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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 14

Section A : Electromagnetics + Computer Organization and Architecture

Section B : Analog Circuits-1 + Electronic Measurements and Instrumentation-1

Section C : Signals & Systems-2 + Basic Electrical Engineering-2

1.	**(a)**	**16.**	**(c)**	**31.**	**(b)**	**46.**	**(b)**	**61.**	**(c)**
2.	**(a)**	**17.**	**(d)**	**32.**	**(a)**	**47.**	**(*)**	**62.**	**(d)**
3.	**(b)**	**18.**	**(c)**	**33.**	**(d)**	**48.**	**(d)**	**63.**	**(c)**
4.	**(a)**	**19.**	**(a)**	**34.**	**(a)**	**49.**	**(b)**	**64.**	**(a)**
5.	**(b)**	**20.**	**(c)**	**35.**	**(d)**	**50.**	**(c)**	**65.**	**(a)**
6.	**(d)**	**21.**	**(d)**	**36.**	**(b)**	**51.**	**(b)**	**66.**	**(a)**
7.	**(d)**	**22.**	**(c)**	**37.**	**(c)**	**52.**	**(b)**	**67.**	**(c)**
8.	**(a)**	**23.**	**(d)**	**38.**	**(c)**	**53.**	**(d)**	**68.**	**(b)**
9.	**(b)**	**24.**	**(b)**	**39.**	**(b)**	**54.**	**(d)**	**69.**	**(b)**
10.	**(b)**	**25.**	**(d)**	**40.**	**(c)**	**55.**	**(d)**	**70.**	**(c)**
11.	**(a)**	**26.**	**(b)**	**41.**	**(d)**	**56.**	**(d)**	**71.**	**(c)**
12.	**(a)**	**27.**	**(b)**	**42.**	**(c)**	**57.**	**(d)**	**72.**	**(d)**
13.	**(c)**	**28.**	**(c)**	**43.**	**(a)**	**58.**	**(b)**	**73.**	**(b)**
14.	**(a)**	**29.**	**(d)**	**44.**	**(a)**	**59.**	**(c)**	**74.**	**(b)**
15.	**(c)**	**30.**	**(c)**	**45.**	**(b)**	**60.**	**(a)**	**75.**	**(c)**

Note: Answer key of Q.47 has been updated. (*) Indicates marks to all.

Detailed Explanation
Section A : Electromagnetics + Computer Organization and Architecture

1. (a)

From Maxwell's equation,

$$\nabla\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$$

$$\int_S(\nabla\times\vec{E})\cdot\vec{ds} = -\frac{\partial}{\partial t}\int_S\vec{B}\cdot\vec{ds}$$

$$\oint_L\vec{E}\cdot\vec{dl} = -\frac{\partial}{\partial t}\int_S\vec{B}\cdot\vec{ds} = \mu\left[-\frac{\partial}{\partial t}\int_S\vec{H}\cdot\vec{ds}\right]$$

So, option (a) is incorrect.

2. (a)

Loss tangent,
$$\tan\delta = \frac{\sigma}{\omega\varepsilon} = \frac{10^{-4}}{2\pi\times2.5\times10^6\times\frac{10^{-9}}{36\pi}\times3.6} = \frac{1}{5} = 0.2$$

3. (b)

$$D = \frac{4\pi}{\lambda^2}\times A_{\text{eff}}$$

$$A_{\text{eff}} = \frac{\lambda^2}{4\pi}\times D = \frac{\lambda^2}{4\pi}\times4\pi\left(\frac{d}{\lambda}\right)^2$$

$$A_{\text{eff}} = (d)^2 = 10\times10 = 100\text{ m}^2$$

4. (a)

For TE_{01} mode
$$f_c = \frac{c}{2b} = \frac{3\times10^{10}}{2b}$$

and
$$f = 30\text{ GHz} = 30\times10^9 = 3\times10^{10}\text{ Hz}$$

$\because$
$$\lambda_g = \frac{\lambda_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$\therefore$
$$0.8 = \sqrt{1-\left(\frac{f_c}{f}\right)^2} = \sqrt{1-\left(\frac{3\times10^{10}}{2b\times3\times10^{10}}\right)^2}$$

$$(0.8)^2 = 1-\left(\frac{1}{2b}\right)^2$$

$\Rightarrow$
$$0.36 = \left(\frac{1}{2b}\right)^2$$

$$\frac{1}{2b} = \sqrt{0.36} = 0.6$$

or $$b = \frac{1}{1.2} = 0.83 \text{ cm}$$

5. (b)

Charge stored on a metallic sphere is

$$Q = CV$$

where $$C = 4\pi\varepsilon r$$

$\therefore$ $$Q_1 = 4\pi\varepsilon_0 r_1 V_1$$

and $$Q_2 = 4\pi\varepsilon_0 r_2 V_2$$

or $$\frac{Q_1}{Q_2} = \frac{r_1}{r_2} \qquad (\because V_1 = V_2)$$

$\because$ $$\left(\frac{r_1}{r_2}\right)^2 = 16$$

$\therefore$ $$\frac{Q_1}{Q_2} = \frac{r_1}{r_2} = 4$$

6. (d)

7. (d)

$$\text{Phase difference} = \frac{2\pi}{\lambda} \times \text{path difference} = \frac{2\pi}{\lambda} \times 6 \times 10^{-3}$$

$$\lambda = \frac{v_p}{f} = \frac{c/\sqrt{\varepsilon_r}}{f} = \frac{3 \times 10^8}{10^{10} \times 2.5} = \frac{3}{250} \text{m}$$

$\therefore$ $$\text{Phase difference} = \frac{2\pi \times 250}{3} \times 6 \times 10^{-3}$$

$$= 4\pi \times 250 \times 10^{-3} = \pi \text{ radians}$$

8. (a)

$$v_p = \frac{1}{\sqrt{\mu\varepsilon}} = \frac{c}{\sqrt{\mu_r \varepsilon_r}} = \frac{3 \times 10^8}{\sqrt{36}}$$

$$= \frac{3 \times 10^8}{6} = 5 \times 10^7 \text{ m/s}$$

Also, $$\omega = \pi \times 10^8 \text{ rad/sec} \quad \text{(given)}$$

$\therefore$ $$\beta = \frac{\omega}{v_p} = \frac{\pi \times 10^8}{5 \times 10^7} = 2\pi \text{ rad/m}$$

9. **(b)**

$$\frac{E_r}{E_i} = \frac{-H_r}{H_i} = \Gamma = \frac{Z_2 - Z_1}{Z_2 + Z_1} = \frac{\frac{Z}{2} - Z}{\frac{Z}{2} + Z} = \frac{-\frac{1}{2}}{\frac{3}{2}} = -\frac{1}{3}$$

So, $$\frac{E_i}{E_r} = -3 \text{ and } \frac{H_i}{H_r} = 3$$

10. **(b)**

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

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

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

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

11. **(a)**

According to the Gauss's law

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

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

As the charge density is zero for $r < 2$ m,

∴ $$Q_{\text{enclosed}} = 0$$

∴ $$\vec{E} = 0$$

12. **(a)**

$\vec{F}$ and $(\nabla \times \vec{F})$ are mutually orthogonal.

So, $$\vec{F}\cdot(\nabla \times \vec{F}) = 0$$

13. **(c)**

$$\vec{E}\times\vec{H} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ 4 & -2 & 2 \\ -6 & 8 & -3 \end{vmatrix}$$

$$= (6-16)\hat{a}_x - (-12+12)\hat{a}_y + (32-12)\hat{a}_z$$

or $$= -10\hat{a}_x + 20\hat{a}_z$$

$$\left|\vec{E}\times\vec{H}\right| = \sqrt{(10)^2+(20)^2} = \sqrt{500} = 10\sqrt{5}\ \text{kW/m}^2$$

∴ Time averaged power density,

$$P = \frac{1}{2}\times 10\sqrt{5} = 5\sqrt{5}\ \text{kW/m}^2$$

14. (a)

1. $\vec{E} = -\nabla V = -\text{Grad } V$
2. Electric field due to a finite line of charge at a point depends upon the length of the line charge.
3. The direction of the electrostatic potential gradient at a point is opposite to the direction of the electric field at that point.
4. Electric field at a point due to an infinite line of charge is given by

$$E = \frac{\rho_L}{2\pi\varepsilon R}$$

$$\therefore \quad E \propto \frac{1}{R}$$

15. (c)

Since the line is lossless and Z_0 and Z_L ($Z_L > Z_0$) are real,

$$S = \frac{Z_L}{Z_0} = \frac{100}{50} = 2$$

$$\therefore \quad Z_{\text{max}} = Z_0 \times S = 50 \times 2 = 100\ \Omega$$

and $$Z_{\text{min}} = \frac{Z_0}{S} = \frac{50}{2} = 25\ \Omega$$

16. (c)

The capacitance of a isolated spherical capacitor of radius R is,

$$C = 4\pi\varepsilon_0 R$$

Since the two spheres are identical and separated by a distance very much larger than R, it can be assumed as the series combination of capacitances.

∴ net capacitance between two sphere is given by,

$$C = \frac{C_1C_2}{C_1+C_2} = \frac{4\pi\varepsilon_0 R\times 4\pi\varepsilon_0 R}{4\pi\varepsilon_0 R+4\pi\varepsilon_0 R} = 2\pi\varepsilon_0 R$$

17. (d)

Emf induced in a loop carrying a time varying magnetic flux ϕ is,

$$V_{\text{emf}} = -\frac{d\phi}{dt} = -\frac{d}{dt}\left(-\frac{1}{8}Kt^2\right) = \frac{2}{8}Kt$$

at $t = 5$ sec, $$15 = \frac{1}{4}K\times 5$$

$$K = 12$$

18. (c)

Given, $\vec{E} = 10\sin(\omega t - \pi z)\hat{a}_x + \sqrt{10}\cos(\omega t - \pi z)\hat{a}_y$ V/m

$\therefore$ Field components are, $E_x = 10\sin(\omega t - \pi z)$

$$E_y = \sqrt{10}\cos(\omega t - \pi z) = \sqrt{10}\sin(\omega t - \pi z - \pi/2)$$

$\because$ $|E_x| \neq |E_y|$ and phase difference is $\pi/2$

$\therefore$ Elliptical polarization.

19. (a)

For TE mode $E_y \propto \sin\left(\frac{m\pi x}{a}\right)\cos\left(\frac{n\pi y}{b}\right)$

$\therefore$ Here, $m = \frac{4}{2} = 2$

and $n = 0$

$\therefore$ TE_{20} mode

20. (c)

$$G_d(\theta, \phi) = \frac{U(\theta,\phi)}{U_{avg}} = \frac{U_{avg}}{U_{avg}} = 1$$

$\therefore$ $D = (G_d)_{max} = 1$

21. (d)

$$\text{Power radiated} = P = \frac{1}{2}I_0^2 R_{rad}$$

For same current, $P_{rad} \propto R_{rad}$

$\because$ $R_{rad} = 80\pi^2\left(\frac{dl}{\lambda}\right)^2$

$\therefore$ $R_{rad} \propto \left(\frac{dl}{\lambda}\right)^2 \propto f^2(dl)^2$

For first antenna, $dl \times f = 2 \times 10^{-3} \times 10^8 = 2 \times 10^5$

For second antenna $dl \times f = 40 \times 10^{-3} \times 10^6 = 4 \times 10^4$

$\therefore$ $\frac{R_{rad_1}}{R_{rad_2}} = \frac{(dl \times f)_1^2}{(dl \times f)_2^2} = \frac{(2 \times 10^5)^2}{(4 \times 10^4)^2} = 25$

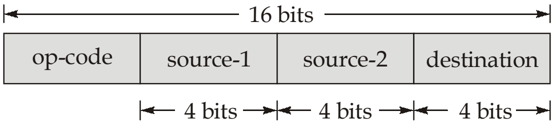
$\therefore$ $P_{rad_1} = 25P_{rad_2}$

22. **(c)**

$$\text{Total number of registers} = 16$$

$$\log_2(16) = 4$$

So, 4 bits are needed to represent one register in either source or destination field of an instruction.



Op-code field contains = (16) – (4 + 4 + 4) = 4 bits
using 4-bits, 16 op-codes can be formed at most.

23. **(d)**
RISC architecture uses hardwired control unit.

24. **(b)**

$$\text{Speedup} = \frac{NK}{K+(N-1)}$$

Here, $N = 20$ and $K = 5$

So,
$$\text{Speedup} = \frac{20\times5}{5+19} = \frac{100}{24} \simeq 4.17$$

25. **(d)**

26. **(b)**

Total number of memory words (or) total number of memory addresses = $\dfrac{4\times2^{30}}{2} = 2\times2^{30} = 2^{31}$

To represent 2^{31} addresses, at least 31 address lines are required.

27. **(b)**
In absolute addressing mode, the address of the operand is inside the instruction.

28. **(c)**
The goal of structured programming is to be able to infer the flow of control from the program text.

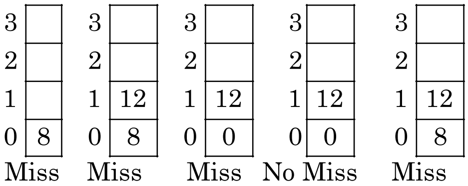
29. **(d)**
The principle of locality justifies the use of cache memory.

30. **(c)**

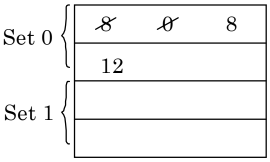
Sequence 8, 12, 0, 12, 8

Apply the LRU as follows

Page Frame



or



Total number of cache misses = 4

31. **(b)**

Average memory access time = Hit ratio × access time in cache memory + (1 – Hit ratio) × access time in main memory

$$
\begin{aligned}
120 &= \text{Hit ratio} \times 100 + (1 - \text{Hit ratio}) \times 1200 \\
12 &= (10 - 120)\ \text{Hit ratio} + 120 \\
110 \times \text{Hit ratio} &= 108 \\
\therefore \quad \text{Hit ratio} &= \frac{108}{110} = 0.98 \quad \text{or} \quad \text{Hit ratio} = 98\%
\end{aligned}
$$

32. **(a)**

The daisy-chaining method of establishing priority consists of a serial connection of all devices that request an interrupt. The device with the highest priority is placed in the first position, followed by lower-priority devices up to the device with the lowest priority, which is placed last in the chain. The farther the device is from the first position, the lower is its priority. Therefore daisy-chain gives non-uniform priority to various devices.

33. **(d)**

$$600 \text{ rotation} = 60 \text{ sec}$$

$$\text{So,} \quad 1 \text{ rotation time} = \frac{60}{600} = 0.1 \text{ sec}$$

$$\text{Averation rotational delay} = \frac{\text{Rotation latency}}{2} = \frac{0.1}{2} = 50 \text{ ms}$$

$$
\begin{aligned}
\text{Capacity of track} &= \text{Number of sector /track} \times \text{Number of bytes/sector} \\
&= 100 \times 500 = 50{,}000 \text{ bytes}
\end{aligned}
$$

In 1 rotation, we can transfer the whole track.

For 50,000 bytes ⇒ 0.1 sec

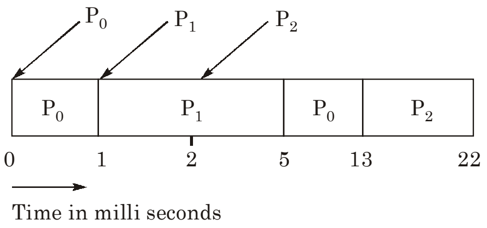
For 250 bytes $\Rightarrow \frac{0.1 \times 250}{50000} = 0.5$ ms

$$\text{Average seek time} = \frac{0+1+2+3...+499}{500} = \frac{499 \times 250}{500} = 249.5 \text{ ms}$$

Average time to transfer = Average seek time + Average rotational delay + Average data transfer time for transferring 250 bytes

So, Average time to transfer = 249.5 + 50 + 0.5 = 300 ms

34. **(a)**



$$\text{Average waiting time} = \frac{w_1 + w_2 + w_3}{3} = \frac{(5-1)+0+(13-2)}{3} = 5.0 \text{ ms}$$

35. **(d)**

Generally every thread of a process have their own Program Counter and Stack. Both heap and global variables are shared by every thread of a process.

36. **(b)**

Swap space is an area on disk that temporarily holds a process memory image. When physical memory demand is sufficiently low, process memory images are brought back into physical memory from swap area.

37. **(c)**

Virtual memory allows the user to run the programs larger than the physical memory size. And with virtual momory, processes can be given protected address spaces.

38. **(c)**

$$\text{Number of entries in page table} = \frac{\text{Virtual address space}}{\text{Page size}} = \frac{2^{32}}{2^{12}} = 2^{20}$$

$$\text{Frame size} = \frac{2^{26}}{2^{12}} = 2^{14}$$

$\therefore$ Page table have to be stored in one frame so entry size must be 2 bytes, hence size of Page table will be = $2^{20} \times 2 = 2^{21}$ = 2 MB.

39. (b)

$$\text{Biased exponent} = 18 + 64 = 82$$

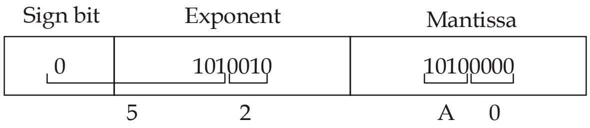
Representing 82 in binary

$$(82)_{10} = (1010010)_2$$

Representing mantissa in binary

$$(0.625)_{10} = (0.10100000)$$

Floating point representation is as follows:



40. (c)

Lossless join decomposition into BCNF is always possible. But dependency preserving BCNF decomposition may not be possible for all relations.

41. (d)

The wavelength $\lambda_1 = \dfrac{c}{f}$ (For vacuum)

For any other dielectric medium,

$$\lambda_2 = \frac{v_p}{f} = \frac{c}{f \times \sqrt{\varepsilon_r}}$$

$$\because \quad \varepsilon_r > 1$$

$$\therefore \quad \lambda_2 < \lambda_1 \Rightarrow \text{Statement-I is wrong.}$$

42. (c)

The statement II explains the Stoke's theorem.

43. (a)

When transmission line is open or short circuited,

$$\because \quad Z_{OC} = -jZ_0 \cot \beta l$$

$$\text{and} \quad Z_{SC} = jZ_0 \tan \beta l$$

$$\text{For} \quad l = \frac{\lambda}{4}$$

$$Z_{OC} = 0 \quad \text{and} \quad Z_{SC} = \infty$$

That means quater wave transmission line represent an infinite impedance at input terminals (when short circuited), just like a parallel LC resonant circuit and zero impedance at input terminals (when open circuited) just like a series LC resonant circuit.

44. (a)

45. (b)

Section B : Analog Circuits-1 + Electronic Measurements and Instrumentation-1

46. **(b)**

In capacitive filters, a surge protection resistor is used to control the forward current flowing through the diode, which is also called as surge current.

47. **(*) (Marks to all)**

[Please note that there is a printing error in the given question. In the place of $I_B = 200\ \mu\text{A}$, it was given as $I_B = 200\ \text{mA}$. We deeply regret for the inconvenience caused to you and full marks will be awarded for every student for this question]

The following solution is valid for $I_B = 200\ \mu\text{A}$:

$$I_C = \beta I_B + (\beta + 1)I_{CB0}$$

$$I_C = (\beta + 1)I_B + (\beta + 1)I_{CB0} - I_B$$

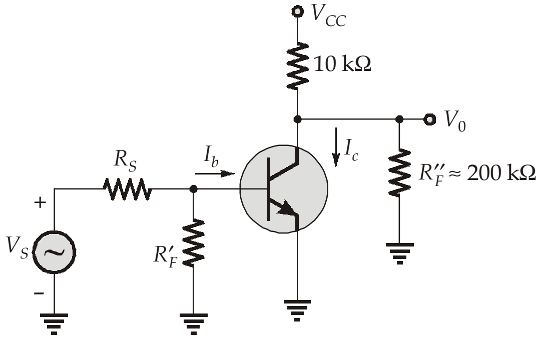
$$\therefore \quad \beta + 1 = \frac{I_C + I_B}{I_B + I_{CB0}}$$

$$\beta = \frac{I_C + I_B}{I_B + I_{CB0}} - 1$$

$$\beta = \frac{12.427 \times 10^{-3} + 0.2 \times 10^{-3}}{0.2 \times 10^{-3} + 7 \times 10^{-6}} - 1 = 60$$

48. **(d)**

We can use Millers theorem and split the feedback resistance.



$$\therefore \quad A_I = \frac{I_c}{I_b} = \frac{h_{fe}}{1 + h_{oe}R_L}$$

Now, $$R_L = 10\ \text{k}\Omega \ ||\ 200\ \text{k}\Omega = 9.52\ \text{k}\Omega$$

$$\therefore \quad A_I = \frac{50}{1 + 25 \times 10^{-6} \times 9.52 \times 10^{3}} = 40.3\ \text{A/A}$$

49. **(b)**

$$g_m = \frac{-2}{V_P}\sqrt{I_D I_{DSS}}$$

$$g_m = \frac{-2}{-2}\sqrt{1.65 \times 10^{-3} \times 0.8 \times 10^{-3}} = 1.15\ \text{mS}$$

50. (c)

$$I_c(V_A) = I_c\left(1+\frac{V_{CE}}{V_A}\right)$$

$\Rightarrow$ $$I_{c1} = I_c\left(1+\frac{5}{100}\right) = I_c\left(\frac{21}{20}\right)$$

and $$I_{c2} = I_c$$

$\therefore$ $$\Delta I_c\% = \frac{\frac{21}{20}I_c - I_c}{I_c}\times 100 = 5\%$$

51. (b)

The dynamic resistance of the diode is given by

$\because$ $$r_d = \frac{\eta V_T}{I_{DC}}$$

here, $$I_{DC} = \frac{5-0.7}{8.6}\times 10^{-3} = 0.5\text{ mA}$$

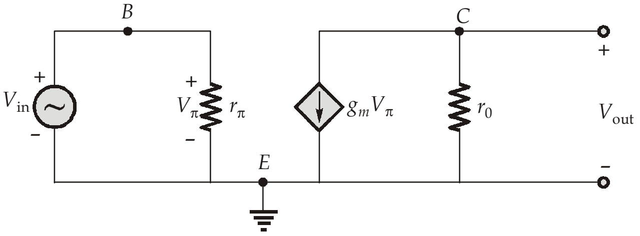
(the capacitor will act as an open circuit while performing DC analysis)

$\therefore$ $$r_d = \frac{26\times 10^{-3}}{0.5\times 10^{-3}} = 52\ \Omega$$

52. (b)

Since the current source is ideal, the collector resistance $R_C \rightarrow \infty$.

Small signal model,



$$V_\pi = V_{in}$$

$$\frac{V_{out}}{V_{in}} = -g_m r_0$$

$$g_m = \frac{I_C}{V_T}$$

$$r_0 = \frac{V_A}{I_C}$$

$$\frac{V_{out}}{V_{in}} = -\frac{V_A}{V_T} = \frac{-10000}{25} = -400$$

53. (d)

In the moving iron ammeter, deflection angle, $\theta \propto i_{\text{rms}}^2$

$$\frac{\theta_1}{\theta_2} = \left[\frac{i_{\text{rms}1}}{i_{\text{rms}2}}\right]^2$$

$$\frac{20^\circ}{\theta_2} = \frac{(1)^2}{\left(\frac{3}{\sqrt{2}}\right)^2}$$

$$\therefore \quad \theta_2 = \frac{9}{2} \times 20^\circ = 90^\circ$$

54. (d)

Count range for $4\frac{1}{2}$ DVM is from 0 to 19999 i.e., 20000 counts.

$$\text{Voltage per count} = \frac{500 \text{ mV}}{20000} = 0.025 \text{ mV}$$

55. (d)

From the nodal analysis, $I_1 - I_2 - I_3 = 0$

$\therefore \quad I_3 = I_1 - I_2 = 100 \text{ mA} - 90 \text{ mA}$

$I_3 = 10 \text{ mA}$

$\delta I_1 = 1$ mA (1% of 100 mA) and $\delta I_2 = 1.35$ mA (1.5% of 90 mA)

$\delta I_3 = \delta I_1 + \delta I_2 = 2.35 \text{ mA}$

$\therefore \quad I_3 = 10 \text{ mA} \pm 23.5\%$

56. (d)

It is Maxwell's bridge,

$\therefore \quad Z \Rightarrow R$ and C in parallel.

57. (d)

58. (b)

$$\text{Controlling torque} = NBAI = 240 \times 10^{-6}$$

$$I = \frac{240 \times 10^{-6}}{100 \times 1 \times 40 \times 30 \times 10^{-6}}$$

$$I = 2 \text{ mA}$$

59. (c)

Sensistors have positive temperature coefficient of resistance.

60. (a)

Section C : Signals and Systems-2 + Basic Electrical Engineering-2

61. (c)

$x(n)$ can be written as,

$$\begin{aligned} x(n) &= 0.8^n[u(n) - u(n-6)] \\ &= 0.8^n u(n) - 0.8^n u(n-6) \\ &= 0.8^n u(n) - 0.8^6[0.8^{n-6} u(n-6)] \end{aligned}$$

Taking DTFT, we get,

$$X(e^{j\omega}) = \frac{1}{1-0.8e^{-j\omega}} - \frac{0.8^6 \times e^{-j6\omega}}{1-0.8e^{-j\omega}}$$

$$X(e^{j\omega}) = \frac{1-0.8^6 e^{-j6\omega}}{1-0.8e^{-j\omega}}$$

62. (d)

$$X(z) = \frac{z-a}{1-az}$$

Using initial value theorem,

$$x(0) = \lim_{z\to\infty} X(z)$$

$$x(0) = \lim_{z\to\infty} \frac{1-\frac{a}{z}}{\frac{1}{z}-a} = \frac{-1}{a}$$

63. (c)

Since $N = 8$,

$$X[k] = \sum_{n=0}^{7} x(n)\left(e^{-j\frac{2\pi}{N}}\right)^{nk} = \sum_{n=0}^{7} x(n)\left(e^{-j\frac{\pi}{4}}\right)^{nk}$$

$$X[k] = \sum_{n=0}^{7} \left(e^{-j\frac{\pi}{4}}\right)^{nk} \qquad [\because x[n] = 1 \text{ for } 0 \le n \le 7]$$

$$= \frac{1-\left(e^{-j\frac{\pi}{4}}\right)^{8k}}{1-\left(e^{-j\frac{\pi}{4}}\right)^{k}} = \frac{1-\left(e^{-j2\pi}\right)^{k}}{1-\left(e^{-j\frac{\pi}{4}}\right)^{k}}$$

above expression gives,

$$\begin{aligned} X[k] &= 0; \text{ when } k \neq 0; \\ X[0] &= 8 \end{aligned}$$

so,

$$X[k] = [8, 0, 0, 0, 0, 0, 0, 0]$$

64. (a)

The transfer function of an FIR digital filter is a polynomial in z^{-1}.

65. (a)

$$\phi(f) = kf^2$$

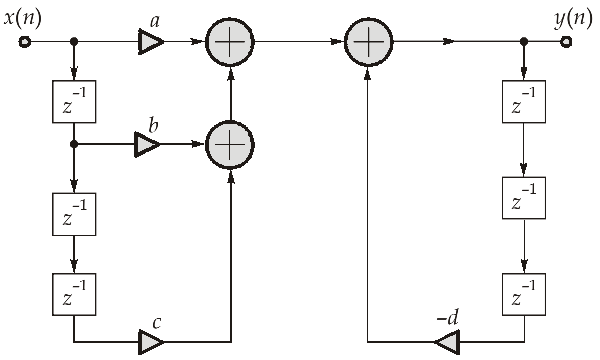
$$\text{group delay} = -\frac{d\phi(f)}{df} = -2\,kf$$

66. (a)

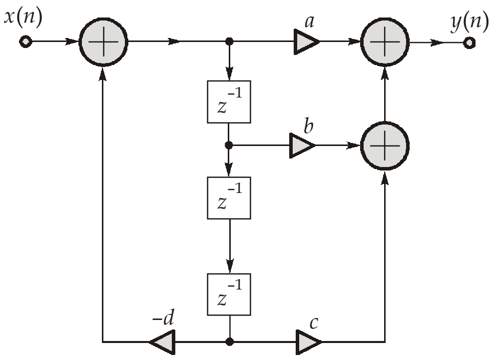
At 75% of full load, efficiency is maximum.

So,
$$(0.75)^2 P_{cu(FL)} = P_{i(FL)}$$
$$\left(\frac{3}{4}\right)^2 P_2 = P_1$$
$$\frac{P_1}{P_2} = \frac{9}{16} = 0.5625$$

67. (c)



Direct from-1



Direct from-2

Direct form-1 realization requires 6 unit delay elements.

Direct form-2 realization requires 3 unit delay elements.

68. (b)

The ratio of height to width of window should be increased to reduce the leakage flux.

69. (b)

This is the case of a transformer with turns ratio as 1 : 1. Such a transformer is mainly required for isolation.

$$\text{Rated current} = \frac{3000}{230} \simeq 13\,A$$
$$P_{cu(FL)} = 120 \text{ W} \Rightarrow \text{ from S.C. Test}$$
$$P_{i(FL)} = 100 \text{ W} \Rightarrow \text{ from O.C. Test}$$
$$P_{out(FL)} = 3000 \times 0.8 = 2400 \text{ W}$$

Full-load efficiency,
$$\eta = \frac{2400}{2400 + 100 + 120} \times 100\%$$
$$= \frac{2400}{2620} \times 100 \simeq 91.6\%$$

70. (c)

71. **(c)**

To get maximum torque at starting,

$$\frac{T_{\text{start}}}{T_{\max}} = \frac{2a}{a^2+1} = 1 \Rightarrow a = 1$$

where, $$a = \frac{R_2 + R_{\text{ext}}}{X_{20}}$$

So, $$R_{\text{ext}} = X_{20} - R_2 = 0.6 - 0.08 = 0.52\ \Omega$$

72. **(d)**

Frequency of rotor emf, $$f_r = \frac{100}{60} = \frac{5}{3}\text{Hz}$$

Slip, $$s = \frac{f_r}{f} = \frac{\left(\frac{5}{3}\right)}{50} = \frac{1}{30}$$

$$P_{\text{mech}} = \left(1 - \frac{1}{s}\right) P_{\text{rotor}} = \left(1 - \frac{1}{30}\right) 150 = 145\ \text{kW}$$

73. **(b)**

74. **(b)**

75. **(c)**

Statement (II) is wrong. In wound rotor additional resistance can be connected in the rotor circuit to increase starting torque.

❍❍❍❍