DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

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

DETAILED EXPLANATIONS

1. (a)

Spontaneous magnetization is not a result of cooperative effect among domains.

2. (c)

The internal field of a magnetic material is,

$$H_i = H_0 + \gamma M$$

where, $\gamma = 0.1$; $H_0 = 12$ A/m; $M = 74$ A/m

$$H_i = 12 + (0.1)74 = 19.4 \text{ A/m}$$

3. (c)

Piezoelectric materials converts electrical energy to mechanical energy and vice versa.

4. (c)

5. (c)

$$H = \frac{NI}{l}$$

and $$B = \mu H = \mu_r \mu_0 H$$

$$H = \frac{0.04}{\mu_0} = \frac{0.04}{4\pi \times 10^{-7}} \quad [\because \mu_r = 1 \text{ in vacuum}]$$

$$\therefore \quad \frac{0.04}{4\pi \times 10^{-7}} = \frac{200 \times I}{150 \times 10^{-3}}$$

$$I = \frac{0.04 \times 150 \times 10^{-3}}{200 \times 4\pi \times 10^{-7}} = \frac{75}{\pi}$$

6. (b)

For BCC, Packing efficiency = 0.68

z = 2 atoms/unit cell

7. (b)

Ceramics have high electrical resistance and are extensively used in industry.

8. (c)

9. (c)

Dip-Pen Nanolithography (DPN) is an atomic force microscope (AFM) based patterning technique in which molecules are transported from a sharp tip to a surface. With DPN, the molecules to be deposited are first loaded onto the tip by dipping the tip into a melt or solution of the substance to be deposited. Similar to a pen which people use to write notes on a paper, the atomically sharp tip is scanned in contact with a sample surface. The ink molecules are transported to the surface driven by capillary forces normally generated by the condensed water or melted ink when tip contacts surface.

10. (a)

$$\text{Divergence of } \vec{A} = \nabla\cdot\vec{A}$$

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

$$= 2xz + (-2 \times 3y^2 \times z^2) + kxy^2$$

$$= 2xz - 6y^2z^2 + kxy^2$$

At point (1, –1, 1), $\nabla\cdot\vec{A} = -5$

$$2(1)(1) - 6(-1)^2(1)^2 + k(1)(-1)^2 = -5$$

$$2 - 6 + k = -5$$

$$k = -5 + 4 = -1$$

11. (c)

$$D_n = \rho_s = 2\text{ nC/m}^2$$

$$\vec{D} = 2\hat{a}_y\text{ nC/m}^2$$

So, for $y > 0$,

$$\vec{E} = \frac{\vec{D}}{\varepsilon_0\varepsilon_r} = \frac{2\times10^{-9}}{\frac{10^{-9}}{36\pi}\times4} = 18\pi\,\hat{a}_y\text{ V/m}$$

For $y < 0$, $\vec{E} = 0$

12. (c)

The tangential component of electric field at a dielectric-conductor boundary is zero.

13. (c)

$$v = \frac{1}{\sqrt{\mu\varepsilon}} = \frac{c}{\sqrt{\varepsilon_r}} = \frac{\omega}{\beta} = \frac{2\pi\times10^7}{0.1\pi} = 2\times10^8\text{ m/s}$$

$$\frac{3\times10^8}{\sqrt{\varepsilon_r}} = 2\times10^8$$

$$\sqrt{\varepsilon_r} = \frac{3}{2}$$

$$\therefore\quad \eta = \sqrt{\frac{\mu}{\varepsilon}} = \frac{120\pi}{\sqrt{\varepsilon_r}} = \frac{120\pi}{3/2} = 80\pi\ \Omega$$

14. (c)

Reflection coefficient,

$$\Gamma = \frac{z_L - z_0}{z_L + z_0} = \frac{900-600}{900+600} = \frac{300}{1500} = \frac{1}{5}$$

Transmission coefficient,

$$\tau = 1 + \Gamma = 1 + \frac{1}{5} = 1.2$$

15. (c)

Let, dimensions are $(a' \times b') = (a\sqrt{3} \times a)$ cm

So, $b' = \dfrac{a'}{\sqrt{3}}$

Cut-off frequency of TE_{10} mode, $f_{10} = \dfrac{c}{2a'} = 3\text{ GHz}$

Cut-off frequency of TM_{11} mode, $f_{11} = \dfrac{c}{2}\sqrt{\left(\dfrac{1}{a'}\right)^2 + \left(\dfrac{1}{b'}\right)^2} = \dfrac{c}{2}\sqrt{\left(\dfrac{1}{a'}\right)^2 + \left(\dfrac{\sqrt{3}}{a'}\right)^2} = \dfrac{c}{a'}$

So, $f_{11} = 2f_{10} = 6$ GHz

16. (a)

$$z_{in} = z_0\left[\frac{z_L + jz_0 \tan\beta l}{z_0 + jz_L \tan\beta l}\right]$$

For short circuited load, $z_L = 0$

$\therefore$ $z_{in} = jz_0 \tan \beta l$

17. (d)

$$d_{min} = \frac{2D^2}{\lambda} = \frac{2\times 2^2}{3\times 10^8}\times 3\times 10^9 = 80 \text{ m}$$

18. (d)

$$\frac{E^2}{2\eta} = \frac{G\times P_{rad}}{4\pi d^2}$$

$$E^2 = \frac{G\times P_{rad}\times 2\eta}{4\pi d^2} = \frac{10\times 10\times 10^3\times 2\times 120\pi}{4\pi(100)^2}$$

$$= 2\times 120\times 10/4 = 600(\text{V/m})^2$$

$$E = \sqrt{600} = 10\sqrt{6} \text{ V/m}$$

19. (b)

$$|J_d| = |J_c|$$

$$\sigma = \omega\varepsilon$$

or $\varepsilon_r = \dfrac{\sigma}{\omega\varepsilon_0} = \dfrac{\sigma}{2\pi f\varepsilon_0} = \dfrac{10}{2\pi\times 90\times 10^9\times \dfrac{10^{-9}}{36\pi}} = \dfrac{18}{9} = 2$

20. (b)

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{\sqrt{\varepsilon_{r_1}} - \sqrt{\varepsilon_{r_2}}}{\sqrt{\varepsilon_{r_1}} + \sqrt{\varepsilon_{r_2}}} = \frac{2-1}{2+1} = \frac{1}{3}$$

Power density for $z > 0$,

$$P_t = (1 - |\Gamma|^2)P_i = \left(1 - \frac{1}{9}\right) \times \frac{E_0^2}{2\eta_1}$$

$$\eta_1 = \frac{120\pi}{\sqrt{\varepsilon_{r_1}}} = \frac{120\pi}{2} = 60\pi\ \Omega$$

$$P_t = \frac{8}{9} \times \frac{1}{2} \times \frac{100}{60\pi} = 235.8\ \text{mW/m}^2$$

21. (b)

$$I_1 = 2I_2$$

and $V_2 = 0.125 I_2$

also, $V_1 = 0$

from Y-parameter model,

$$I_1 = Y_{11}V_1 + Y_{12}V_2$$
$$I_2 = Y_{21}V_1 + Y_{22}V_2$$

$\because$ $V_1 = 0$

$$Y_{22} = \frac{I_2}{V_2} = \frac{1}{0.125} = 8\ \mho$$

and $Y_{12} = \dfrac{I_1}{V_2} = \dfrac{2I_2}{0.125 I_2} = 16\ \mho$

22. (c)

The equivalent impedance seen w.r.t. the load terminals is

$$Z_{Th} = (3 + j2) \,||\, (4 - j3)$$

$$= \frac{18 - j}{7 - j} = \left(\frac{127}{50} + j\frac{11}{50}\right) = (2.54 + j0.22)\Omega$$

For maximum power transfer, $Z_L = Z_{Th}^* = (2.54 - j0.22)\Omega$

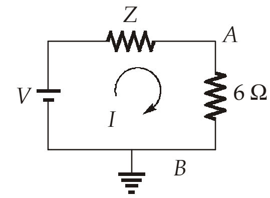
23. (c)

Using Millman's Theorem

$$V = \frac{\sum_{i=1}^{5} V_i Y_i}{\sum_{i=1}^{5} Y_i} = \frac{1\times 1 - 2\times\frac{1}{2} + 3\times\frac{1}{3} - 4\times\frac{1}{4} + 5\times\frac{1}{5}}{1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5}} = \frac{60}{137}\text{V}$$

and $Z_{eq} = \dfrac{1}{\Sigma Y} = \dfrac{1}{1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5}} = \dfrac{60}{137}\Omega$

$$\therefore \quad I = \frac{V}{Z+6} = \frac{\frac{60}{137}}{\frac{60}{137}+6} = \frac{60}{882}$$



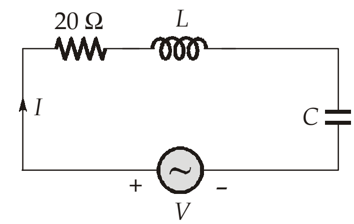
$$\therefore \quad V_{AB} = \frac{60}{882} \times 6 = \frac{60}{147} \text{ V}$$

24. (c)

According to the question,

$$R = 20\ \Omega,\ V = 25\ \text{V},\ f = 400\ \text{Hz}$$
$$I = 0.5\ \text{A and } V_C = 150\ \text{V}$$

when the current is maximum, means the circuit is in resonance.



$$\therefore \quad X_L = X_C$$

$$\therefore \quad X_C = \frac{V_C}{I} = \frac{150}{0.5} = 300\ \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi \times 400 \times C} = 300\ \Omega$$

or
$$C = \frac{1}{2\pi} \times \frac{1}{400 \times 300} = \frac{4.16}{\pi} \mu\text{F}$$

25. (a)

$$Q = \frac{f_r}{\text{BW}} = \frac{1}{2\xi}$$

26. (d)

$$\text{Total number of node pair voltages} = b = \frac{n(n-1)}{2}$$

$$66 = \frac{n(n-1)}{2}$$

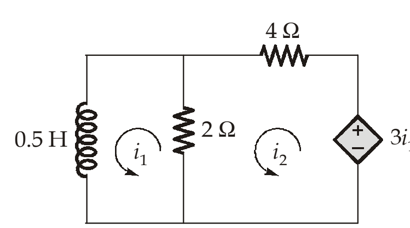
$$n^2 - n - 132 = 0$$

$$n = -11, 12$$

$$\therefore \quad \text{Total number of } f\text{-loop matrices} = b - n + 1 = 66 - (12) + 1 = 55$$

27. (d)

By applying KVL to the loop (1),



$$\frac{1}{2}\frac{di_1}{dt} + 2(i_1 - i_2) = 0$$

for loop (2),
$$i_2 = \frac{5}{6} i_1$$

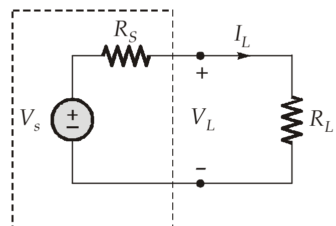
$$\therefore \quad \frac{di_1}{dt} + \frac{2}{3} i_1 = 0$$

or $$i_1(t) = i_1(0)e^{-2t/3} = 10e^{-2t/3} \text{ A ; for } t > 0$$

$$i_x(t) = i_2(t) - i_1(t) = \frac{5}{6}i_1(t) - i_1(t) = -\frac{1}{6}i_1(t)$$

$$= -\frac{10}{6}e^{-2t/3} = -\frac{5}{3}e^{-2t/3}\text{A ; for } t > 0$$

28. (b)



The terminal voltage when load is disconnected i.e., open circuited

$$V_s = V_{oc} = 12.5 \text{ V}$$

when the load is connected P_L = 2 W and V_L = 12 V

$$P_L = \frac{V_L^2}{R_L} \Rightarrow R_L = 72\ \Omega$$

The load current, $$I_L = \frac{V_L}{R_L} = \frac{12}{72} = \frac{1}{6}\text{A}$$

∴ $$12.5 - 12 \Rightarrow 0.5 = R_S\, I_L$$

$$R_S = 3\ \Omega$$

29. (a)

$$\phi_1 = \text{primary coil flux}$$

$$\phi_{12} = \text{mutual flux}$$

$$\phi_{12} = K\phi_1$$

or $$\phi_1 = \frac{\phi_{12}}{K} = \frac{0.7}{0.5} = 1.4 \text{ Wb}$$

∴ $$L_1 = \frac{N_1\phi_1}{I_1}$$

$$N_1 = \frac{L_1 I_1}{\phi_1} = \frac{5\times 70}{1.4} = \frac{5\times 700}{14} = 250$$

30. (c)

Let R be the value of one resistor,

∴ The power dissipated by combined resistor is,

$$P_1 = \frac{V^2}{4R} \qquad (\because R_{eq} = R + R + R + R = 4R)$$

$$\frac{V^2}{R} = 4 \times 25 = 100$$

When resistors are connected in parallel,

$$R_{eq} = \frac{1}{\frac{1}{R}+\frac{1}{R}+\frac{1}{R}+\frac{1}{R}} = \frac{R}{4}\,\Omega$$

$$P_2 = \frac{V^2}{R_{eq}} = \frac{V^2}{R}\times 4 = (100)\times 4 = 400\text{ W}$$

31. (a)

For parallel RLC circuit,

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

$\therefore$ $$\xi = \frac{1}{2Q} = \frac{1}{2R}\sqrt{\frac{L}{C}}$$

$\because$ $\xi = 1$ for critically damped response.

$\therefore$ $$R = \frac{1}{2}\sqrt{\frac{L}{C}} = \frac{1}{2}\sqrt{\frac{8}{2}} = 1\,\Omega$$

32. (c)

$$\frac{Y(s)}{U(s)} = \frac{\frac{1}{s^2}+\frac{1}{s}}{1+\frac{2}{s^2}+\frac{2}{s}+\frac{1}{s}+1} = \frac{\frac{s+1}{s^2}}{\frac{s^2+2+2s+s+s^2}{s^2}}$$

$$\frac{Y(s)}{U(s)} = \frac{s+1}{2s^2+3s+2}$$

33. (c)

Given, $$\frac{dx}{dt} = y \quad \text{...(i)}$$

$$\frac{dy}{dt} = -x \quad \text{...(ii)}$$

by differentiating equation (ii),

$$\frac{d^2y}{dt^2} = -\frac{dx}{dt} = -y$$

$$s^2Y(s) - y(0) = -Y(s)$$

$$s^2Y(s) + Y(s) = y(0)$$

$$Y(s)[s^2 + 1] = y(0)$$

$$Y(s) = \frac{y(0)}{s^2+1}$$

$\therefore$ The characteristic equation is $s^2 + 1 = 0$

$\therefore$ roots are $-j$, $+j$.

34. (b)

At each corner frequency, the slop changes are

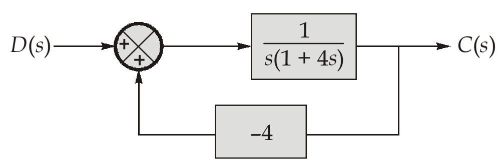
+40 dB/dec = 2 zeros
–20 dB/dec = 1 pole
+40 dB/dec = 2 zeros
–60 dB/dec = 3 poles
– 40 dB/dec = 2 poles
– 20 dB/dec = 1 pole
+40 dB/dec = 2 zeros

35. (c)

36. (c)

The steady state error is to be calculated due to $D(s)$ input, hence $R(s) = 0$.

The reduced block diagram is,



$$\frac{C(s)}{D(s)} = \frac{1}{s(1+4s)+4} = \frac{1}{4s^2+s+4}$$

$$D(s) = \frac{1}{s}$$

So,
$$C(s) = \frac{1}{s(4s^2+s+4)}$$

$$c(\infty) = \lim_{s\to 0} sC(s) = \frac{1}{4} = 0.25$$

$D(s)$ is a disturbance. So, the steady state error due to $D(s)$ will be 0.25.

37. (a)

$$\text{settling time} \propto \frac{1}{\xi\omega_n}$$

for system 1: $2\xi\omega_n = 5 \Rightarrow \xi\omega_n = 2.5$
for system 2: $2\xi\omega_n = 4 \Rightarrow \xi\omega_n = 2$
for system 3: $2\xi\omega_n = 3.6 \Rightarrow \xi\omega_n = 1.8$

- large value of $\xi\omega_n$ indicates small settling time.
- Hence, option (a) is correct.

38. (c)

Given, $\frac{C(s)}{R(s)} = \frac{16}{s^2 + 4.8s + 16} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$

here, $\omega_n = 4$ rad/s, $2\xi\omega_n = 4.8$

$\therefore$ $\xi = 0.6$

$$\text{peak time} = \frac{n\pi}{\omega_d} = \frac{n\pi}{\omega_n\sqrt{1-\xi^2}}$$

For overshoots, $n = 1, 3, 5, ...$

For undershoots, $n = 2, 4, 6, ...$

For third overshoot, $t_p = \frac{5\pi}{4\sqrt{1-0.6^2}} = \frac{25\pi}{16} \simeq 4.91$ sec

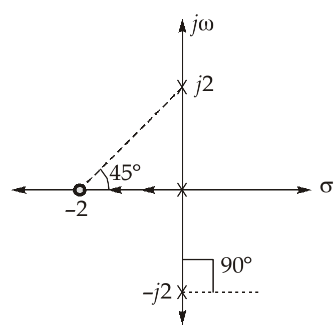
39. (c)

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

Here, $p = 3$, $z = 1$, $p - z = 2$

No. of branches of RL terminating at zero = 1

No. of branches of RL terminating at infinity = 2.



Here, two branches of RL has to terminate at infinity.

Thus, the two imaginary poles will terminate at infinity.

Hence, we need to find angle of departure for which we join all poles and zeros with the imaginary pole at $s = j2$.

Now, $\phi = \Sigma(\phi_z - \phi_p)$

$\Sigma\phi_z = 45°$

$\Sigma\phi_p = 90° + 90° = 180°$

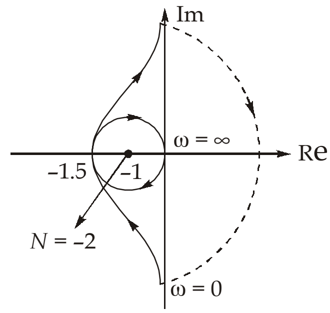
$\therefore$ $\phi = 45° - 180° = -135°$

$\therefore$ Angle of departure, $\phi_D = 180 + \phi$

$\therefore$ $\phi_D = 180° - 135° = 45°$

40. (b)

By drawing Nyquist plot from the given polar plot.



∴ Number of encirclements about $(-1 + j0) = -2$ and number of right sided poles in open-loop system $P = 0$.

∴
$$N = P - Z$$
$$-2 = 0 - Z$$
∴
$$Z = 2$$

∴ Closed loop system is unstable with two poles on the right half of s-plane.

41. (c)

The step response of the first system

$$c_1(t) = 0.5(1 + e^{-2t})u(t)$$

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

Now transfer function;

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

The impulse response of the another function,

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

Now, the overall response of the cascaded system,

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

42. (c)

Given,
$$h(t) = 25\, e^{-3t} \sin 4t,\ t \ge 0$$

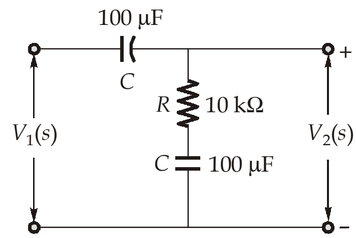
$$r(t) = u(t) \quad \Rightarrow \quad R(s) = \frac{1}{s}$$

$$\frac{C(s)}{R(s)} = H(s) = 25 \times \frac{4}{(s+3)^2 + 4^2} = \frac{100}{(s+3)^2 + 4^2}$$

$$\therefore \quad C(s) = \frac{100}{s\left((s+3)^2+16\right)}$$

$$\lim_{t\to\infty} c(t) = \lim_{s\to 0} sC(s) = \lim_{s\to 0} s \times \frac{100}{s\left((s+3)^2+16\right)} = \frac{100}{25} = 4$$

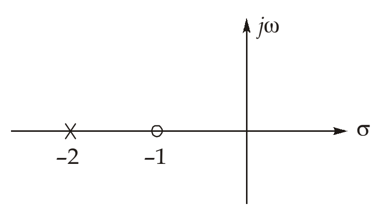
43. (b)



$$\frac{V_2(s)}{V_1(s)} = \frac{R+\frac{1}{sC}}{\frac{1}{sC}+R+\frac{1}{sC}} = \frac{1+RCs}{2+RCs}$$

$$= \frac{1+10\times10^3\times100\times10^{-6}s}{2+10\times10^3\times100\times10^{-6}s}$$

$$\frac{V_2(s)}{V_1(s)} = \frac{1+s}{2+s} = \frac{1+\tau s}{1+\alpha\tau s}$$



Clearly, given one is phase lead compensator.

$$\text{maximum phase lead, } \phi_m = \sin^{-1}\left[\frac{1-\alpha}{1+\alpha}\right]$$

where; $\alpha = \frac{1}{2}$

$$\therefore \quad \phi_m = \sin^{-1}\left[\frac{1}{3}\right] = 19.47°$$

44. (b)

When we apply sinusoidal waves on both X and Y plates, then pattern is Lissajous figure.
When phase difference is zero between them then we get a straight line inclined at 45°, in other cases ellipse is formed.

45. (b)

The resonance occurs in Q-meter at an angular frequency, $\omega = \dfrac{1}{\sqrt{LC}}$

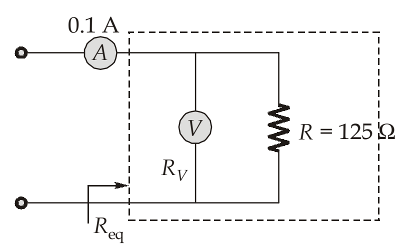
$$10^6 = \frac{1}{\sqrt{L \times 50 \times 10^{-12}}}$$

$$(10^6)^2 = \frac{1}{L \times 50 \times 10^{-12}}$$

$$\therefore \quad L = \frac{1}{50 \times 10^{-12} \times 10^{12}} = \frac{1}{50} \text{ H}$$

$$\therefore \quad L = 20 \text{ mH}$$

46. (d)



$$\text{equivalent resistance, } R_{eq} = R_V \parallel R$$

$$R_{eq} = \frac{R_V \times 125}{R_V + 125}$$

given voltmeter reads, 10 V

i.e., $\quad 0.1 \times R_{eq} = 10 \text{ V}$

$$0.1 \times \frac{125 R_V}{125 + R_V} = 10$$

$$125\, R_V = 100\, (125 + R_V)$$

$$125\, R_V = 12500 + 100\, R_V$$

$$25\, R_V = 12500$$

$$R_V = 500\ \Omega$$

47. (c)

$$\text{Error} = 30 \times \frac{1.2}{100} = 0.36$$

$$\%\text{ limiting error} = \frac{0.36}{10} \times 100\% = 3.6\%$$

48. (a)

$$\text{Unknown resistance, } R_x = \frac{R_2 R_3}{R_1}$$

$$R_x = \frac{1000 \times 500}{100} = 5000\ \Omega$$

Relative limiting error of unknown resistance,

$$\frac{\delta R_x}{R_x} = \pm\left(\frac{\delta R_2}{R_2}+\frac{\delta R_3}{R_3}+\frac{\delta R_1}{R_1}\right) = \pm(0.5 + 0.5 + 1)\% = \pm 2\%$$

$$\text{limiting error in ohms} = \pm\frac{2}{100}\times 5000 = \pm 100\ \Omega$$

∴ Guaranteed values of resistance are in between: 5000 – 100 = 4900 Ω and 5000 + 100 = 5100 Ω

49. (c)

The resistance of the potentiometer at its normal position = $\frac{10000}{2} = 5000\ \Omega$

Resistance of potentiometer per unit length = $\frac{10000}{25} = 400\ \Omega/\text{mm}$

Change of resistance from its normal position = 5000 – 4500 = 500 Ω

∴ linear displacement of potentiometer from its normal position = $\frac{500}{400} = 1.25\ \text{mm}$

50. (b)

51. (b)

Bellows are not suitable for dynamic pressure measurement.

52. (c)

Torque produced by MI instrument,

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

given, I = 10 A; T = 200 μN-m = 200 × 10^{-6} N-m

$$200\times 10^{-6} = \frac{1}{2}\times 10^2\times\frac{dL}{d\theta}$$

∴ Rate of change of self-inductance,

$$\frac{dL}{d\theta} = 4\ \mu\text{H/radian}$$

53. (d)

54. (a)

55. (c)

56. (a)

Statements 1 and 2 are correct.

Statement 3 is incorrect.

GaAs is a III-V compound semiconductor. When group IV atoms (like Si and Ge) are added to GaAs, they act as donors when they are built into the sites of Ga and they act as acceptors when they are built into the sites of As.

57. (d)

$$\eta = \frac{I_L / q}{P_{\text{in}} / h\nu} = \frac{I_L \times h\nu}{P_{\text{in}} \times q}$$

Units : $I_L \to$ A, $q \to$ C, $P_{\text{in}} \to$ W, $h\nu \to$ J

$$h\nu = 2 \text{ eV} = 2 \times 1.6 \times 10^{-19} \text{ J}$$

$$q = 1.6 \times 10^{-19} \text{ C}$$

$$\eta = \frac{I_L(2 \times 1.6 \times 10^{-19})}{P_{\text{in}}(1.6 \times 10^{-19})} = \frac{I_L(2)}{P_{\text{in}}}$$

$$I_L = \frac{\eta \times P_{\text{in}}}{2} = \frac{0.8 \times 10}{2} \text{ mA} = 4 \text{ mA}$$

58. (a)

59. (a)

There is no depletion region when MOS interface is in accumulation mode.

$W_{\text{dep}} \propto (\phi_s)^{1/2}$ in depletion mode of operation.

and $$W_{d\max} = \left[\frac{2\varepsilon_s 2\phi_B}{qN_a}\right]^{1/2}$$

$W_{d\max}$ is constant in inversion region where ϕ saturates at $2\phi_B$.

60. (d)

61. (c)

$$I_{D(\text{sat})} = \frac{\mu_n C_{ox} W}{2L}(V_{GS} - V_T)^2$$

$$W = \frac{2LI_{D(\text{sat})}}{\mu_n C_{ox}(V_{GS} - V_T)^2} = \frac{2 \times 1.25 \times 4 \times 10^{-3}}{500 \times 8 \times 10^{-8} \times (6-1)^2} \mu\text{m}$$

$$= \frac{10 \times 10^5}{4000 \times 25} = 10 \ \mu\text{m}$$

62. (b)

63. (c)

The conduction angle, $$\omega \Delta t = \sqrt{\frac{2 \times V_r}{V_P}} = \sqrt{\frac{2 \times 2}{110}} = 0.1907 \text{ rad}$$

diode conducts for $\dfrac{0.1907}{2\pi} \times 100 = 3.035\%$ of the cycle.

64. (c)

65. (d)

66. (a)

For sustained oscillations the magnitude of gain must be at least equal to $\frac{C_2}{C_1}$ and since gain must be greater than unity,

$$\text{required gain} = \frac{10 \times 10^{-9}}{1 \times 10^{-9}} = 10$$

67. (c)

Duty cycle of the given circuit (Astable multivibrator with 555 IC),

$$\text{Duty cycle} = \frac{T_H}{T_H + T_L} = \frac{R_A + R_B}{R_A + 2R_B}$$

Hence capacitor has no effect on duty cycle.

68. (c)

Since $V_f = \beta I_0$; this is a transconductance amplifier.

For a transconductance amplifier,

$$R_{if} = (1 + A\beta)R_{in} \Rightarrow \text{voltage mixing}$$
$$R_{of} = (1 + A\beta)R_{out} \Rightarrow \text{current sampling}$$

69. (b)

$\because$ V_{out} is 12 V peak to peak,

$$V_{max} = 6 \text{ V}$$

$$\eta = \frac{1}{2}\frac{V_0^2}{I_C R_L V_{CC}} \times 100\% = \frac{1}{2} \times \frac{36}{72 \times 10^{-3} \times 100 \times 12} \times 100\%$$

$$\Rightarrow \quad \eta = 20.8\%$$

70. (a)

For the differential amplifier.

Input resistance = $2r_\pi$

where $$r_\pi = \frac{V_T}{I_B}$$

$$I_B = \frac{I_E}{1+\beta}$$

Since $$I_E = \frac{0.8}{2} = 0.4 \text{ mA}$$

$$I_B = \frac{0.40 \text{ mA}}{100}$$

$$r_\pi = \frac{25 \times 10^{-3}}{0.4 \times 10^{-5}}$$

$$r_i = 2r_\pi = 12.5 \text{ k}\Omega$$

71. (a)

$$V_B = 10\text{ V}$$
$$V_E = 10 - 0.7\text{ V} = 9.3\text{ V}$$

$\Rightarrow$ $$I_E = \frac{9.3}{10} = 0.93\text{ mA}$$

$\Rightarrow$ $$I_B = \frac{0.93}{100} = 9.3\ \mu\text{A}$$

Since $$I_{100\text{ k}\Omega} = \frac{20-10}{100} = 0.1\text{ mA} = 100\ \mu\text{A}$$
$$I_{\text{diode}} = 100 - 9.3 = 90.7\ \mu\text{A}$$

72. (a)

$$10.7 = 0.7 + I_B R_B$$
$$I_B = \frac{10}{100\text{k}} = 0.1\text{ mA}$$
$$I_C = \beta I_B = 100 \times 0.1\text{ mA} = 10\text{ mA}$$
$$I_C R_C = V_0$$
$$R_C = \frac{V_0}{I_C} = \frac{5\times 10^3}{10} = 500\ \Omega$$

73. (c)

From the circuit, if 'D_1' is 'ON' Kirchoff's laws are not satisfied

$\therefore$ D_1 is OFF and D_2 is ON

$\therefore$ $$I_1 = 0\text{ mA}$$

74. (b)

V_1	V_2	M_1	M_2	M_3	M_4	Y
0	0	OFF	OFF	ON	ON	V_{DD}
0	V_{DD}	OFF	ON	OFF	ON	0
V_{DD}	0	ON	OFF	ON	OFF	0
V_{DD}	V_{DD}	ON	ON	OFF	OFF	0

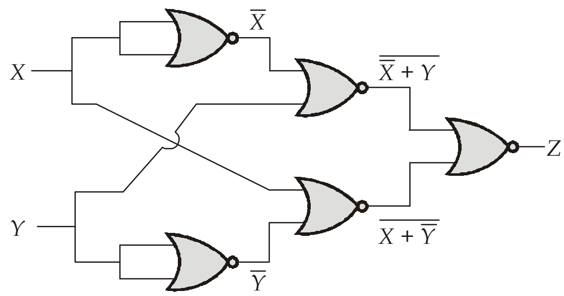
Thus, the given CMOS circuit satisfies the functions of a positive logic NOR gate.

75. (c)

Since

$$S_1 = A$$
$$S_0 = B$$
$$Y = \bar{S}_1 \bar{S}_0 I_0 + \bar{S}_1 S_0 I_1 + S_1 \bar{S}_0 I_2 + S_1 S_0 I_3$$
$$= \bar{A}\bar{B}A + \bar{A}BB + A\bar{B}A + ABB$$
$$= 0 + \bar{A}B + A\bar{B} + AB$$
$$= A + \bar{A}B = A + B \quad \Rightarrow \quad \text{OR gate}$$

76. (d)



$$Z = \overline{\overline{\bar{X} + Y} + \overline{X + \bar{Y}}}$$

$$= \overline{\overline{\bar{X} + Y}} \cdot \overline{\overline{X + \bar{Y}}}$$

$$= (\bar{X} + Y)(X + \bar{Y})$$

$$Z = \bar{X}\bar{Y} + XY \quad \Rightarrow \quad \text{XNOR gate}$$

77. (c)

$$(55)_{10} - (55)_{16} = (55)_{10} - (85)_{10} = (-30)_{10}$$

$$(30)_{10} \rightarrow (011110)_2$$

In 2's complement representation,

$$(-30)_{10} \rightarrow (100010)_2$$

78. (b)

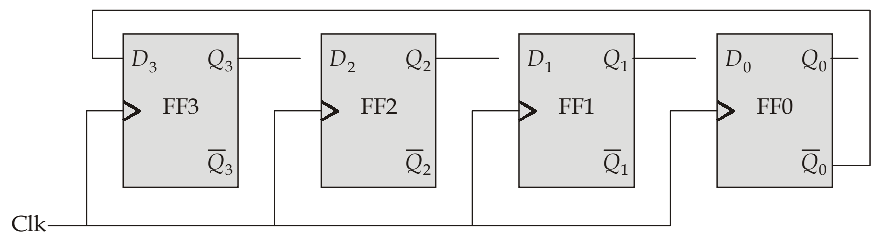
There is an ambiguity, when all outputs of encoder are equal to zero because it could be the code corresponding to the inputs, when only least significant input is one or when all inputs are zero.

79. (a)

Present state	Inputs		Next state
S	X	Y	S^+
0	X	0	1
0	X	1	0
1	0	X	0
1	1	X	1

$\therefore$ $$S^+ = \bar{S}\bar{Y} + SX$$

80. (d)



Clock	$D_3 = \overline{Q}_0$	Q_3	Q_2	Q_1	Q_0	
		0	**0**	**0**	**0**	← initial state
1	1	1	0	0	0	← 8
2	1	1	1	0	0	← 12
3	1	1	1	1	0	← 14
4	1	1	1	1	1	← 15
5	0	0	1	1	1	← 7
6	0	0	0	1	1	← 3
7	0	0	0	0	1	← 1
8	0	0	0	0	0	← 0

Hence, the switching sequence is : 0, 8, 12, 14, 15, 7, 3, 1, 0

81. (d)

82. (d)

- The impulse noise voltage is directly proportional to the bandwidth.
- The industrial noise is usually of the impulse type.

83. (a)

$$P_{SSB} = \frac{P_C \mu^2}{4} = 0.5 \text{ kW}$$

$$P_C = \frac{4 \times 0.5}{(0.8)^2} = 3.125 \text{ kW}$$

84. (b)

85. (c)

$$s(t) = \cos(200\pi t)\cos(5\sin 2\pi t) - \sin(200\pi t)\sin(5\sin 2\pi t)$$

$$= \cos[200\pi t + 5\sin 2\pi t]$$

$$\theta(t) = 200\pi t + 5\sin 2\pi t$$

$$f_i = \frac{1}{2\pi}\frac{d\theta(t)}{dt} = [100 + 5\cos(2\pi t)] \text{ Hz}$$

86. (c)

87. (b)

The minimum channel bandwidth required to transmit a signal shaped by a raised cosine filter with a roll-off factor of 'α' will be,

$$(BW)_{min} = \frac{R_b}{2}(1+\alpha) = \frac{200}{2}(1+0.25) \text{ kHz}$$

$$= 100\ (1.25) \text{ kHz} = 125 \text{ kHz}$$

88. (c)

For an M-ary QAM, $E_{avg} = \frac{2}{3}(M-1)E_0$

M = 16 for 16-ary QAM.

So, $E_{avg} = \frac{2}{3}(16-1)E_0 = 10E_0$

89. (a)

The entropy of a Gaussian random variable is independent of its mean value.

$$h(X) = \frac{1}{2}\log_2(2\pi e\sigma^2)$$

90. (c)

$$R_X(\tau) = E[X(t)\ X(t+\tau)]$$

$$R_Y(\tau) = E[Y(t)\ Y(t+\tau)] = E[2X(3t+4)\ 2X(3t+3\tau+4)]$$

$$= 4E[X(3t+4)\ X(3t+3\tau+4)]$$

$$R_Y(\tau) = 4R_X(3\tau)$$

91. (b)

In class B total 2^{14} addresses are possible.
Class A : 1.X.X.X to 126.X.X.X
Class B : 128.0.X.X to 191.255.X.X
Class C: 192.0.0.X to 223.255.255.X

92. (b)

ICMP cannot be used for error correction, it only detects error, and it cannot be used for special purpose addresses.

93. (a)

94. (b)

Since coupling efficiency $= (NA)^2 = (\sin 30°)^2 = 0.25$

Power coupled in the fiber $= 1.2 \times 10^{-3} \times 0.25 = 0.3$ mW

95. (a)

96. (c)

Maximum value of normalized frequency for graded index fiber for single mode operation will be

$$V = 2.405\left(1+\frac{2}{\alpha}\right)^{\frac{1}{2}} = 2.405\left(1+\frac{2}{2}\right)^{\frac{1}{2}} \qquad (\because \alpha = 2)$$

$$= 2.405 \times 1.41$$

$$\text{the maximum core radius} = a = \frac{V\lambda}{2\pi(\text{NA})} = \frac{V\lambda}{2\pi n_1 (2\Delta)^{1/2}} = \frac{2.405 \times 1.41 \times 1.3 \times 10^{-6}}{2\pi \times 1.5 \times (0.02)^{1/2}}$$

$$a = 3.3\ \mu\text{m}$$

Core diameter, $2a = 6.6\ \mu\text{m}$

97. (a)

Since $E_b = P_t T_b$

$$\Rightarrow \quad 10 \log E_b = 10 \log P_t + 10 \log T_b$$
$$= 10 \log P_t - 10 \log f_b$$
$$= 10 \log 1000 - 10 \log (50 \times 10^6)$$
$$= 30 - 10 \log 50 - 60$$
$$= 30 - 10 \log 100 + 10 \log 2 - 60$$
$$= 30 - 20 - 60 + 3$$
$$= -47 \text{ dBW/bps}$$

98. (d)

99. (a)

$$\phi = (7-1) \times (11-1) = 60$$

If private key = e; public key = p then $(e \times p) \bmod \phi = 1$.

So, $e_{\min} = 43$

100. (a)

UHF frequency range is 300 MHz - 3 GigaHz. Space wave propagation is used for transmission of these frequency ranges.

101. (b)

$$\text{number of cells in a cluster} = i^2 + j^2 + ij$$
$$3^2 + 3^2 + 3 \times 3 = 27$$

102. (d)

103. (a)

104. (c)

$$S_{\max} = \frac{t_n}{t_p} = \frac{50\text{ ns}}{10\text{ ns}} = 5$$

105. (b)
USB supports data transfer at different rates.

106. (a)

107. (b)

108. (c)

109. (d)

110. (c)
Using Gantt chart,

A	B	A	B	C	D	B	C

0 2 4 5 7 9 11 13 15

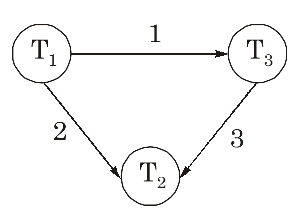
$$\text{Average turnaround time} = \frac{(5-0)+(13-1)+(15-4)+(11-6)}{4}\text{ms}$$
$$= \frac{5+12+11+5}{4} = \frac{33}{4} = 8.25 \text{ ms}$$

111. (c)
logical address space contains 256 = 2^8 pages
Page size = 2^{10} bytes
size of logical address space = $2^8 \times 2^{10} = 2^{18}$ bytes
So, a logical address contain 18 bits.

112. (b)
Let, the maximum page fault be "p".
$[(1 - p) \times 100 \text{ ns}] + p[(0.8 \times 10 \text{ µs})] + (0.2 \times 500 \text{ ns})] = 200 \text{ ns}$
$[(1 - p)100] + p[8000 + 100] = 200$
$p[8000 + 100 - 100] = 200 - 100 = 100$
$$p = \frac{100}{8000} = \frac{1}{80} = 0.0125 \quad \text{(or)} \quad 1.25\%$$

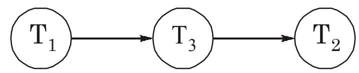
113. (b)
fun1(435)
$(435)_{10} = (1\ 1\ 0\ 1\ 1\ 0\ 0\ 1\ 1)_2$
So, count value 9. i.e., the number of bits in the binary code.

114. (a)
By using the precedence graph we solve this problem



1. Read (x) in T_1 is followed by write (x) in T_2
2. Read (x) in T_1 is followed by write (x) in T_3
3. Read (y) in T_3 is followed by write (y) in T_2

So it in clear from precedence graph



115. (c)

Statement 1 true.

To check the validity of statement 2 taking an example:

Consider a system $H(s) = \frac{e^s}{s+1} R_e\{s\} > -1$

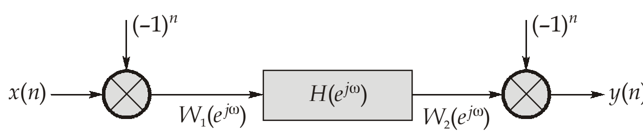
ROC for this system is right of right most pole.

but $$\frac{e^s}{s+1} \xrightarrow{ILT} e^{-(t+1)}u(t+1)$$

which is not a causal system.

116. (a)

117. (d)



$$w_1(n) = x(n) \times (-1)^n$$
$$w_1(n) = e^{j\pi n}\, x(n) \qquad [\because (-1)^n = e^{j\pi n}]$$
$$\Rightarrow \quad W_1(e^{j\omega}) = X(e^{j(\omega - \pi)})$$
$$W_2(e^{j\omega}) = H(e^{j\omega})X(e^{j(\omega - \pi)})$$

also,
$$y(n) = (-1)^n w_2(n)$$
$$\Rightarrow \quad y(n) = e^{j\pi n} w_2(n)$$
$$\Rightarrow \quad Y(e^{j\omega}) = W_2(e^{j(\omega-\pi)})$$
$$\Rightarrow \quad Y(e^{j\omega}) = H(e^{j(\omega - \pi)})\ X(e^{j(\omega - 2\pi)})$$
$$\Rightarrow \quad Y(e^{j\omega}) = H(e^{j(\omega - \pi)}\ X(e^{j\omega})$$

Where $H(e^{j(\omega - \pi)})$ will be a high pass filter.

118. (c)

119. (b)

120. (d)

121. (b)

122. (c)

The given state diagram is an example of serial adder.

123. (c)

After "XRA A", the content of the accumulator (A) will be "00H" and zero flag will set, irrespective of the initial content of A.

So, the instruction stored at the location "LOOP" will be executed only for one time.

124. (d)

125. (a)

Given,

$$\mu_r = 50$$

$$\mu_0 = 4\pi \times 10^{-7}$$

We know that, $\mu = \mu_0\mu_r$

Cross-section area, $A = 5\text{ cm}^2 = 5 \times 10^{-4}\text{ m}^2$

Core length, $l = 25\text{ cm} = 25 \times 10^{-2}\text{ m}$

Now, $$\text{Reluctance} = \frac{l}{\mu_0\mu_r A} = \frac{25\times10^{-2}}{4\pi\times10^{-7}\times50\times5\times10^{-4}}$$

Also, $$\text{Flux} = \frac{\text{mmf}}{\text{Reluctance}}$$

$$= \frac{500\times4\pi\times10^{-7}\times50\times5\times10^{-4}}{25\times10^{-2}}$$

$$= 0.628 \times 10^{-4}\text{ Wb} = 0.0628\text{ mWb} \approx 0.06\text{ mWb}$$

126. (b)

Mutual inductance between two circuits can be increased by increasing the permeance (or) decreasing the reluctance offered to the mutual flux.

127. (c)

Proportion of full load at maximum efficiency,

$$x = \sqrt{\frac{P_i}{P_{cu(fl)}}} = \sqrt{\frac{600}{900}} = 0.8164 = 81.64\%$$

128. (c)

$$N_s = \frac{120f}{P} = \frac{120\times50}{8} = 750\text{ rpm}$$

$$s = \frac{N_s - N_r}{N_s} = \frac{750-710}{750} = 0.053$$

Electrical power input, P_i = 35 kW

Stator copper loss = 1.0 kW

Power across air gap, $P_g = P_{\text{input}}$ – Stator copper loss

= 35 – 1 = 34 kW

$$P_m = (1 - s)P_g$$

$$= (1 - 0.053) \times 34$$

$$= 32.186\text{ kW}$$

129. (b)

- As mutual flux remains practically constant, hence when air-gap length is increased, the magnetizing current will increase.
- With increased air gap length, stator winding and rotor winding get away from each other hence leakage flux is increased.

130. (a)

Let, synchronous speed of motor $= N_{sm}$

Also, $$N_{sm} = \frac{120 \times f_m}{P_m}$$

$\therefore$ $$N_{sm} = \frac{120 \times 60}{P_m}$$

Synchronous speed of alternator,

$$N_{sg} = \frac{120 \times f_g}{P_g} = \frac{120 \times 25}{20} = 150 \text{ rpm}$$

Since alternator and motor are directly coupled

$$N_{sg} = N_{sm}$$

(or) $$150 = \frac{120 \times 60}{P_m}$$

$\Rightarrow$ $$P_m = 48$$

131. (a)

Wound-motor construction requires slip rings, brushes, short circuiting devices etc. As a result of it, wound rotor motor is costlier than a cage induction motor.

132. (c)

All statements are correct.

133. (a)

Commutation can be improved by increasing the brush contact resistance. This causes more voltage drop at the brush bar contacts as compared with the reactance voltage and commutation is improved.

134. (b)

$$\text{Back emf, } E_b = \frac{P\phi NZ}{60A}$$

($A = P$ for lap winding)

$$= \frac{0.6 \times 10^{-3} \times 750 \times 2000}{60} = 15 \text{ V}$$

135. (c)

Given, terminal voltage $= 250$ V

Flux per pole, $\phi = 10 \times 10^{-3}$ Wb

No. of conductors, $Z = 600$,

$$P = 4,$$
$$A = 2$$
$$\text{Back emf, } E_b = \frac{P\phi NZ}{60A},$$
$$\text{Since motor output, } P_{out} = 5 \times 10^3 \text{ W},$$
$$\text{Power developed} = E_b \times I_a$$
$$\therefore \quad E_b = \frac{5\times10^3}{I_a} = \frac{5\times10^3}{50} = 100 \text{ V}$$
$$N = \frac{100\times60\times2}{10\times10^{-3}\times600\times4} = 500 \text{ rpm} = \frac{500}{60}\text{rps}$$
$$\text{Power} = \text{Torque} \times \text{Speed}$$
$$\Rightarrow \quad \text{Torque} = \frac{5\times1000\times60}{2\pi\times500} = 95.49 \text{ Nm}$$

136. (b)

137. (c)

As the permanent dipoles are absent in diamagnetic materials, it cannot be made magnets.
In antiferromagnetic materials, the magnetic moments of equal magnitude are aligned in opposite directions.

138. (d)

Laplacian operator ∇^2 of a scalar function ϕ can be defined as $\nabla \cdot \nabla\phi$ i.e., divergence of the gradient of the scalar ϕ.

139. (c)

When two ideal voltage sources are connected in parallel, KVL violation occurs.

140. (d)

We know that, $Q = \frac{\omega L}{R}$ with Q meter resistance considered, the measured or indicated Q is $\frac{1}{1.1}$ times the actual Q.

141. (a)

142. (c)

Avalanche breakdown diode has positive temperature coefficient. To compensate the effect of temperature, a forward biased diode is connected in series.
For Si diode if temperature increases by 1°C then forward voltage decreases by 1.7 mV.
Hence, to achieve temperature compensation breakdown voltage should increase by 1.7 mV/°C.

143. (b)

144. (d)

The coding efficiency with Huffman coding will not be 100% all the time, even though the source is producing the equiprobable symbols.

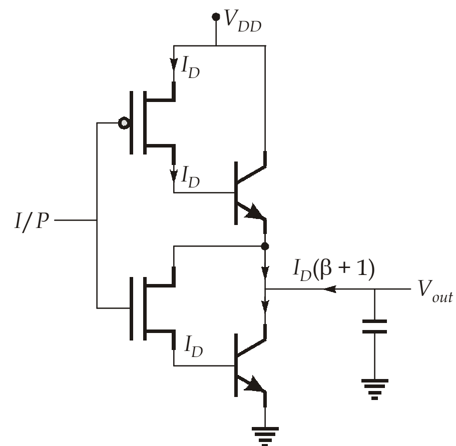
145. (b)

146. (a)

147. (b)

148. (a)

BiCMOS circuit:



149. (a)

Both statements are correct and statement-II is the correct explanation of statement-I.

150. (d)

❍❍❍❍