{Number of lines} = 512\text{ K}$$

So,
$$\text{number of sets} = \frac{512\text{K}}{8}$$

$$\Rightarrow \quad \frac{2^{19}}{2^{3}} = 2^{16}$$

40 bit

Tag	Set offset	Word offset
24	16	Block size not given. So, no word offset.

So, TAG size is 24 bits.

56. (a)

$$\text{MM size} = 2^{32}\text{ B, Block size} = 32\text{ B}$$

Direct CM,

$$\text{Number of lines} = 512$$

Address format is

32 bit

Tag	LO	WO
18 bit	$\log_2 512$ = 9 bit	$\log_2 32$ = 5 bit

57. (d)

The major characteristics of a RISC processor are:

1. Relatively few instructions.
2. Relatively few addressing modes.
3. More registers.
4. Hardwired rather than micro-programmed control.

58. (a)

In this sequence initially CPU ideal for '1' unit of time but after that, smaller jobs don't have to wait for so long time, so it is ideal.

59. (d)

Draw Gantt chart and place jobs according to round robin scheduling with time quantum '1' unit.

0	1	2	3	4	5	6	7	8	9
A	B	C	D	A	C	A	C	A	C

So correct answer is '9'.

60. (b)

Process	Execution time	Arrival time
P1	20	0
P2	25	15
P3	10	30
P4	15	45

The Gantt chart for SRT Scheduling algorithm is

P_1	P_2	P_3	P_2	P_4

0 20 30 40 55 70

So the waiting time for

$$P_2 = (20 - 15) + (40 - 30) = 5 + 10 = 15$$

61. (d)

Optimal page replacement policy:

✓	✓	✓	✓	×	×	✓	✓	×	×	✓
		3	4	4	4	4	4	4	4	6
	2	2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	5	3	3	3	3
1	2	3	4	2	1	5	3	2	4	6

$\therefore$ 7 page faults

62. (c)

Assuming X be the hexadecimal number equivalent,

$$(16521)_8 = (X)_{16}$$

$$(16521)_8 = (001\ 110\ 101\ 010\ 001)_2$$

Pairing for hexadecimal from LSM

$$\underbrace{001}_{1}\ \underbrace{1101}_{D}\ \underbrace{0101}_{5}\ \underbrace{0001}_{1}$$

So, $(X)_{16} = (1D51)_{16}$

63. (b)

The net inductance between the telecommunication line is

$$L = \frac{\mu_0}{\pi}\ln\left(\frac{D_2}{D_1}\right)\text{H/m}$$

$\therefore$ Net reactance between the telecommunication line will be

$$X_L = 2\pi fL\ \Omega/\text{m}$$

$$= 2\pi f \times \frac{\mu_0}{\pi}\ln\left(\frac{D_2}{D_1}\right)\Omega/\text{m}$$

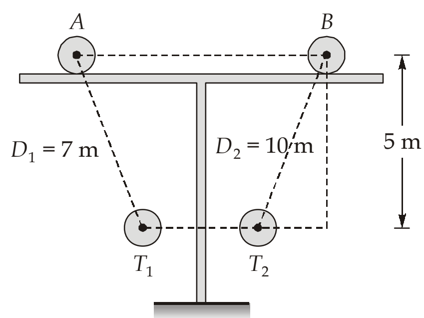
$$= 2\pi f\mu_0 \ln\left(\frac{D_2}{D_1}\right)\Omega/\text{m}$$

∴ Induced voltage per meter between the two telecommunication lines is

$$V_{\text{ind}} = I_A X_L = I_A \times 2 f \mu_0 \ln\left(\frac{D_2}{D_1}\right) \text{V/m}$$

$$= 75 \times 2 \times 50 \times 4\pi \times 10^{-7} \ln\left(\frac{10}{7}\right) \text{V/m}$$

$$= 3.4 \times 10^{-3} \text{ V/m}$$



Total induced voltage over the line length of 150 m is

$$V = V_{\text{ind}} \times l$$

$$= 3.4 \times 10^{-3} \times 150 = 0.51 \text{ Volts}$$

64. (b)

In AC conductors, the magnetic flux linking the inner part is greater, increasing inductive reactance. This causes current to move towards the surface, increasing effective resistance.

65. (a)

Electrical breakdown is influenced by cavity properties like location, size, shape, gas pressure and corona inception stress.

66. (d)

Since, the transmission line is terminated with a load resistance of value equal to its surge impedance hence it is an infinite line and for such lines reflection coefficient value is zero.

67. (c)

Since critical disruptive voltage,

$$V_C = 90 \text{ kV per phase}$$

and per phase voltage, $V_{\text{ph}} = \dfrac{80}{\sqrt{3}} \text{kV} = 46.16 \text{ kV}$

$$V_{\text{ph}} < V_c$$

∴ No corona power loss will occur

∴ $P_L = 0 \text{ kW/km/phase}$

68. (b)

$$r = 5 \text{ cm}$$
$$d = 5 \text{ m} = 500 \text{ cm}$$
$$m_0 = \text{surface irregularity factor} = 1.0$$

rms value of critical disruptive voltage,

$$v_c = m_0 g r \delta \ln\left(\frac{d}{r}\right) \text{kV/ph}$$
$$= 1.0 \times 21.1 \times 5 \times \delta \ln\left(\frac{500}{5}\right) \text{kV/ph}$$
$$= 21.1 \times 5 \times \delta \times 2 \ln 10 \text{ kV/ph}$$
$$= 485.3\, \delta \text{ kV/ph}$$

69. (a)

$$n = 3$$
$$\frac{V_1}{V_3} = \frac{4}{9}$$

and
$$\frac{V_2}{V_3} = \frac{7}{9}$$

$\therefore$
$$\%\eta = \frac{1}{3}\left(\frac{V_1 + V_2 + V_3}{V_3}\right) \times 100$$
$$= \frac{1}{3}\left(\frac{V_1}{V_3} + \frac{V_2}{V_3} + 1\right) \times 100$$
$$= \frac{1}{3}\left(\frac{4}{9} + \frac{7}{9} + 1\right) \times 100 = 74.07\%$$

71. (c)

- Reflection coefficients of voltage (R_v) and current (R_I) are:

  $$R_V = \frac{Z_L - Z_S}{Z_L + Z_S} = -R_I$$

  For infinite line, the line is terminated with its surge impedance,

  i.e. $$Z_L = Z_S$$

  $\therefore$ $$R_V = R_I = 0$$

- The reactive power requirement of the line inductance is supplied by the line capacitance, so that line is operating at upf.

72. (d)

The voltage profile is flat voltage profile along the line length. It is a lossless line/tuned line/matched line/infinite line.

For infinite line, $$Z_L = Z_S$$

73. (b)

If there are N_g voltage-controlled buses, excluding the slack bus, in the system of N buses then the size of the Jacobian matrix will be $(2N - N_g - 2)$.

In Newton-Raphson

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

75. (b)

$$\text{Fault current} = 5000 \text{ A}$$

$$\text{CT ratio} = \frac{400}{5} = 80$$

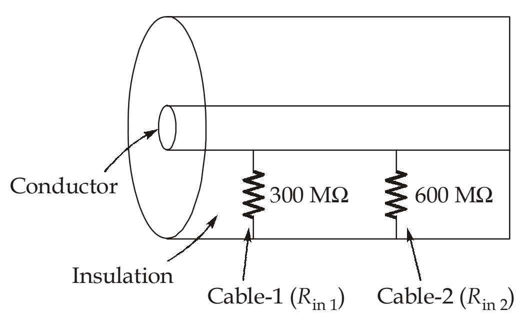
$$\text{Relay current setting} = 125\% \text{ of } 5 \text{ A}$$

$$= 1.25 \times 5 = 6.25 \text{ A}$$

$$\text{PSM} = \frac{\text{Primary current (fault current)}}{\text{Relay current setting} \times \text{CT ratio}} = \frac{5000}{6.25 \times 80} = 10$$

From the table given for PSM of 10, the operating time is 2.8 sec. The operating time for TMS of 0.3 will be equal to 0.3 × 2.8 = 0.84 sec.

76. (b)



$$\frac{1}{(R_{\text{insulation}})_{\text{eq}}} = \frac{1}{R_{\text{in}_1}} + \frac{1}{R_{\text{in}_2}}$$

$$(R_{\text{insulation}})_{\text{eq}} = \frac{300 \times 600}{(300 + 600)} = 200 \text{ M}\Omega$$

77. (a)

$$V_{CE} = V_{BE} + V_{CB}$$

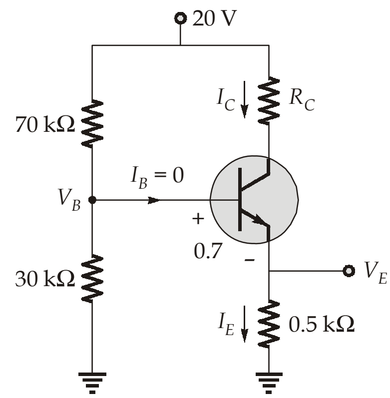
$$= 0.7 + 0.2 = 0.9 \text{ V}$$

$$(V_{CE})_{\text{sat}} = 0.2 \text{ V}$$

Therefore $\quad V_{CE} > (V_{CE})_{\text{sat}}$

It is in normal active mode.

78. (a)



β is large, I_B neglected

$$V_B = 20 \times \frac{30\text{k}}{100\text{k}} = 6 \text{ V}$$

$$V_E = V_B - 0.7 = 6 - 0.7 = 5.3 \text{ V}$$

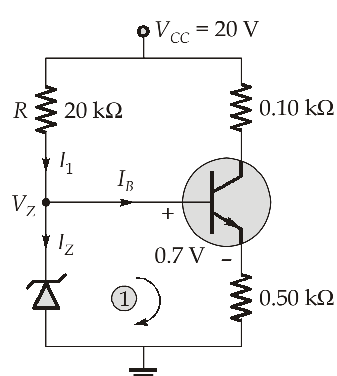
$$I_E = I_C = \frac{V_E}{R_E} = \frac{5.3}{0.5\text{k}} = 10.6 \text{ mA}$$

Option (a) is correct.

79. (d)

A good transconductance amplifier should have very high input resistance and very high output resistance.

80. (b)



The current, $$I_1 = \frac{V_{CC} - V_Z}{R} = \frac{20-5}{20} = 0.75 \text{ mA}$$

So, base current, $$I_B = I_1 - I_Z = 0.75 - 0.50 = 0.25 \text{ mA}$$

By applying KVL in loop (1), $$V_Z = V_{BE} + (\beta + 1)I_B R_E$$

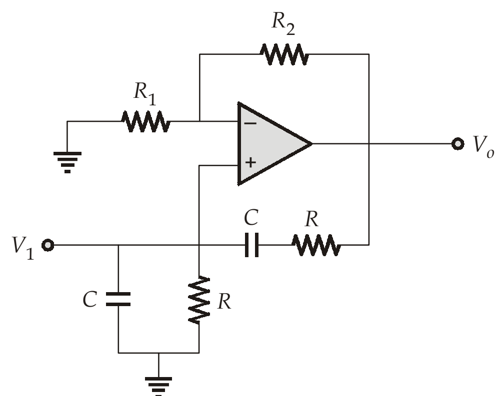
$$5 = 0.7 + (\beta + 1) \times 0.25 \times 0.50$$

$$(\beta + 1) = \frac{5-0.7}{0.25\times 0.50} = 34.4$$

$$\beta = 34.4 - 1 = 33.4 \cong 33 \quad \text{(nearest to integer)}$$

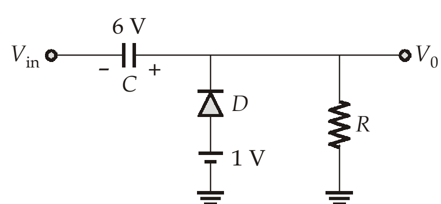
81. (b)

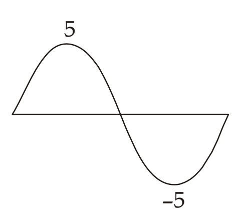
The circuit diagram of the Wien bridge oscillator is



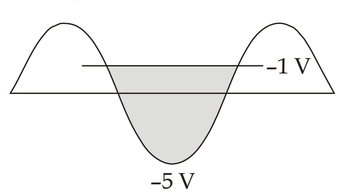
- The feedback network consists of series and parallel connection of the two RC networks that act as a lead-lag network in feedback.
- The op-amp is the non-inverting amplifiers.

82. (c)





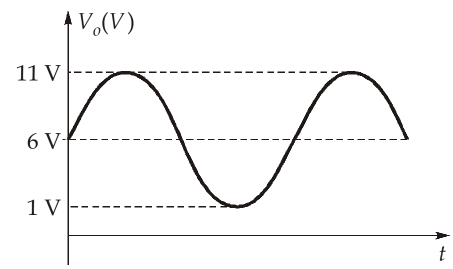
When diode is in upward direction the signal will be clamped above the reference voltage $V_R = 1$ V



$$V_{0\,max} = V_{in} + 6 = V_{in\,max} + 6$$

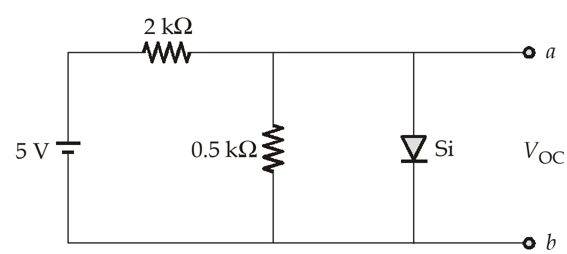
$$= 5 + 6 = 11 \text{ V}$$

$$V_{0\,min} = V_{in\,min} + 6 = -5 + 6 = 1 \text{ V}$$



83. (a)

The open circuit voltage



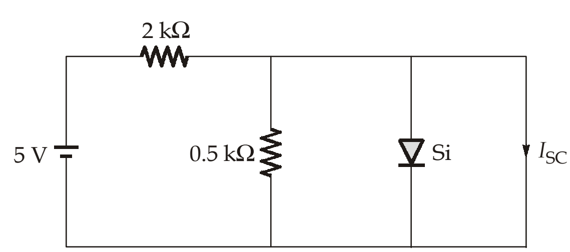
Assuming diode as off,

$$V_{OC} = \frac{0.5}{2+0.5} \times 5 = 1 \text{ V} > 0.7 \text{ V}$$

So, diode will be ON.

So, $V_{OC} = 0.7$ V

The short circuit current (I_{SC})

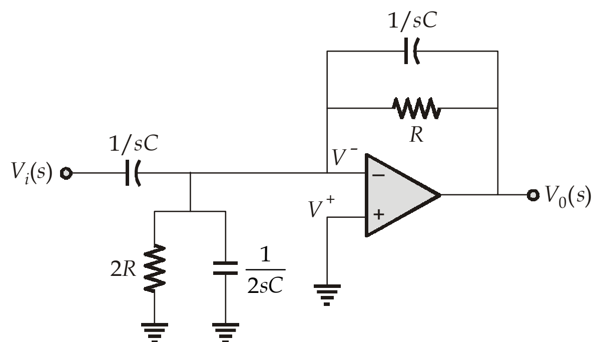


The short circuit current, $I_{SC} = \frac{5}{2} = 2.5 \text{ mA}$

So, Norton equivalent resistance,

$$R_N = \frac{V_{OC}}{I_{SC}} = \frac{0.7}{2.5} = 0.28 \text{ k}\Omega$$

84. (b)



Due to virtual ground,

$$V^+ = V^- = 0 \text{ V}$$

KCL at node V^-

$$\frac{0-V_i(s)}{1/Cs}+\frac{0-V_0(s)}{R}+\frac{0-V_0(s)}{1/Cs} = 0$$

$$V_0(s)\left[\frac{1+sCR}{R}\right] = -sC\,V_i(s)$$

$$\frac{V_0(s)}{V_i(s)} = \frac{-sCR}{1+sCR}$$

Putting $s = j\omega$

$$\frac{V_0(j\omega)}{V_i(j\omega)} = \frac{-j\omega CR}{(1+j\omega CR)}$$

When $\omega = 0$; $V_0(j\omega) = 0$

When $\omega = \infty$; $V_0(j\infty) \neq 0$

So, it is a HPF

Cut off frequency, $f_c = \dfrac{1}{2\pi RC} = \dfrac{1}{2\pi\times 2\times 10^{-3}} = 79.58$ Hz

85. (b)

We assume that BJT is in active

$$I_E = \frac{2-V_{BE}}{R_E}=\frac{2-0.7}{1\text{ k}\Omega}=1.3\text{ mA}$$

Now applying KVL in collector-emitter loop

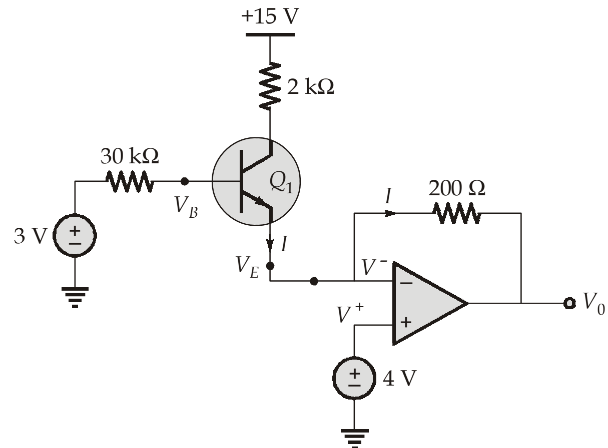
$$10 - 10\,kI_C - V_{CE} - 1\,kI_C = 0$$

$$V_{CE} = -4.3 \text{ V}$$

$$V_{BC} = V_{BE} - V_{CE} = 0.7 - (-4.3) = 5 \text{ V}$$

Since V_{BC} is positive, then transistor is in saturation.

86. **(c)**



By concept of virtual short, $V^- = V^+ = 4\text{ V}$

Here, $(V_{BB} = 3\text{ V}) < (V_E = 4\text{ V})$

So BJT is in cut-off mode,

So, current, $I = 0$

So, $V_0 = V^- - 200I = 4 - 200 \times 0$

$V_0 = 4\text{ V}$

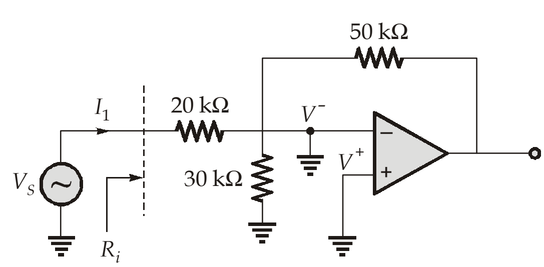
87. **(c)**

$$r_\pi = \frac{h_{fe}}{g_m} = \frac{h_{fe}}{I_c} \times V_T = \frac{h_{fe}}{h_{fe} I_b} \times V_T$$

$$= \frac{25\text{ mV}}{1\text{ mA}} = 25\ \Omega$$

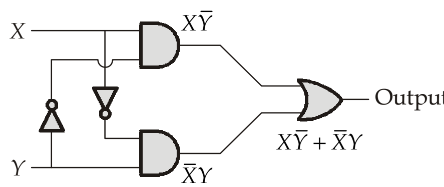
88. **(c)**

By concept of virtual short, $V^+ = V^- = 0\text{ V}$



$$R_i = \frac{V_s}{I_l} = 20\text{ k}\Omega$$

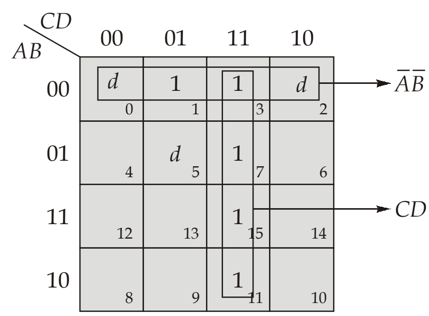
89. (a)



90. (a)

Given : $f(A, B, C, D) = \Sigma_m(1, 3, 7, 11, 15) + \Sigma_d(0, 2, 5)$

where d denotes don't care



The simplified expression is

$$f(A, B, C, D) = \bar{A}\bar{B}+CD$$

91. (d)

For $f = 1$

$$A \cdot B = 1, \quad \text{and} \quad \overline{B \cdot C}=1$$

For $A \cdot B = 1$, $\quad A = B = 1$

If $B = 1$, then $C = 0$ for getting $\overline{B \cdot C}=1$

$\therefore \quad A = 1, \quad B = 1, \quad C = 0$

92. (a)

$$D_1 = \bar{Q}_0$$
$$D_0 = Q_1 + \bar{Q}_0$$

Present	State	Input		Next State	
Q_1	Q_0	D_1	D_0	Q_1	Q_0
0	0	1	1	1	1
1	1	0	1	0	1
0	1	0	0	0	0
0	0	1	1	1	1

Three transition states

Hence the sequence is

$$\rightarrow 00 \rightarrow 11 \rightarrow 01$$

93. (d)

For execution of 12 T-states, total time required,

$$T = 3.6\ \mu\text{sec}$$

Time required for 1 T-state,

$$T_{clk} = \frac{3.6}{12}\mu\text{sec} = 0.3\ \mu\text{sec}$$

Clock frequency, $$f_{clk} = \frac{1}{T_{clk}} = \frac{1}{0.3\times10^{-6}} = 3.33\ \text{MHz}$$

94. (b)

PUSH Rp stores or push the content of register pair into stack memory. Therefore, the content of stack pointer will decrement by two.

95. (b)

Given PDF, $$f_X(x) = ke^{-(x-4)^2} \quad \text{...(i)}$$

Standard Gaussian PDF, $$f_X(x)= \frac{1}{\sqrt{2\pi\sigma^2}}\, e^{\frac{-(x-\bar{X})^2}{2\sigma^2}} \quad \text{...(ii)}$$

By comparing equations (i) and (ii), we get,

$$2\sigma^2 = 1$$

So, $$k = \frac{1}{\sqrt{2\pi\sigma^2}} = \frac{1}{\sqrt{\pi}}$$

96. (b)

When white noise is passed through a BPF,

$$P_{out} = \left(\frac{N_0}{2}\right)(2B)$$

$$= (4)\ (2 \times 2)\ \mu\text{W}$$

$$= 16\ \mu\text{W}$$

97. (d)

Power, $$P = \frac{1}{T}\int_{-T/2}^{T/2} [f_1(t) + f_2(t)]^2\, dt$$

$$= \frac{1}{T}\int_{-T/2}^{T/2} f_1(t)^2\, dt + \frac{1}{T}\int_{-T/2}^{T/2} f_2(t)^2\, dt + 2\cdot\frac{1}{T}\int_{-T/2}^{T/2} f_1(t)\cdot f_2(t) dt$$

$$= P_1 + P_2 + 2R$$

$$= 3 + 5 + 2 \times 5 = 18$$

98. (b)

The given modulated signal is an AM signal.

$$s(t) = (2.5 + 5\cos\omega_m t)\cos\omega_c t$$
$$= 2.5(1 + 2\cos\omega_m t)\cos\omega_c t$$

So, the modulation index of the given AM signal is,

$$\mu = 2$$

As $\mu > 1$, synchronous detector is more suitable.

99. (d)

$$\phi_{\text{Am}}(t) = [A + m(t)]\cos\omega_c t$$

$$\phi_{\text{Am}}(t) \leftrightarrow \frac{1}{2}[m(\omega+\omega_c)+m(\omega-\omega_c)]+\pi A[\delta(\omega+\omega_c)+\delta(\omega-\omega_c)]$$

So, both carrier and sideband frequencies are present in the Am signal.

100. (b)

$$P_T = P_C\left(1+\frac{m^2}{2}\right)$$
$$= P_C\left(1+\frac{1^2}{2}\right) = 100\times\frac{3}{2} = 150\text{ W}$$
$$P_{\text{USB}} = P_{\text{LSB}}$$
$$= \frac{P_{\text{SB}}}{2} = \frac{P_T - P_C}{2} = \frac{150-100}{2} = 25\text{ W}$$

101. (d)

Signal image frequency, f_{si} = Signal frequency + 2 × Intermediate frequency

$$= f_s + 2IF$$
$$= 1200 + 2\times 450 = 2100\text{ kHz}$$

102. (a)

The output voltage is

$$v_0(t) = \sum_{n=1,3,5,7,\ldots}^{\infty}\frac{2V_{dc}}{n\pi}\sin(n\omega t)$$

The load current is

$$i_0(t) = \sum_{n=1,3,5,7,\ldots}^{\infty}\frac{2V_{dc}}{n\pi R}\sin(n\omega t)$$

n^{th} harmonic RMS current

$$I_{on} = \frac{2V_{dc}}{n\pi R\sqrt{2}}$$

Harmonic factor of 5th harmonic component of the load current is,

$$HF_n = \left|\frac{I_{on}}{I_{01}}\right| \qquad \text{where } n = 5$$

$$HF_5 = \left|\frac{\dfrac{2V_{dc}}{5\pi R\sqrt{2}}}{\dfrac{2V_{dc}}{\pi R\sqrt{2}}}\right| = \frac{1}{5} = 0.2 \text{ or } 20\%$$

103. (b)

Given,

$$V_{dc} = 230 \text{ V}$$
$$R = 1\ \Omega$$
$$\omega L = 6\ \Omega$$
$$\frac{1}{\omega C} = 7\ \Omega$$
$$T_0 = 20 \text{ msec} \quad \Rightarrow \quad f_0 = \frac{1}{T_0} = 50 \text{ Hz}$$
$$|Z_n| = \sqrt{R^2\left(n\omega L - \frac{1}{n\omega C}\right)^2} = \sqrt{1+\left(6n - \frac{7}{n}\right)^2}$$

$\because$
$$\hat{V}_{on} = \frac{4V_{dc}}{n\pi}$$

$\therefore$
$$\hat{I}_{on} = \frac{4V_{dc}}{n\pi|Z_n|}$$

$$\text{RMS value } I_{on} = \frac{2\sqrt{2}V_{dc}}{n\pi|Z_n|}$$

RMS value of fundamental component

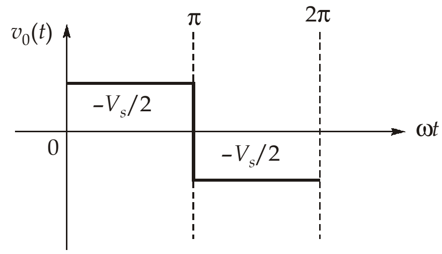
$$I_{01} = \frac{2\sqrt{2}\times 230}{1\times\pi\sqrt{1+\left(6\times 1-\frac{7}{1}\right)^2}} = 146.4 \text{ A}$$

Reactive power loss due to fundamental component is

$$Q = I_{01}^2\left(\frac{1}{\omega C} - \omega L\right)$$
$$= (146.4)^2\,[7 - 6] = (146.4)^2$$

$\Rightarrow$
$$Q = 21.43 \text{ kVAR}$$

104. (c)



$$v_0(t) = \sum_{n=1,3,5,7,9,...}^{\infty} \frac{2V_s}{n\pi}\sin(n\omega t)$$

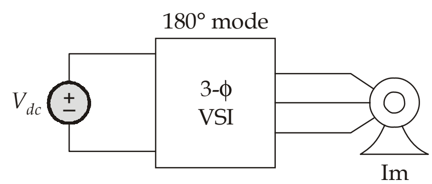
It has a square waveshape and independent of the load parameters.

105. (a)

For linear modulation, $M_A = 1$

For over modulation, $M_A > 1$

106. (d)



The Fourier series of the phase voltage of the output of 3-ϕ VSI or the input of 3-ϕ Induction Motor (*IM*) is

$$V_{pn}(t) = \left.\sum_{n=6k\pm1}^{\infty} \frac{2V_{dc}}{n\pi}\sin(n\omega t)\right\} \text{ has six-step waveform}$$

where , $k = 0, 1, 2, 3, ...$

Harmonic spectrum, $n = 6k \pm 1$ where, $k = 0, 1, 2, 3, ...$

$n = 1, 5, 7, 11, 13, ...$

107. (c)

$$V_{dc} = 220 \text{ V}$$

$$R_1 = 15\ \Omega$$

Line voltage for 120° mode of operation is

$$V_L = \frac{V_{dc}}{\sqrt{2}} = \frac{220}{\sqrt{2}} = 110\sqrt{2} \text{ volts}$$

The phase voltage is $$V_p = \frac{V_L}{\sqrt{3}} = \frac{110\sqrt{2}}{\sqrt{3}} \text{volts}$$

Line/phase current of Y-connected load

$$I_{ph} = I_L = \frac{V_p}{R_1} = \frac{110\sqrt{2}/\sqrt{3}}{15} = 5.99 \text{ A}$$

108. (d)

For 1-ϕ full brdige VSI, with PWM scheme,

$$V_0(t) = \sum_{n=1,3,5,7,....}^{\infty} \frac{4V_s}{n\pi}\sin(nd)\sin(n\omega t)$$

To eliminate n^{th} harmonic, $\sin nd = 0$

$$nd = \pi, 2\pi, 3\pi, ...$$

$$2d = \frac{2\pi}{n}, \frac{4\pi}{n}, \frac{6\pi}{n}, ... \text{ provided } 2d < \pi$$

For $2d = \frac{2\pi}{3}$

$$d = \frac{\pi}{3}$$

$$\Rightarrow \quad nd = \frac{n\pi}{3}$$

For tipplen harmonics, i.e., 3, 6, 9, ...

$$nd = \pi, 2\pi, 3\pi, ...$$

$$\Rightarrow \quad \sin(nd) = 0$$

So, tipplen harmonics are eliminated with $2d = \frac{2\pi}{3}$.

110. (b)

For Buck-converter

$$\text{Average output voltage} = DV_s$$

Where, D = Duty ratio, V_s = input voltage

$$V_s = 40 \text{ V},$$

$$V_0 = 16 \text{ V},$$

$$f = 20 \text{ kHz}$$

$$16 = D \times 40$$

$$D = \frac{16}{40} = 0.4$$

Peak to peak ripple current, $\Delta I_L = \frac{V_s D(1-D)}{Lf}$

$$0.8 = \frac{40 \times 0.4 \times 0.6}{L \times 20 \times 10^3}$$

$$L = 600 \ \mu\text{H}$$

111. (a)

Voltage drop in BJT is less as compare to MOSFET is correct statement.

In MOSFET channel length is relatively small compare to channel width.

112. (c)

Due to absence of minority carrier reverse recover time of schottky diode is in nanosecond. It is used in SMPS.

113. (b)

The essential requirements for instrument springs are:

- They should be non-magnetic.
- They should be proof from mechanical fatigure.
- Where springs are used to lead current into moving system they should have a small resistance, their cross-sectional area must be sufficient to carry the current without temperature rise affecting their constant.

114. (d)

Permanent magnets must retain their magnetization even after the external magnetizing field is removed. For this, they should have:

- This mean they have high coercivity and retentivity, essential for magnetization.
- This ensures that the magnet can store a large amount of magnetic energy.
- This is the maximum energy product, a key measure of the strength of a permanent magnet.

115. (a)

Rate of change of inductance with deflection

$$\frac{dL}{d\theta} = \frac{d}{d\theta}(10+5\theta-\theta^2) = (5 - 2\theta)\ \mu\text{H/rad}$$

the deflection is

$$\theta = \frac{1}{2}\frac{I^2}{K}\frac{dL}{d\theta}$$

$$\theta = \frac{1}{2}\times\frac{(10)^2}{12\times10^{-6}}\times(5-2\theta)\times10^{-6}$$

$$24\theta = 100(5 - 2\theta)$$

$$= 500 - 200\theta$$

$$224\theta = 500$$

$$\theta = \frac{500}{224} = 2.23\ \text{rad}$$

116. (c)

Thermocouple instruments can measure very high frequencies accurately, even in the radio frequency range.

117. (b)

The product of different frequency terms have zero average value,

$$P_{avg} = \frac{1}{2}[E_1 I_1 \cos\phi_1 + E_5 I_5 \cos\phi_5]$$

118. (b)

Meter constant,
$$K = \frac{\text{No. of revolutions}}{\text{Measured energy}}$$

$$K = \frac{N}{E} = \frac{1380}{\frac{230 \times 20}{1000} \times 2} = 150 \text{ rev/kWh}$$

119. (a)

$$W_1 = V_L I_L \cos(30 - \phi)$$
$$W_2 = V_L I_L \cos(30 + \phi)$$

120. (c)

Advantages of PMMC:

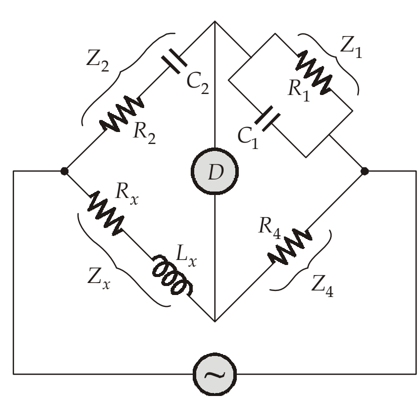
- Torque/Weight ratio high
- Self shielding properties
- Uniform scale
- Less power consumption
- More accurate

Disadvantages of PMMC:

- Not suitable for AC
- Cost is higher (more complex construction) than MI and EMMC.

121. (a)

Let



At balance point,

$$Z_1 Z_x = Z_2 Z_4$$

$$(R_x + j\omega L_x)\left(\frac{R_1 \cdot \frac{1}{j\omega C_1}}{R_1 + \frac{1}{j\omega C_1}}\right) = \left(R_2 + \frac{1}{j\omega C_2}\right)R_4$$

$$(R_x + j\omega L_x)\left(\frac{R_1}{1 + j\omega R_1 C_1}\right) = R_2 R_4 + \frac{R_4}{j\omega C_2}$$

$$R_x R_1 + j\omega R_1 L_x = \left(R_2 R_4 + \frac{R_4}{j\omega C_2}\right)(1 + j\omega R_1 C_1)$$

$$R_x R_1 + j\omega R_1 L_x = R_2 R_4 + j\omega R_1 R_2 R_4 C_1 + \frac{R_4}{j\omega C_2} + \frac{R_1 R_4 C_1}{C_2}$$

Compare real and imaginary parts

$$R_x R_1 = R_2 R_4 + \frac{R_1 R_4 C_1}{C_2}$$

$$R_x = \frac{R_2 R_4}{R_1} + \frac{R_4 C_1}{C_2}$$

Put all the values, $$R_x = \frac{500 \times 100}{200} + \frac{100 \times 0.05}{0.2} = 275\ \Omega$$

$$\omega R_1 L_x = \omega R_1 R_2 R_4 C_1 - \frac{R_4}{\omega C_2}$$

$$L_x = R_2 R_4 C_1 - \frac{R_4}{\omega^2 R_1 C_2}$$

$$= 500 \times 100 \times 0.05 \times 10^{-6} - \frac{100}{(10^5)^2 \times 200 \times 0.2 \times 10^{-6}}$$

$$= 2.25 \times 10^{-3} = 2.25 \text{ mH}$$

122. (c)

For given wattmeter arrangement current in current coil,

$$I_{CC} = \frac{400}{5\angle 60^\circ} = 80\angle -60^\circ \text{ A}$$

Voltage read by potential coil, $V_{CC} = 100\angle 0^\circ$ V

Power read by wattmeter $= 80 \times 100 \cos 60^\circ$

$= 4000$ W

123. (c)

For odd function, $f(x) = -f(-x)$

So, DC term and cosine terms are zero. Only sine terms are present.

124. **(d)**

(a), (b) are pure periodic function.

1 is constant dc signal which is also periodic function.

e^{-4t} cos $8x$ is non-periodic function.

125. **(c)**

By Parseval's theorem, the energy of a signal $x(t)$ is,

$$E_{x(t)} = \int_{-\infty}^{\infty} |x(t)|^2\, dt = \frac{1}{2\pi}\int_{-\infty}^{\infty} |X(\omega)|^2\, d\omega$$

126. **(d)**

We know, for Gaussian function, fourier transform is also Gaussian in nature.

$$e^{-ax^2}, a > 0 \Longleftrightarrow \sqrt{\frac{\pi}{a}}e^{-\frac{\omega^2}{4a}}$$

Here, $a = \pi$

$$e^{-\pi x^2} \Longleftrightarrow \sqrt{\frac{\pi}{\pi}}\, e^{-\frac{\omega^2}{4\pi}}$$

Put $\omega = 2\pi f$

$$e^{-\pi x^2} \Longleftrightarrow 1 \cdot e^{-\frac{(2\pi f)^2}{4\pi}}$$

$$\Longleftrightarrow e^{-\frac{4\pi^2 f^2}{4\pi}}$$

$$\Longleftrightarrow e^{-\pi f^2}$$

127. **(c)**

For an LTI system to be stable,

$$\sum_{n=-\infty}^{+\infty} |h[n]| < \infty \;.... + q^{-3} + q^{-2} + q^{-1} + 1 + p + p^2 + p^3 + ... < \infty$$

For this series to be finite, $p < 1$

$q > 1$

128. **(c)**

Final value theorem

$$h[\infty] = \lim_{z\to 1} H(z)(1-z^{-1}) = \lim_{z\to 1}\frac{1}{3}\cdot\frac{(1-z^{-3})}{1-2z^{-1}+z^{-2}}\cdot(1-z^{-1})$$

$$= \lim_{z\to 1}\frac{1}{3}\cdot\frac{(1-z^{-1})(1+z^{-1}+z^{2})}{(1-z^{-1})^2}\cdot(1-z^{-1})$$

$$= \lim_{z\to 1}\frac{1}{3}\cdot\frac{(1-z^{-1})(1+z^{-1}+z^{-2})}{(1-z^{-1})^2}\cdot(1-z^{-1})$$

$$= \lim_{z \to 1} \frac{1}{3} \times (1 + z^{-1} + z^{-2})$$

$$= \frac{1}{3} \times (1+1+1) = 1$$

129. (d)

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1+5z^{-1}}{6+5z^{-1}+z^{-2}}$$

$$6Y(z) + 5z^{-1}Y(z) + z^{-2}Y(z) = X(z) + 5z^{-1}X(z)$$

Inverse z-transform

$$6\,y(n) + 5y(n-1) + y(n-2) = x(n) + 5x(n-1)$$

130. (a)

$$H(z) = \frac{1+\frac{8}{9}z^{-1}}{1-\frac{4}{5}z^{-1}+z^{-2}}$$

$$H(-1) = \frac{1+\frac{8}{9}\times(-1)}{1-\frac{4}{5}\times(-1)+(-1)^{-2}} = 0.0396$$

$$H(1) = \frac{1+\frac{8}{9}\times 1}{1-\frac{4}{5}\times 1^{-1}+(1)^{-2}} = 1.574$$

$\because$ $H(1) > H(-1)$

$\therefore$ Given transfer function is low-pass filter.

131. (c)

$$y(n) = e^{x(n)}$$

As $y(n)$ does not depend on the future values of $x(n)$, $\therefore$ it is causal.

It is a non-linear system.

$$y_1(n) + y_2(n) = e^{x_1(n)} + e^{x_2(n)} \neq e^{x_1(n)+x_2(n)}$$

Hence, the system is stable, causal and non-linear.

132. (c)

$$y(t) = ax(t) + b$$

Let, $x(t) = x_1(t) + x_2(t)$

Then, $y(t) = a[x_1(t) + x_2(t)] + b$

$$= ax_1(t) + ax_2(t) + b \qquad \ldots\text{(i)}$$

and
$$y_1(t) = ax_1(t) + b$$
$$y_2(t) = ax_2(t) + b$$
$$y'(t) = y_1(t) + y_2(t)$$
$$= ax_1(t) + ax_2(t) + 2b \quad \text{...(ii)}$$

here,
$$y(t) \neq y'(t)$$
$$y(t) \neq y_1(t) + y_2(t) \quad \text{for } b \neq 0$$

if $b = 0$,
$$y(t) = y_1(t) + y_2(t) = ax_1(t) + ax_2(t)$$

So,
$$y(t) = \begin{cases} \text{Non-linear}; & b \neq 0 \\ \text{Linear}; & b = 0 \end{cases}$$

133. (d)

For the existence of Fourier series of a given function the following conditions must be satisfied:

- The function should have finite number of maxima or minima.
- The function should have finite number of discontinuities.
- The function should be absolutely integrable.

134. (b)

$$x(t) = -e^{3t}\, u(t) * t\, u(t)$$

$$X(s) = -L\left[e^{3t}u(t)\right]\cdot L\left[t\,u(t)\right] = \frac{-1}{(s-3)}\cdot\frac{1}{s^2}$$

$$X(s) = \frac{-1}{s^2(s-3)}$$

135. (d)

All expansion are correct.

136. (b)

Given equation is,

$$y\,dx - x\,dy + xy^2\,dx = 0$$

Which could be converted into exact form

i.e,
$$\frac{y\,dx - x\,dy}{y^2} + x\,dx = 0$$

$$d\left(\frac{x}{y}\right) + d\left(\frac{x^2}{2}\right) = 0$$

Integrating both the sides, we get

$$\frac{x}{y} + \frac{x^2}{2} = \text{constant}$$

or
$$\frac{x}{y} + \frac{x^2}{2} = \lambda$$

137. (*)

Properties of matrix multiplication:

1. Multiplication of matrices is not commutative,
$$AB \neq BA$$
2. Matrix multiplication is associative, if conformability is assured,
$$A(BC) = (AB)C$$
3. Matrix multiplication is distributive with respect to addition,
$$A(B + C) = AB + AC$$
4. Multiplicative inverse of a matrix exists
if $|A| \neq 0$
$$A \cdot A^{-1} = A^{-1} \cdot A = I$$

138. (c)

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

Directional derivative of $\phi = \nabla \phi$

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

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

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

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

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

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

$$= e^t\hat{i} + (\sin 2t + 1)\hat{j} + (1 - (0.5t))\hat{k}$$

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

Tangent (at t = 0)

$$= e^0\hat{i} + 2(\cos 0)\hat{j} + (\sin 0)\hat{k}$$

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

Required directional derivative along tangent

$$= (2\hat{i} + 2\hat{j} - 2\hat{k})\frac{(\hat{i} + 2\hat{j})}{\sqrt{1+4}}$$

$$= \frac{2+4+0}{\sqrt{5}} = \frac{6}{\sqrt{5}}$$

139. (a)

$$\frac{1+2i}{1-(1-i)^2} = \frac{1+2i}{1-(1-1-2i)^2} = \frac{1+2i}{1+2i} = 1 + 0\,i$$

$$\therefore \quad \left|\frac{1+2i}{1-(1-i)^2}\right| = |1+0i| = \sqrt{1^2} = 1$$

Principle argument of $\frac{1+2i}{1-(1-i)^2}$ = principle argument of $1+0\hat{i}$

$$= \tan^{-1}\frac{0}{1} = \tan^{-1}0 = 0°$$

140. (a)

Let, $$u(x, y) = x^3 - 3xy^2 + 3x^2 - 3y^2$$

$$\frac{\partial u}{\partial x} = 3x^2 - 3y^2 + 6x$$

$$\frac{\partial u}{\partial y} = -6xy - 6y$$

We know that,

$$dV = \frac{\partial V}{\partial x}dx + \frac{\partial V}{\partial y}dy$$

$$dV = -\frac{\partial u}{\partial y}dx + \frac{\partial u}{\partial x}dy$$

$$dV = (6xy + 6y)dx + (3x^2 - 3y^2 + 6x)dy$$

This is an exact differential equation

$$V = \int(6xy+6y)dx + \int -3y^2 dy + c$$

$$= 3x^2y + 6xy - y^3 + c$$

141. (b)

Probability at A hitting the target = $\frac{3}{5}$

Probability of B hitting the target = $\frac{2}{5}$

Probability of C hitting the target = $\frac{3}{4}$

Probability of at least two shots hitting the target

= Probability that 2 shots hit the target + Probability of 3 shots hitting the target

$$= \frac{6}{25}\times\frac{1}{4} + \frac{9}{20}\times\frac{3}{5} + \frac{6}{20}\times\frac{2}{5} + \frac{3}{5}\times\frac{2}{5}\times\frac{3}{4} = \frac{63}{100}$$

142. (b)

Let a and b be eigen value of A,

$$\text{trace }(A) = a + b = 10$$

$$\text{trace }(A^3) = a^3 + b^3 = 100$$

$$\text{determinant} = |A| = ab$$

We know, $$a^3 + b^3 = (a + b)(a^2 - ab + b^2)$$

$$= (a + b)^3 - 3ab(a + b)$$

Put all the value, $$100 = (10)^3 - 3ab(10)$$

$$30ab = 1000 - 100$$

$$ab = \frac{900}{30} = 30$$

Hence, $$\text{determinant} = |A| = ab = 30$$

143. (a)

$$u = \tan^{-1}\left(\frac{x^2y + xy^2}{x + y}\right)$$

$$f(u) = \tan u = \frac{x^2y + xy^2}{x + y}$$

Homogeneous function of degree 2

By Euler's formula,

$$x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = n\frac{f(u)}{f'(u)}$$

$$= 2 \times \frac{\tan u}{\sec^2 u} = 2 \times \frac{\sin u}{\cos u \times 1}\cos^2 u$$

$$= 2 \times \sin u \cos u$$

$$= \sin 2u$$

144. (d)

$$5x + 6y = 7$$

$\Rightarrow$ $$y = \underbrace{-\frac{5x}{6}}_{b_{yx}} + \frac{7}{6}$$

$$2x + 3y = 9$$

$\Rightarrow$ $$x = \underbrace{-\frac{3y}{2}}_{b_{xy}} + \frac{9}{2}$$

Coefficient of correlation is given by

$$r = \sqrt{b_{yx}\, b_{xy}}$$

and it must lie in $-1 < r < 1$

Here, $$r = \sqrt{\frac{-5}{6} \times \left(-\frac{3}{2}\right)} = 1.118 > 1$$

So, $r = 1.118$ is not possible

Again, $$5x + 6y = 7$$

$$\Rightarrow \quad x = \underbrace{-\frac{6}{5}}_{-b_{xy}} y + \frac{7}{5}$$

$$2x + 3y = 9$$

$$\Rightarrow \quad y = \underbrace{-\frac{2x}{3}}_{-b_{yx}} + \frac{9}{3}$$

$$r = \sqrt{\left(-\frac{6}{5}\right) \times \left(-\frac{2}{3}\right)} = 0.894 < 1$$

Hence, $r = 0.894$

145. **(a)**

A material in which the external magnetic field produces a resultant dipole moment in the opposite direction is called diamagnetic. i.e., induced moment is negative.

$\therefore$ The susceptibility is negative.

146. **(c)**

On addition of lagging load on synchronous generator, the terminal voltage V_T decreases significantly.

147. **(d)**

Nuclear power plants are used as a base load power plant.

Hence statement I is false.

148. **(b)**

Both of the given statements are individually true but statement (II) is not the correct explanation of statement (I).

150. **(c)**

Statement (I) is true, but Statement (II) is wrong.

■■■■