DETAILED SOLUTIONS

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ESE 2023 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

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

DETAILED EXPLANATIONS

1. (c)

For $f(1, 1, 1)$

$$f = Z_{11} + \overline{Z_{11}} \qquad (M \text{ can be any function})$$

$$f = 1$$

2. (b)

A $2^k \times n$ ROM contains a $k \times 2^k$ decoder followed by n OR gates.

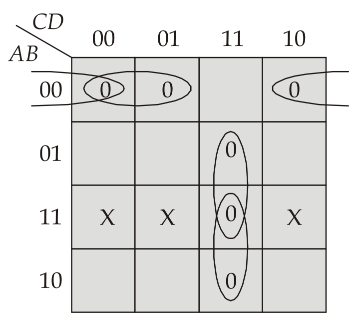
3. (d)

$$(\text{C000})_{16} = (1100\ 0000\ 0000\ 0000)_2$$
$$(\text{ABCD})_{16} = (1010\ 1011\ 1100\ 1101)_2$$
$$(\text{FF22})_{16} = (1111\ 1111\ 0010\ 0010)_2$$
$$(\text{F1D7})_{16} = (1111\ 0001\ 1101\ 0111)_2$$

$\therefore$ Most number of 1's is contained in the binary code of $(\text{F1D7})_{16}$

4. (c)

Using k-Map



Minimum POS expression $F = (A+B+C)(A+B+D)(\bar{B}+\bar{C}+\bar{D})(\bar{A}+\bar{C}+\bar{D})$

5. (c)

$\because$ $T = Q + \bar{Q} = 1$ i.e., always 1

Hence, the flip-flop output will toggle after each clock cycle.

$$\therefore \quad f_{\text{out}} = \frac{f_{clk}}{2}$$

$$f_{\text{clk}} = 2 f_{\text{out}} = 2 \times 15 = 30 \text{ kHz}$$

6. (b)

The propagation delay is the time required for a gate to change its state.

7. (c)

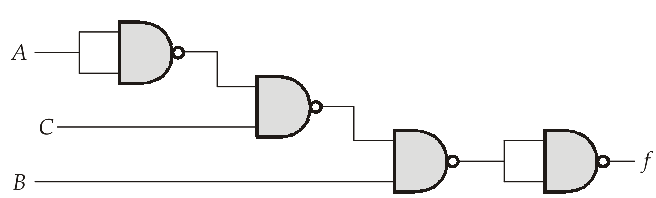
Let the base is 'x'

$$\therefore \quad 3x^2 + 2 = 2x\left(x + 2 + \frac{1}{x}\right)$$

$$3x^2 + 2 = 2x^2 + 4x + 2$$
$$x^2 = 4x$$
$\therefore$ $$x = 0, 4$$
$\therefore$ Minimum possible Non zero base for the given equation to be valid is 4.

8. (a)

$$f = AB\bar{C} \oplus AB \oplus B\bar{C}$$
$$= \left[\left(\overline{AB\bar{C}}\right)AB + AB\bar{C}(\overline{AB})\right] \oplus B\bar{C}$$
$$= ABC \oplus B\bar{C}$$
$$= (\overline{ABC}) \cdot B\bar{C} + (ABC)(\overline{B\bar{C}})$$
$$= (\bar{A} + \bar{B} + \bar{C})B\bar{C} + ABC[\bar{B} + C]$$
$$= \bar{A}B\bar{C} + B\bar{C} + ABC$$
$$= \bar{A}B\bar{C} + B[\bar{C} + AC]$$
$$= \bar{A}B\bar{C} + B\bar{C} + AB$$
$$= B\bar{C} + AB$$
$$f = B(A + \bar{C})$$
$$f = B\left(\overline{\bar{A} \cdot C}\right)$$



$\therefore$ Minimum number of NAND gates required are 4.

9. (d)

- In TTL logic, open/floating input behaves as if a logic '1' is applied to it.
- In ECL logic, open/floating input behaves as if a logic '0' is applied to it.

10. (a)

The time taken from submission of process of request until the first response is produced during the process execution is called response time.

11. (b)

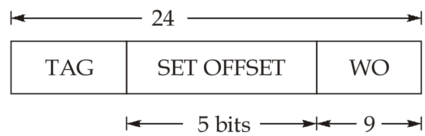
$$\text{EMAT} = H \times T_c + (1 - H)(T_c + T_m)$$
$$= 0.8 \times 5 + (1 - 0.8)[5 + 100]$$
$$= 0.8 \times 5 + 0.2 \times 105$$
$$\text{EMAT} = 25 \text{ nsec}$$

12. (d)

DRAM → Used in Main Memory.

SRAM → Used in Cache Memory.

13. (b)



$$\text{Main memory size} = 32768 \times 512 = 2^{15} \times 2^{9} = 2^{24} \text{ Bytes}$$

Hence, 24 bits are required to access the cache memory.

$$\text{Word offset} = \log_2[512] = 9 \text{ bits}$$

$$\text{Number of sets} = \frac{128}{4} = 32$$

$$\text{Set offset} = \log_2(32) = 5 \text{ bits}$$

$$\therefore \quad \text{TAG} = 24 - 5 - 9 = 10 \text{ bits}$$

15. (b)

Files and programs can be shared but printer can't be shared.

16. (a)

Ready queue $\Rightarrow$ $P_1\ P_2\ P_1\ P_3\ P_2\ P_1\ P_4\ P_3\ P_2\ P_4\ P_3\ P_2\ P_4\ P_3\ P_4\ P_3\ P_4$

Gantt chart:

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

0 2 4 6 8 10 11 13 15 17 19 21 22 24 26 28 29 33

P_{id}	AT	BT	CT	$TAT = CT - AT$
P_1	0	5	11	11
P_2	1	7	22	21
P_3	4	9	29	25
P_4	7	12	33	26

$$\text{Average TAT} = \frac{11 + 21 + 25 + 26}{4} = 20.75$$

17. (c)

The concept of locking can be used to solve the problem of lost update, uncommitted dependency and prevents inconsistency among data but it is not capable of preventing the deadlock always.

18. (d)

Shared memory multiprocessor fit best into MIMD computer.

20. (c)

In a self-bias current, if I_C tends to increase, the current in emitter resistance R_E increases, and as a result, base-current is decreased which will cause decrease in I_C. Hence, the self-bias circuit stabilizes the collector current.

21. (c)

$$\frac{dV_0}{dt} = A\frac{dV_i}{dt}$$

Given $$SR = \left.\frac{dV_0}{dt}\right|_{max} = \frac{2V}{\mu\,sec} = 2 \times 10^6 \text{ V/sec}$$

$\therefore$ $$2 \times 10^6 \geq A \times \frac{0.5}{10} \times 10^6$$

$$A \leq 40$$

22. (b)

$$\%\eta = 40.5 \times \frac{R_L}{(R_F + R_L)} \quad \text{(for half wave rectifier)}$$

$$= 40.5 \times \frac{1000}{(1000 + 30)}$$

$$\%\eta = 39.3\%$$

23. (d)

Small signal voltage gain $A_V = -g_m(r_d \parallel R_D)$

$$= -5[5 \parallel 5]$$

$$A_V = -12.5$$

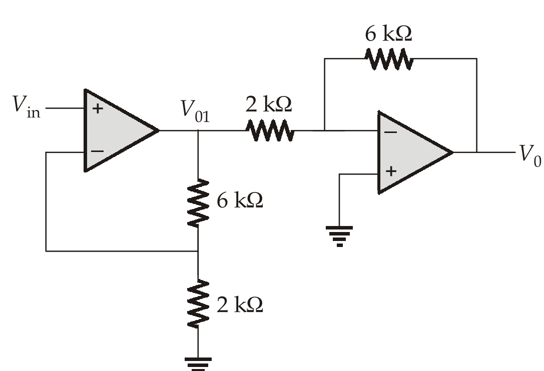
24. (d)

Rise time $$t_r = 1.1\sqrt{t_{r_1}^2 + t_{r_2}^2}$$

$$= 1.1\sqrt{(0.5)^2 + (1.2)^2}$$

$$t_r = 1.43 \text{ msec}$$

25. (a)



$$V_{01} = \left(1+\frac{6}{2}\right)V_{in} = 4V_{in} = 4\text{ mV}$$

$$V_0 = -\frac{6}{2}\times V_{01}$$

$$V_0 = -3 \times 4$$

$$V_0 = -12\text{ mV}$$

26. (a)

Region of operation, which are mainly responsible for heating of the transistor under switching operation are

1. Saturation region
2. Transition from saturation to cutoff
3. Transition from cutoff to saturation.

27. (a)

$$\%\text{ Regulation} = \frac{V_{DCNL}-V_{DCFL}}{V_{DCFL}}\times 100$$

$$= \frac{25-24}{24}\times 100 = \frac{100}{24} = 4.167\%$$

28. (c)

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

$$\int_0^1 K(x-x^3)dx = 1$$

$$K\left[\frac{x^2}{2}-\frac{x^4}{4}\right]_0^1 = 1$$

$$K\left[\frac{1}{2}-\frac{1}{4}\right] = 1$$

$$K = 4$$

29. (c)

In FM systems, the power of the transmitted signal is proportional to the amplitude of the unmodulated carrier signal and it is constant. Therefore, FM is usually more power-efficient than AM systems.

30. (a)

Given, $2\Delta f = 120\text{ kHz} = \text{Carrier swing}$

$$\Delta f = 60\text{ kHz}$$

$$\beta = 6$$

For FM: $\beta = \dfrac{\Delta f}{f_m}$

$$f_m = \frac{\Delta f}{\beta} = \frac{60}{6} = 10 \text{ kHz}$$

31. (b)

$$h(t) = 4e^{-2t}u(t),\ m_y = 5$$

$$H(\omega) = \frac{4}{j\omega + 2}$$

$$|H(0)| = \frac{4}{2} = 2$$

We know, $m_y = |H(0)|\, m_x$

$$5 = \frac{4}{2} m_x$$

$$m_x = 2.5$$

32. (c)

From the figure, it is clear that

$$f_1 = 0.25 \text{ MHz}$$

$$f_3 = 0.75 \text{ MHz}$$

We know, Roll off factor $\alpha = \dfrac{f_3 - f_1}{f_3 + f_1} = \dfrac{0.75 - 0.25}{0.75 + 0.25}$

$$\alpha = 0.5$$

33. (d)

Probability of error for non-coherent FSK

$$P_e = \frac{1}{2} \cdot e^{-E_b/4N_0}$$

34. (b)

Upon comparing the output with standard AM signal we get,

$$A_c = 14.14$$

$$B = \frac{A_c \mu}{2}$$

given $\mu = 0.7$

$\therefore$ $B = \dfrac{14.14 \times 0.7}{2}$

$$B = 4.949$$

35. (b)

$$f_{m1} = 3 \text{ kHz},\ f_{m2} = 1.5 \text{ kHz},\ f_{m3} = 1.5 \text{ kHz}$$

$\therefore$ $f_{s1} = 6 \text{ kHz},\ f_{s2} = 3 \text{ kHz},\ f_{s3} = 3 \text{ kHz}$

The overall sampling rate $= 6 + 3 + 3$

$= 12$ kHz

$\therefore$ Speed in sample/second = 12000 samples/sec

Number of samples in a minute = 12000 × 60 samples

and in 1 rotation,total samples taken = 2 + 1 + 1 = 4

$\therefore$ 4 samples taken = 1 rotation

12000 × 60 samples taken per minute = $\frac{1 \times 12000 \times 60}{4}$ rotation/min

$\therefore$ Speed of commutator = 180000 rpm

36. (d)

Given $P(x_1) = P(x_2) = 0.5$

$$P[Y] = P[X] \cdot P\left[\frac{Y}{X}\right]$$

$$= \begin{bmatrix} 0.5 & 0.5 \end{bmatrix} \begin{bmatrix} 0.8 & 0.2 & 0 \\ 0 & 0.2 & 0.8 \end{bmatrix}$$

$$P[Y] = \begin{bmatrix} 0.4 & 0.2 & 0.4 \end{bmatrix}$$

$\therefore$ $P(y_1) = 0.4$

37. (c)

Given: $h(n) = \left(\frac{1}{2}\right)^n u(n)$

$$x(n) = 2\delta(n) + \delta(n - 3)$$

$$y(n) = h(n) * x(n)$$

$$= \left(\frac{1}{2}\right)^n u(n) * [2\delta(n) + \delta(n-3)]$$

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

at $n = 1$; $y(1) = 2\left(\frac{1}{2}\right)^1 u(1) + \left(\frac{1}{2}\right)^{1-2} u(1-3)$

$$= 2 \times \frac{1}{2} + 0$$

$$y(1) = 1$$

at $n = 4$; $y(4) = 2\left(\frac{1}{2}\right)^4 u(n) + \left(\frac{1}{2}\right)^{4-3} u(4-3)$

$$= 2 \times \frac{1}{16} + \frac{1}{2} \times 1 = \frac{1}{8} + \frac{1}{2}$$

$$y(4) = \frac{5}{8}$$

40. (b)

Given: $y(n) = ay(n-1) + bx(n)$

The frequency response, $Y(\omega) = ae^{-j\omega}Y(\omega) + bX(\omega)$

$$\frac{Y(\omega)}{X(\omega)} = H(\omega) = \frac{b}{1-ae^{-jw}} = \frac{b}{1-a\cos\omega + ja\sin\omega}$$

Hence, $$|H(\omega)| = \frac{b}{\sqrt{(1-a\cos\omega)^2 + (a\sin\omega)^2}}$$

$$|H(0)| = \frac{b}{1-a} = 1$$

$$a + b = 1$$

41. (a)

By using matrix approach

$$y(n) = \begin{bmatrix} 2 & 1 & 0 & 1 \\ 1 & 2 & 1 & 0 \\ 0 & 1 & 2 & 1 \\ 1 & 0 & 1 & 2 \end{bmatrix}\begin{bmatrix} 5 \\ 3 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 14 \\ 13 \\ 8 \\ 9 \end{bmatrix}$$

42. (d)

Given: $$X(z) = \frac{z}{3z^2 - 4z + 1}$$

$$X(z) = \frac{A}{z-1} + \frac{B}{z - \frac{1}{3}}$$

Poles are at $z = 1, 1/3$

For anticausal, the ROC must be left side i.e., inwards.

$$\text{i.e.,}\ |z| < \frac{1}{3}$$

43. (d)

$$X(z) = \sum_{n=0}^{\infty} x(n)z^{-n}$$

Let, $$Y(z) = \sum_{n=0}^{\infty} x(n+2)z^{-n}$$

Take $k = n + 2 \Rightarrow n = k - 2$

$$Y(z) = \sum_{k=2}^{\infty} x(k)z^{-k}z^2 = z^2\sum_{k=2}^{\infty} x(k)z^{-k}$$

$$= z^2\left[\left(\sum_{k=0}^{\infty} x(k)z^{-k}\right) - x(0) - z^{-1}x(1)\right]$$

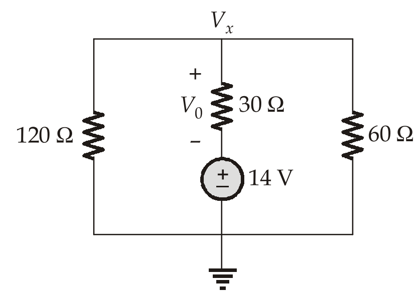
$$= z^2[X(z) - x(0) - z^{-1}x(1)] = z^2X(z) - z^2x(0) - zx(1)$$

44. (c)

- The magnitude response of Chebyshev filters has equiripple passband and maximally flat stopband.
- The magnitude response of an elliptical filter has equiripple passband and stopband.

46. (d)

Given:



Apply nodal analysis at node V_x

$$\frac{V_x - 14}{30} + \frac{V_x}{120} + \frac{V_x}{60} = 0$$

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

$$V_0 = -14 + 8 = -6 \text{ V}$$

47. (c)

- The internal impedance of ideal voltage source is zero.
- The internal impedance of ideal current source is infinite.

48. (c)

$$H(s) = \frac{V_0(s)}{I(s)} = \frac{(s+1)}{(5s+8)(3s+2)}$$

$\because$ $$i(t) = 4u(t) \Rightarrow I(s) = 4/s$$

$\therefore$ $$V_0(s) = \frac{(s+1)}{(5s+8)(3s+2)} \times 4/s$$

$\therefore$ Final value, $$\lim_{s \to 0} sV_0(s) = \lim_{s \to 0} \frac{(s+1)}{(5s+8)(3s+2)} \times 4$$

$$= \frac{1}{8 \times 2} \times 4 = \frac{4}{16} = \frac{1}{4} = 0.25$$

49. (c)

Given: $$V_1 = 6V_2\big|_{I_1 = 0}$$

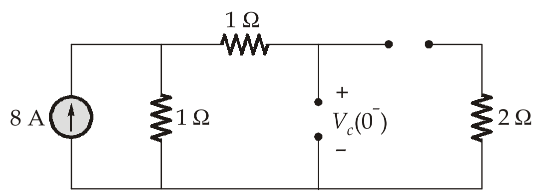
$$\left.\frac{V_1}{V_2}\right|_{I_1 = 0} = 6 = h_{12}$$

$$I_2 = 8.6\, V_2\big|_{I_1 = 0}$$

$$\left.\frac{I_2}{V_2}\right|_{I_1 = 0} = 8.6\ \mho = h_{22}$$

50. (d)

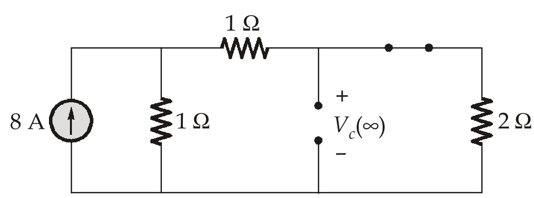
At $t = 0^-$; the switch is open and the capacitor acts as open-circuit in the steady-state.



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

At $t = \infty$; in the steady state, the circuit can be drawn as below:

$$R_{eq} = 2 \parallel 2 = 1\ \Omega$$



$$V_c(\infty) = 4\text{ V}$$

The capacitor voltage,

$$V_c(t) = V_C(\infty) - [V_C(\infty) - V_C(0^+)]e^{-t/R_{eq}C}$$

$$V_c(t) = 4 - [4 - 8]e^{-t/R_{eq}C}$$

$$V_c(t) = [4 + 4e^{-t}]\text{ V}$$

51. (d)

Potential drop across inductor, $V_L = L\dfrac{di_L}{dt}$

Current through a capacitor, $i_c = C\dfrac{dV_c}{dt}$

52. (a)

$\Rightarrow$ Total number of branches, $b = 16$

Total number of nodes, $n = 9$

Number of links $= b - n + 1 = 16 - 9 + 1 = 8$

53. (a)

For R-L-C parallel circuit

Damping ratio,

$$\xi = \frac{1}{2R}\sqrt{\frac{L}{C}} = \frac{1}{2 \times 5}\sqrt{\frac{12}{3}}$$

$$\xi = 0.2$$

54. (c)

$$\text{Resonant frequency, } \omega_0 = \frac{1}{\sqrt{L_{eq}C}}$$

$$L_{eq} = 5 + 3 + 2 \times 2 = 12 \text{ mH}$$

$$\omega_0 = \frac{1}{\sqrt{L_{eq}C}} = \frac{1000}{\sqrt{12 \times 16}} = \frac{1000}{8\sqrt{3}}$$

$$\omega_0 = \frac{125}{\sqrt{3}} \text{ rad/sec}$$

$$\omega_0 = 72.17 \text{ rad/sec}$$

55. (b)

The steam power plant operates on the rankine cycle. Rankine cycle is an ideal cycle of heat engine which uses water and steam as a working fluid to generate power with the help of a steam turbine.

56. (c)

An autotransformer does not provide isolation between the primary and secondary windings.

57. (c)

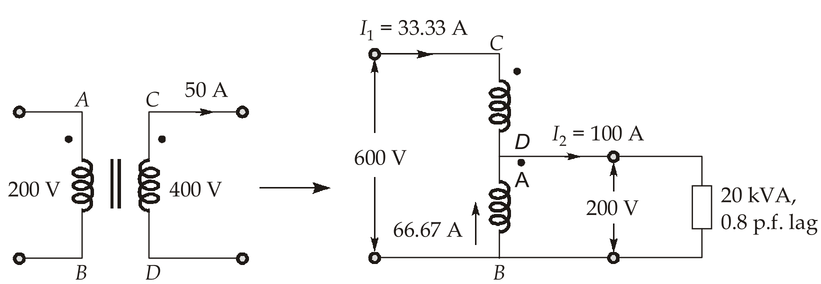
Two winding must be connected in series with the proper polarity so that 600 V can be applied across the total windings.

With 20 kVA load, load current

$$I_2 = \frac{20 \times 1000}{200} = 100 \text{ A}$$

$$I_1 = \frac{20 \times 1000}{600} = 33.33 \text{ A}$$

$$\text{current in common winding} = (100 - 33.33) \text{ A} = 66.67 \text{ A}$$



For auto transformer rating,

$$S_{auto} = \frac{S_{TW}}{1 - x}$$

Where, $$x = \frac{200}{600}$$

then $$S_{auto} = \frac{20 \text{ kVA}}{1 - \frac{1}{3}} = 30 \text{ kVA}$$

58. (a)

The core loss for constant flux density,

$$P_L = Af + bf^2$$

For f = 40 Hz, $52 = 40A + 1600B$ ...(i)

For f = 60 Hz, $102 = 60A + 3600B$ ...(ii)

On solving equation (i) and (ii),

$$A = 0.5, \quad B = 0.02$$

So, core loss at f = 50 Hz

$$P_L(50\text{ Hz}) = 0.5 \times 50 + 0.02 \times (50)^2$$

$$P_L = 75\text{ W}$$

59. (b)

$$\frac{\text{Pole arc}}{\text{Pole pitch}} = 0.75, \quad Z = 800, A = 2 \text{ and } P = 10$$

The number of conductors in compensating winding in each pole,

$$Z_{CW} = \frac{Z}{AP}\left(\frac{\text{Pole arc}}{\text{Pole pitch}}\right) = \frac{800}{2\times10}(0.75) = 30$$

60. (b)

EMF induced in an alternator, $E = \sqrt{2}\,\pi f N \phi_m k_p k_d$

61. (d)

Synchronous speed	Damper winding torque
$N_s = N_r$	Zero
$N_s > N_r$	Induction motor torque
$N_s < N_r$	Induction generator torque

62. (a)

Given: N_r = 1200 rpm at T_{max}.

$$N_s = \frac{120f}{P} = \frac{120\times50}{4} = 1500\text{ rpm}$$

$$S_{T_{max}} = \frac{1500-1200}{1500} = 0.2$$

$$\frac{T_{st}}{T_{max}} = \frac{2S_{T_{max}}}{S_{T_{max}}^2+1} \quad \{S_{st}=1\}$$

$$= \frac{2\times0.2}{1+(0.2)^2} = \frac{0.4}{1.04} = 0.385$$

63. (c)

At no-load, the induction motor operates at very poor lagging power factor. At no-load because of presence of only magnetizing current in the stator windings, causes low power factor operation, since magnetizing current is highly inductive in nature.

64. (c)

The root locus is the strongest tool for determining stability and the transient response of the system as it gives the exact pole-zero location and also their effect on the response.

65. (d)

Open loop transfer function,

$$\text{OLTF} = \frac{s+6}{s^2+4s+9-s-6} = \frac{s+6}{s^2+3s+3}$$

$$\text{DC gain}\big|_{s=0} = 2$$

66. (a)

Feedback control systems are more sensitive to feedback path parameter changes than to forward path parameter changes.

For feedback control system, transfer function

$$T = \frac{G}{1 \pm GH}$$

We have, $S_G^T = \frac{1}{1 \pm GH}$ and $S_H^T = \frac{-GH}{1 \pm GH}$. Hence, $S_H^T > S_G^T$

67. (c)

Given: $G(s) = \frac{K}{s(s+6)}$

Characteristic equation, $s^2 + 6s + K = 0$

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

$$2\xi\omega_n = 6$$

$$\omega_n = \frac{6}{2 \times 0.8} = 3.75$$

$$K = \omega_n^2 = (3.75)^2 = 14.06$$

Undershoot time, $t = \frac{n\pi}{\omega_d}\bigg|_{n=2,4,6,\ldots}$

For second undershoot, $n = 4$

$$\omega_d = \omega_n\sqrt{1-\xi^2} = 3.75\sqrt{1-(0.8)^2} = \frac{9}{4}$$

$$t = \frac{4\pi}{3.75\sqrt{1-0.8^2}} = \frac{16\pi}{9}\text{ sec}$$

68. (d)

$$\text{Angle of Asymptotes, } \theta_k = \frac{(2k+1)\pi}{m-n},\ k = 0, 1, 2 \ldots m-n-1.$$

69. (c)

Given: $G(s) = \dfrac{se^{-2Ts}}{s+4}$

$$G(j\omega) = \frac{j\omega e^{-j2\omega T}}{j\omega + 4}$$

$$\angle G(j\omega) = 90° - \tan^{-1}\left(\frac{\omega}{4}\right) - 2T\omega$$

At $\omega = \omega_o$,

$$\angle G(j\omega) = 0$$

$$0 = 90° - \tan^{-1}\left(\frac{\omega_o}{4}\right) - 2T\omega_o$$

$$2T\omega_o = \cot^{-1}\left(\frac{\omega_o}{4}\right)$$

$$\omega_o = 4\cot(2T\omega_o)$$

70. (d)

$$G(s) = \frac{K(s+5)}{s^2(s+8)(s+10)}$$

71. (a)

Given, $R_1 = 2\ \Omega,\quad R_2 = 4\ \Omega,\quad C = 4\text{ F}$

$$\tau = R_1C = 2 \times 4 = 8$$

$$\alpha = \frac{R_2}{R_1 + R_2} = \frac{4}{2+4} = \frac{2}{3}$$

Frequency at which maximum phase occurs,

$$\omega_m = \sqrt{\frac{1}{\tau} \cdot \frac{1}{\alpha\tau}} = \frac{1}{\tau}\sqrt{\frac{1}{\alpha}}$$

$$\omega_m = \frac{1}{8}\sqrt{\frac{1}{2/3}} = \frac{\sqrt{3}}{8\sqrt{2}} \text{ rad/sec}$$

72. (b)

R-H criteria,

s^5	1	4	3
s^4	4	2	1
s^3	$\frac{7}{2}$	$\frac{11}{4}$	0
s^2	$-\frac{8}{7}$	1	0
s^1	$\frac{93}{16}$		
s^0	1		

There are two sign changes, so 2 roots lies on *R-H* of *s*-plane.

73. (b)

MOV CX, AX : Register mode
MOV BX, [SI + 16] : Indexed mode
ADC CX, [AX + SI] : Based Indexed mode
MOV AL, FFH : Immediate mode

74. (b)

LDA 4200 H:	[A] = [4200 H]
	[A] = 55 H
	A : 01010101
CMA	$\bar{A}$: 10101010 ⇒ [A] = AAH
ADI 01 H	A : AAH + 01 H = ABH
STA 4300H	: [4300 H] = ABH
HLT	

76. (c)

LOOP and ROTATE instructions uses the contents of a CX register as a counter in 8086.

77. (a)

For RST 6.5, vector address is

$$6.5 \times 8 = (52)_{10} = 0034 \text{ H}$$

78. (d)

LXI H, 1234 H → (HL) = 1234 H

XRA A → (A) = 00 H

After the execution of XRA, S = 0, Z = 1, AC = 0, P = 1, CY = 0

DCR A → $(00)_H - 1 = -01H = FFH$

DCR operation doesn't affect carry flag. Hence,

S = 1, Z = 0, AC = 1, P = 1

CMP H → (A) > (H).

Hence, CY = 0 and Z = 0.

The result is not stored in accumulator as it is a comparison operator.

Flag Register							
S	Z	X	AC	X	P	X	CY
1	0	0	1	0	1	0	0

(A) = FF H, (flag register) = 10010100 = 94 H

∴ PSW = | Accumulator | Flag register | = (FF94) H

80. (b)

Fabrics are extensively made out of nano materials like Fullerenes.

82. (b)

The Neel temperature plays a similar role in antiferromagnetic materials as does the curie temperature in ferromagnetic materials.

83. (b)

Neodymium Iron Boron (NdFeB) or "neo" magnets offer the highest energy product of around 300 kJ/m^3.

84. (b)

An electret is a dielectric material that has a permanent electric charge or dipole moment. These materials are the electrical analogy to a permanent magnet.

85. (d)

The given material is paramagnetic. Hence,

Magnetization, $M = \chi_m H$

where $\chi_m \rightarrow$ magnetic susceptibility

$H \rightarrow$ magnetic field intensity

So, in terms of magnitude, $M \propto H$

According to Curie law,

$$\chi_m = \frac{C}{T}$$

$$\Rightarrow \quad \chi_m \propto \frac{1}{T}$$

So, for constant H, $M \propto \frac{1}{T}$

86. (c)

Graphene ia a good conductor of heat and electricity.

88. (a)

A materials's magnetic property is largely determined by the magnetic dipole moment associated with the electron's intrinsic angular momentum or spin.

89. (d)

Dry oxidation process has lower oxidation growth rate compared to wet oxidation because the oxygen diffuses slower into the silicon compared to O-H.

90. (b)

Since Deal-Grove equation

$$x_0^2 + Ax_0 = B(t + \tau)$$

$$\Rightarrow \quad x_0 = \frac{B(t+\tau)}{x_0} - A \qquad ...(1)$$

For the given plot, $$x_0 = 0.2\frac{(t+\tau)}{x_0} - 0.5 \qquad ...(2)$$

Comparing (1) and (2) we get,

$$A = 0.5;\ B = 0.2$$

So, $$\text{Linear rate constant} = \frac{B}{A} = \frac{0.2}{0.5} = 0.4\ \mu\text{m/Hour}$$

91. (d)

$N = 20, K = 6$

$$\text{Speed up} = \frac{N \cdot K}{N+K-1} = \frac{20\times 6}{20+6-1} = \frac{120}{25} = 4.8$$

92. (a)

Ion implantation requires less operating temperature than diffusion.

94. (b)

The quality of gate oxide should be very high. Dry oxidation produces better quality oxide than other methods. Hence, dry oxidation is used most widely to form gate oxide.

97. (a)

Solid solubility of impurity is a strong function of diffusion temperature but not the diffusion time.

98. (d)

Data translation, compression and encoding, encryption is done in presentation layer of OSI model.

99. (a)

- Data unit in transport layer is known as segment.
- Trailer bits are added in data link layer.
- Transport layer uses a port number to deliver the segmented data to the correct process. A port number is a 16-bit address used by transport layer to identify any client server program.

100. (c)

DES is an example of symmetric key cryptography.

101. (c)

First octet of IP Address for Class A ranges from 0-127.
For Class B ranges from 128-191.

Remember:

- 127.0.0.0 $\Rightarrow$ Class A, network id.
- 127.0.0.1 $\Rightarrow$ Class A, loop back.
- 134.255.255.255 $\Rightarrow$ Class B, broadcast.
- 0.0.0.0 $\Rightarrow$ Class A, backbone.

102. (c)

For Go Back N-ARQ:

$\Rightarrow$ Sender window size is $2^m - 1$.
$\Rightarrow$ Receiver window size is 1.
$\Rightarrow$ Error and flow control is possible.
$\Rightarrow$ Successful pipeline is observed i.e., sending multiple frames before receiving the acknowledgement for the first frame.

103. (a)

- Cluster size, $N = i^2 + j^2 + ij$
  $= 1 + 4 + 2 = 7$
- Co-channel re-use ratio: $Q = \sqrt{3N} = \sqrt{21}$

$\because$ Number of co-channel cells $= i_o = 7$

$\therefore$ Signal to interference ratio is

$$\frac{S}{I} = \frac{(Q)^n}{i_o} = \frac{(\sqrt{21})^2}{7} \ldots n = 2$$

$$= \frac{21}{7} = 3$$

104. (d)

Core R.I. $(n_1) = 1.52$

Cladding R.I. $(n_2) = 1.45$

$\therefore$ The index difference of fiber is

$$\frac{n_1 - n_2}{n_1} = \frac{1.52 - 1.45}{1.52} = 0.046 = 4.6\%$$

105. (c)

We know, $T_e = T_A (F - 1)$

$= 300 (2 - 1)$ .... $F = 3$ dB $= 2$

$= 300$ K $= 10\log_{10}(300)$

$= 10\log_{10}3 + 10\log_{10}100 = 24.77$ dB

Noise power density of the receiver is

$$N_o = kT = K|_{\text{dB}} + T|_{\text{dB}}$$

$$= -228.6 + 24.77 = -203.83 \text{ dB}$$

Remember:

- $\log_{10}3 = 0.47$, $\log_{10}2 = 0.3$.
- $K = 1.38 \times 10^{-23}$ J/K $= -228.6$ dB.

106. (c)

Kepler's Third Law:

"The square of the time period of revolution of a planet around the Sun in an elliptical orbit is directly proportional to the cube of its semi-major axis."

i.e. $T^2 \propto r^3$

where, T = time period and r = orbital radius or semi-major axis.

107. (d)

For a semiconductor to have minimum conductivity (or maximum resistivity),

$$n = n_i\sqrt{\frac{\mu_p}{\mu_n}} \text{ and } p = n_i\sqrt{\frac{\mu_n}{\mu_p}}$$

The minimum conductivity, $\sigma_{\min} = 2n_i q\sqrt{\mu_n \cdot \mu_p}$

But, $\rho_{\max} = \dfrac{1}{2n_i q\sqrt{\mu_n \cdot \mu_p}}$

108. (d)

For direct band-gap semiconductor material, energy from electron releases in form of photon of light.

109. (c)

For *n*-type semiconductor: W = 2 mm, t = 0.2 mm, I = 10 mA, B = 0.1 Wb/m^2, V_H = –1 mV.

$\because$ Hall voltage for n-type semiconductor is negative.

$$\therefore \quad |V_H| = \frac{BIR_H}{W}$$

$$R_H = \frac{|V_H| \cdot W}{BI} = \frac{1\times 2\times 10^{-3}}{0.1\times 10} = 2\times 10^{-3}\ \text{m}^3/\text{C}$$

110. (d)

Schottky Contact:

- $\phi_m > \phi_s$.
- Electron transfer from n-type region to metal.

Ohmic Contact:

- $\phi_m < \phi_s$.
- Electron transfer from metal to n-type region.

111. (c)

Due to increase in temperature, vibration of atoms increases and thus, reduces the mean free path of electrons. Hence, Avalanche breakdown voltage increases with temperature i.e. it have positive temperature coefficient (PTC).

112. (c)

- With increase in base width, the recombination in base region will increase and therefore, base current increases and collector current decreases. So, $\beta = \dfrac{I_C}{I_B}$ decreases.
- As carrier (minority) lifetime in base region increases, the number of recombinations in base region decreases and more carriers reach to collector, therefore I_B decreases and I_C increases and as a result, 'β' increases.
- With increase in collector current, β will remain same, as collector current will increase when base current increases, because base current is controlling current on which collector current depends.
- Increase in base doping will lead to increase in base current and decrease in collector current and hence, 'β' decreases.

113. (c)

For n-channel JFET, pinch-off voltage:

$$V_p = \frac{a^2 q N_D}{2\epsilon}$$

where, N_D = doping of n-type substrate and a = half channel width.

Note:

- Pinch-off voltage for n-channel JFET is negative.
- Pinch-off voltage for p-channel JFET is positive.

114. (a)

We know,
$$E_{max} = \frac{2(V_{bi} + |V_R|)}{W}$$
$$3 \times 10^5 = \frac{2(V_{bi}+3)}{2.5\times10^{-5}}$$
$$V_{bi} = 0.75 \text{ Volt}$$

115. (d)

We know,
$$\text{Energy gap } [E_G] = \frac{1.24}{\lambda(\mu m)} \text{(eV)}$$
$\therefore$
$$\lambda = \frac{1.24}{E_G} = \frac{1.24}{1.6} = 0.775\ \mu\text{m}$$
$$\lambda = 775 \text{ nm}$$

$\because$ Red light have wavelength between 620 to 780 nm, hence radiation emitted will be of red colour.

116. (d)

The time at which volume charge density reduces to 36.8% of its initial value is known as "relaxation time (T_r)" or time constant.

$$T_r = \frac{\epsilon}{\sigma} = \frac{8.85\times10^{-12}}{5.8\times10^7} = 1.53\times10^{-19} \text{ sec}$$

117. (b)

We have,
$$G(\rho, \phi, z) = e^{-z}\left(\rho^2\cdot\hat{a}_\rho + \frac{\pi}{2}\cdot\hat{a}_\phi + 5\hat{a}_z\right)$$
$$= e^{-z}\cdot\rho^2\cdot\hat{a}_\rho + e^{-z}\cdot\frac{\pi}{2}\cdot\hat{a}_\phi + 5e^{-z}\cdot\hat{a}_z$$
$\because$
$$\nabla\cdot\vec{G} = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho\cdot G_\rho) + \frac{1}{\rho}\frac{\partial}{\partial\phi}(G_\phi) + \frac{\partial}{\partial z}(G_z)$$
$$= \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho\cdot e^{-z}\cdot\rho^2) + \frac{1}{\rho}\frac{\partial}{\partial\phi}\left(e^{-z}\cdot\frac{\pi}{2}\right) + \frac{\partial}{\partial z}(5e^{-z})$$
$$= e^{-z}\cdot(3\rho) + 0 - 5e^{-z}$$

At $p(2, 60°, 0)$
$$\nabla\cdot\vec{G} = 3\times2 - 5 = 1$$

118. (b)

Velocity of propagation, $v_p = \frac{1}{\sqrt{LC}}$

Phase constant for lossless line, $\beta = \omega\sqrt{LC}$

and $Z_0 = \sqrt{\frac{L}{C}}$

$\therefore \quad v_p = \frac{Z_0}{L} \text{ or } \frac{\omega}{\beta}$

119. (c)

It measures the rate of flow of energy and its direction is the direction of power flow and is perpendicular to the plane containing the $\vec{E}$ and $\vec{H}$. i.e. $\vec{P} = \vec{E} \times \vec{H}\,(\text{W/m}^2)$.

120. (c)

For good conductor: ($\sigma >> \omega\in$)

$$v_p = \frac{\omega}{\beta};\ \alpha = \beta = \sqrt{\pi f \mu \sigma}$$

$$v_p \propto \sqrt{f}$$

$$\therefore \quad \frac{v_{p_2}}{v_{p_1}} = \sqrt{\frac{f_2}{f_1}}$$

$$\because \quad f_2 = 2f_1$$

$$\therefore \quad v_{p_2} = \sqrt{2}\cdot v_{p_1} = 1.414 v_{p1}$$

Hence, phase velocity increases by 41.4%.

121. (c)

Medium-1 (Perfect dielectric)	Medium-2
$\in_{r1} = 4$	$\in_{r2} = 9$
$\mu_{r1} = 1$	$\mu_{r2} = 4$
$\sigma = 0$	$\sigma = 0$

- Intrinsic impedance of Medium-1,

$$\eta_1 = \sqrt{\frac{\mu_1}{\in_1}} = \eta_o\sqrt{\frac{\mu_{r_1}}{\in_{r_1}}} = \eta_o\sqrt{\frac{1}{4}} = \frac{\eta_o}{2}$$

- Intrinsic impedance of Medium-2,

$$\eta_2 = \sqrt{\frac{\mu_2}{\in_2}} = \eta_o\sqrt{\frac{\mu_{r_2}}{\in_{r_2}}} = \eta_o\sqrt{\frac{4}{9}} = \frac{2}{3}\eta_o$$

Now, Reflection coefficient (Γ) $= \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{\frac{2}{3}\eta_o - \frac{\eta_o}{2}}{\frac{2}{3}\eta_o + \frac{\eta_o}{2}} = \frac{\frac{2}{3} - \frac{1}{2}}{\frac{2}{3} + \frac{1}{2}} = \frac{1}{7}$

122. (d)

Lossless Transmission Line:

- $\alpha = 0$
- $R = 0 = G$
- $Z_o = R_o = \sqrt{\frac{L}{C}}$

"For characteristic impedance of lossless transmission line, reactance value is zero."

Distortionless transmission line:

$$\alpha = \sqrt{RG}\ ; \quad \beta = \omega\sqrt{LC}$$

"A "distortionless line" is one in which the attenuation constant 'α' is frequency **independent** while the phase constant β is linearly dependent on frequency."

$$\gamma = \alpha + j\beta$$

$$\phi = \tan^{-1}\left(\frac{\beta}{\alpha}\right)$$

∵ α and β are positive non-zero real constant, hence phase angle will not be always 0° or 180°.

123. (b)

We know for lossy transmission line;

$$Z_{in} = Z_o\left[\frac{Z_L + Z_o \tan h\gamma l}{Z_o + Z_L \tan h\gamma l}\right]$$

$$\because \quad \cot h\gamma l = \frac{1}{\tan h\gamma l}$$

$$\therefore \quad Z_{in} = Z_o\left[\frac{Z_o + Z_L \cot h\gamma l}{Z_L + Z_o \cot h\gamma l}\right]$$

124. (c)

We have, $$\vec{H}_x = 9\sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{\pi y}{0.5b}\right)\sin(\omega t - \beta z)\,\hat{a}_x \text{ A/m}$$

∵ General equation of $\vec{H}_x$ is given by;

$$\vec{H}_x = H_{ox}\sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)\sin(\omega t - \beta z)\cdot\hat{a}_x \text{ A/m}$$

Now by comparing, $H_{ox} = 9, \quad m = 1$ and $n = 2$

∴ Operating mode of waveguide will be TM_{12} or TE_{12}.

125. (c)

Deflection Type Instrument:

- Finite operational power is required.
- Less accurate and sensitive in nature.
- It is preferred under dynamic condition as the pointer deflection can follow the variations of the quantity being measured, more rapidly.

e.g. PMMC ammeter, Electrodynamometer and moving iron instruments.

126. (c)

$$\text{Resolution} = \frac{V_{FS}}{\text{Total number of counts}} = \frac{10}{20\times10^3} = 0.5\text{ mV}$$

127. (c)

We have, $R_m = 100\ \Omega$

$\%\in_r = 10\%$

$\therefore \quad \in_r = \frac{10}{100}\times R_m = \frac{10}{100}\times 100 = 10\ \Omega$

Range of resistance: $R_m \pm \in_r = 90\ \Omega$ to $110\ \Omega$

128. (a)

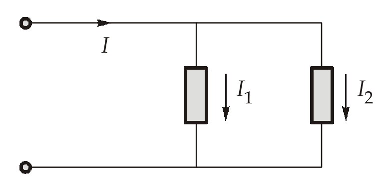
Span = 1000 – 600 = 400°C

$\therefore$ Dead zone = 0.18% of span

$$= \frac{0.18}{100}\times 400 = 0.72°\text{C}$$

Hence, a change of 0.72°C must occur before it is detected.

129. (c)



$$I = I_1 + I_2$$

$$\frac{\delta I}{\delta I_1} = 1$$

$$\frac{\delta I}{\delta I_2} = 1$$

We have, $\sigma_{I_1} = 3$ A and $\sigma_{I_2} = 4$ A

$\therefore$ Standard deviation in the measurement of total current is

$$\sigma_I = \sqrt{\left(\frac{\delta I}{\delta I_1}\right)^2 \cdot \sigma_{I_1}^2 + \left(\frac{\delta I}{\delta I_2}\right)^2 \cdot \sigma_{I_2}^2} = \sqrt{(1)^2\,(3)^2 + (1)^2\,(4)^2} = 5\text{ A}$$

But, Variance = (std. deviation)^2

= $(5)^2$ = 25

130. (a)

$\because$ True power $(P_T) = VI\cos\phi = 250 \times 4 \times 1 = 1000$ Watt

Power loss in current coil = $I^2 \times R_{CC} = (4)^2 \times (1) = 16$ Watt

$\therefore$ Measured power $\Rightarrow$ $P_m = P_T + I^2R_{CC} = 1000 + 16 = 1016$ Watt

Now, $$\%\ \text{Error} = \frac{P_m - P_T}{P_T}\times 100\% = \frac{1016-1000}{1000}\times 100\%$$

$\therefore$ % Error = 1.6%

131. (d)

With $4\frac{1}{2}$ digit voltmeter, number of full digit on a display = 4.

$\therefore$ Resolution, $R = \frac{1}{10^N} = \frac{1}{10^4} = 0.0001$

$\because$ With $4\frac{1}{2}$ digit display, we have 5 digit place.

$\therefore$ 11.93 V will be displayed as 11.930 on its 10 V range.
Because with 10 V range,

$$\text{Resolution} = 0.0001 \times 10 = 0.001 \text{ V}$$

132. (c)

Electrostatic instrument are used as voltmeter to measure RMS value of high range upto KV and of any shape.

133. (d)

- The capacitive transducer can be used for measuring the displacement, pressure and other physical quantities.
- It is a type of passive transducer.
- It works on the principle of variable capacitances by changing area, distance between plates and dielectric constant.

135. (c)

In a voltage sensitive bridge, the bridge output is given by the following expression.

$$E_0 = \frac{E_i}{4} \times G.F \times \frac{\Delta L}{L}$$

where, E_i = 8 V, G.F = 3 and $\frac{\Delta L}{L} = 50\ \mu\text{m/m}$

$\therefore$ $$E_0 = \frac{8}{4} \times 3 \times 50 \times 10^{-6}$$

$\therefore$ $$E_0 = 300\ \mu\text{V}$$

139. (d)

Equalization is required in both telephone lines and wireless communication.

140. (d)

IIR filters are digital filters with infinite impulse response and have feedback. So, IIR filters are known as recursive digital filters.

141. (c)

The net impedance at resonance due to capacitance and inductance is zero in series RLC circuit.

142. (c)

As the DOL starter connects the motor directly to the main supply line, the motor draws a very high current compared to the full load current of the motor (upto 5-8 times higher).

147. (d)

WDM (Wavelength Division Multiplexing) involves the transmission of a number of different peak wavelength optical signal in parallel on a single optical fiber.

148. (c)

A photodiode can be used as either photo conductive or a photo resistive sensor.

149. (b)

From Friis equation:

$$P_r = \frac{P_t \cdot G_t \cdot G_r}{\left(\frac{4\pi d}{\lambda}\right)^2} = \frac{P_t \cdot A_{et} \cdot A_{er}}{(\lambda d)^2}$$

where, $A_{et} = \frac{\lambda^2}{4\pi} \cdot G_t$ and $A_{er} = \frac{\lambda^2}{4\pi} \cdot G_r$

150. (b)

Both statements are correct, but statement 1 is not a reason for statement 2.

❍❍❍❍