DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Hyderabad, Bhopal, Jaipur, Pune, Kolkata

ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 14

Section A : Electromagnetics + Computer Organization and Architecture

Section B : Advanced Comm.-1 + Electronic Measurements & Instrumentation-1

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

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

Detailed Explanation

Section A : Electromagnetics + Computer Organization and Architecture

1. **(c)**

$$\mu^* = j\omega\mu$$
$$\in^* = \sigma + j\omega\in$$

Intrinsic impedance of the magnetic material,

$$\eta = \sqrt{\frac{\mu^*}{\in^*}} = 1$$

$$\text{Reflection coefficient, } \Gamma = \frac{\eta-\eta_0}{\eta-\eta_0} = \frac{1-120\pi}{1+120\pi} = \frac{1-377}{1+377} \cong -0.995 \cong -1$$

$$\text{Transmission coefficient, } \tau = 1 + \Gamma$$
$$\approx 1 - 0.995 \approx 0.005$$

2. **(b)**

- In linear polarization, the electric field oscillates in a single direction (plane) perpendicular to the wave propagation direction.
- Circular polarization is characterized by two perpendicular electric field components with equal magnitudes and a phase difference of 90°. This causes the tip of the electric field vector to trace a circle about the propagation axis as the wave advances.
- The speed of propagation in free space is independent of polarization, as the medium (vacuum) does not distinguish between different polarizations.
- Elliptical polarization occurs when the electric field vector traces an ellipse about the propagation axis as the wave advances. It is characterized by two linear components with different amplitudes and/or a phase difference that is not $\pi/2$. It is the most general case, with linear and circular polarizations being special cases of elliptical polarization.

3. **(d)**

Given that $f = 60$ MHz

$$\in = 3\in_0$$
$$\mu = 4\mu_0$$

$$\text{Intrinsic impedance, } \eta = \sqrt{\left[\frac{j\omega\mu}{\sigma + j\omega\in}\right]}$$

For lossless medium, $\sigma = 0$. Hence,

$$\eta = \sqrt{\frac{\mu}{\in}} = \sqrt{\frac{4\mu_0}{3\in_0}} = \frac{2}{\sqrt{3}} \times 120\pi$$
$$= 138.564\ \pi\Omega$$

4. **(d)**

Given that, VSWR (or) $S = 6$

$$S = \frac{1+|\Gamma|}{1-|\Gamma|} = 6$$

$$1 + |\Gamma| = 6 - 6|\Gamma|$$

$$7|\Gamma| = 5$$

$$|\Gamma| = \frac{5}{7} \qquad [\Gamma = \text{Reflection coefficient at television set}]$$

Thus,
$$P_{\text{reflected}} = \Gamma^2 P_{\text{incident}}$$

$$\frac{P_{\text{reflected}}}{P_{\text{incident}}} = \left(\frac{5}{7}\right)^2 \times 100 = \frac{25}{49} \times 100 = \frac{2500}{49} = 51\%$$

5. (a)

Given,
$$\vec{E_i} = 30\cos(\omega t - z)\hat{a}_y \text{ V/m}$$

$$P_t = \frac{E_{ot}^2}{2\eta_2}\vec{a}_z$$

where
$$E_{ot} = \tau E_{oi}$$

and
$$\tau = \frac{2\eta_2}{\eta_1 + \eta_2} = \frac{2 \times \sqrt{\frac{3}{12}} \times 120\pi}{120\pi\left(1 + \sqrt{\frac{3}{12}}\right)} = \frac{2 \times \frac{1}{2}}{1 + \frac{1}{2}} = \frac{2}{3} \qquad \left[\eta_2 = \sqrt{\frac{\mu^2}{\epsilon_2}}\right]$$

Thus,
$$E_{ot} = \frac{2}{3} \times 30 = 20 \text{ V/m}$$

$$\eta_2 = \sqrt{\frac{\mu_2}{\epsilon_2}} = \sqrt{\frac{\mu_0\mu_r}{\epsilon_0\epsilon_r}} = \sqrt{\frac{3}{12}} \times 120\pi = 60\pi\ \Omega$$

∴
$$P_t = \frac{(20)^2}{2 \times 60\pi} = \frac{20 \times 20}{2 \times 60\pi} = \frac{10}{3\pi}\hat{a}_z \text{ W/m}^2$$

6. (c)

- For a shorted line, the input impedance is given by:

$$Z_{\text{in}} = jZ_0 \tan(\beta l)$$

For $l = \lambda/8$,
$$\beta l = \frac{2\pi}{\lambda} \times \frac{\lambda}{8} = \frac{\pi}{4}$$

$$Z_{\text{in}} = jZ_0 \tan\left(\frac{\pi}{4}\right) = jZ_0$$

- For a shorted line with $l = \frac{\lambda}{4}$,

$$\beta l = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2}$$

$$Z_{\text{in}} = jZ_0 \tan(\beta l) \to j\infty$$

- For an open circuited line, the input impedance is given by

$$Z_{\text{in}} = -jZ_0 \cot(\beta l)$$

For $l = \lambda/2$, $$\beta l = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{2} = \pi$$

$$Z_{\text{in}} = -jZ_0 \cdot \cot(\pi) = -j\infty$$

- For a matched line, the load impedance $Z_L = Z_0$. In this case, there are no reflections and the input impedance equals the characteristic impedance:

$$Z_{\text{in}} = Z_0$$

- The input impedance of a lossless transmission line repeats itself every half wavelength. Thus, the input impedance repeats the load impedance Z_L at every half-wavelength:

$$Z_{\text{in}} = Z_L \text{ for } l = \frac{n\lambda}{2}, \ n = 0, 1, 2 \ldots.$$

7. (c)

The intersection of the constant VSWR circle shown in the figure with the horizontal line (0°) corresponds to voltage maxima. Clockwise movement on the smith chart represent moving towards generator or (away from the load). If the load is assumed at $x = 0$, the first maxima occurs at

$$x_{\max(1)} = \frac{\lambda}{2} + \frac{\lambda}{2}\times\frac{30}{180} = \frac{7\lambda}{12} = 87.5 \text{ m}$$

Since, two consecutive voltage maxima's are half-wavelength ($\lambda/2$) apart, thus, the number of maxima's on the line of length l - 500 m is

$$N = 1 + \left\lfloor \frac{500 - 87.5}{\lambda/2} \right\rfloor = 1 + \left\lfloor \frac{412.5}{75} \right\rfloor$$

$$N = 1 + 5 = 6$$

8. (b)

- In a transmission line, the node–null patterns repeat every half wavelength. Thus, the standing wave pattern repeats every half-wavelength ($\lambda/2$) not the full wavelength (λ).
- For a perfectly matched load ($Z_L = Z_0$), there is no reflection, no standing waves and thus, voltage is constant along the line.
- For a mismatched or reactive load, voltage maxima generally do not occur at the load. They occur at specific points determined by the reflection coefficient.
- For a lossless transmission line, there is no power dissipation in the line itself. The power is either reflected or delivered to the load.
- For a line of length $n\lambda$ ($n = 0, 1, 2, \ldots$), $\beta l = 2n\pi$. Thus, $Z_{in} = Z_0\left(\frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}\right) = Z_0$ i.e., the input impedance matches the load impedance Z_L. Thus, if the load is purely resistive, the input impedance is purely real.

9. (a)

- Evanescent mode occurs when the frequency of the wave is below the cut-off frequency for a given mode, causing exponential decay of fields.
- In such cases, the propagation constant is purely real, i.e. $\gamma = \alpha$ resulting in attenuation of the wave. Thus, the wave is attenuated rather than propagated.
- The mode with $m = 0$ and $n = 0$ cannot occur in a rectangular waveguide. Thus, it does not represent an evanescent mode.

Hence, statements 1 and 2 are correct.

10. (b)

Since $b > a$, TE_{01} represents the dominant mode. The cut-off frequency for the dominant mode,

$$f_c = \frac{c}{2b} = \frac{3\times 10^8}{2\times 16} = 9.375 \text{ MHz}$$

The tunnel will pass 9.375 MHz and above frequencies.

11. (a)

- The power carried by the waveguide is proportional to the poynting vector, which depends on the electric field and magnetic field magnitudes. Since these fields are directly proportional to the wave amplitude, the power is proportional to the square of the field amplitude.
- For frequencies above the cutoff frequency, the wave impedance decreases, allowing higher power transfer. Additionally, higher frequencies generally reduce conductor and dielectric losses, improving the power-handling capability.
- In the TE modes, the electric field has no component in the direction of propagation (z). It lies in the plane perpendicular to the propagation direction.
- The magnetic field in the TE mode forms closed loops and has components parallel to the broad wall (the x-direction) as well as perpendicular components (in the y-direction). Therefore, it is not strictly perpendicular to the broad wall of the waveguide.

12. (d)

- In a rectangular waveguide, the propagation constant (γ) is given by

$$\gamma = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{m\pi}{a}\right)^2 - \omega^2\mu\in} = \frac{2\pi}{c}\sqrt{f_c^2 - f^2}$$

- The attenuation constant (α) for evanescent modes i.e. for $f < f_c$ is given by:

$$\gamma = \alpha = \frac{2\pi}{c}\sqrt{f_c^2 - f^2}$$

Hence, the propagation constant is purely real and the wave attenuates as it propagates.

- For the evanescent modes, the fields (E, H) decay exponentially along the direction of propagation (z), following the relation:

$$E(z) \propto e^{-\alpha z}, \quad H(z) \propto e^{-\alpha z}$$

- In evanescent modes, no real power is carried along the waveguide since the wave does not propagate. The wave energy is localized near the source and decays exponentially away from it.
- Power is only carried in propagating modes (when $f > f_c$).

13. (a)

Length of the dipole is $\frac{\lambda}{2}$

$$l = \frac{\lambda}{2} = \frac{c}{2f} = \frac{3\times10^8}{2\times50\times10^6} = 3\text{ m}$$

14. (c)

s_{11} represents the reflection coefficient Γ at port 1. Thus,

$$\text{VSWR} = \frac{1+|\Gamma|}{1-|\Gamma|} = \frac{1+|S_{11}|}{1-|S_{11}|} = \frac{1+0.6}{1-0.6} = 4$$

15. (d)

At high frequencies, electromagnetic waves penetrate only a small depth into the conductors due to the skin effect which increases the surface resistance. In rectangular coaxial lines, the outer conductor typically has a much larger surface area, so the total resistance due to current flow over its surface dominates the loss mechanisms.

Other mechanisms:

- **Conduction loss in the inner conductor:** Exists but is less significant compared to the outer conductor's surface resistance at high frequencies.
- **Radiation loss:** Generally negligible in well-shielded coaxial structures.
- **Dielectric loss in the material:** can occur but is frequency-dependent and significant only for specific dielectrics. At very high frequencies, metallic losses dominate unless the dielectric is lossy.

16. (b)

Grating lobe is a maximum lobe or back lobe equal in strength as major lobe.
This can be avoided by avoiding multiple maximas in the pattern.
For maxima, $\psi = 0, 2\pi, 4\pi, \ldots$ For single maxima,

$$0 \le \psi < 2\pi$$

$$\alpha + \beta d\cos\theta < 2\pi$$

where, α = phase difference having maximum value of π

and maximum value of $\cos\theta = 1$

$$\therefore \quad d < \frac{\lambda}{2}$$

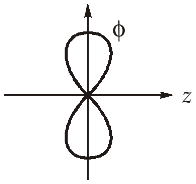
Hence, when $d < \lambda/2$, antenna array will not produce any grating lobe and for $d > \lambda/2$, antenna array will produce grating lobe.

17. (c)

- Increasing the number of elements in an antenna array enhances directivity because it increases the aperture size and focuses the energy in a particular direction. The directivity is approximately proportional to the number of elements for a given array geometry.
- Reducing the spacing below $\lambda/2$ does not necessarily improve directivity. Instead, it can lead to mutual coupling and degrade the array performance. Maintaining a spacing of approximately $\lambda/2$ is typically ideal to avoid grating lobes and ensure effective radiation.

- A progressive phase difference allows for beam steering in a specific direction, which enhances the overall directivity of the array in the desired direction.
- Isotropic radiations are hypothetical and do not exist in practical scenarios. Using isotropic radiators does not inherently improve the directivity of the array since they radiate equally in all directions without focusing energy. Instead, using directional elements in the array can enhance directivity.

18. (b)



By definition of broadside array, the maximum radiation is at $\frac{\pi}{2}$ (or) $\frac{3\pi}{2}$ i.e. perpendicular to the axis of the array.

19. (b)

The Gantt chart using LRTF CPU Scheduling algorithm is as follows:

P_2	P_2	P_2	P_2	P_1	P_2	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Process id	Arrival Time	CPU Brust Time	Completion Time (CT)	Turn Around Time (TAT)	Waiting Time (WT)
P_0	0	2	12	12	10
P_1	0	4	13	13	9
P_2	0	8	14	14	6

Turn around time for P_0 = 12 – 0 = 12 sec

Turn around time for P_1 = 13 – 0 = 13 sec

Turn around time for P_2 = 14 – 0 = 14 sec

$$\text{Average turn around time} = \frac{39}{3} = 13 \text{ sec}$$

20. (b)

- In First Come First Serve (FCFS), if a process with a very large burst time comes before other processes, the other processes will have to wait for a very long time, but it is obvious that other processes will definitely get their chance to execute, so it not likely that the process will suffer from starvation.
- There is no starvation in Round Robin because there is a defined time duration and every process will have a chance to run.
- If higher priority processes keep coming in priority-based scheduling, low priority processes will starve.
- If processes with short burst time continue to arrive in shortest job first (SJF) scheduling, processes with longer burst times will have to wait and starve.

21. (c)

The floating point number represented using the IEEE 754 standard is given by

$$N = (-1)^S \text{ x } (1.M) \times 2^{(\text{BE-Bias})}$$

where S = Sign bit = 0 (for positive number), M = Mantissa (in binary), BE = Biased Exponent (in decimal) and Bias = 127

(a) Exponent = 00000001 = $(1)_{10}$ and mantissa = 00000000000000000000000

$$N = 1.0 * 2^{1-127} = 1.0 * 2^{-126}$$

(b) Exponent = 11111111 = $(255)_{10}$ and mantissa = 00000000000000000000001

$$N = 1.00000000000000000000001 * 2^{255-127} \approx 1 * 2^{128}$$

(c) Exponent = 00000000 = $(0)_{10}$ and mantissa = 00000000000000000000001

$$N = 1.00000000000000000000001 * 2^{0-127} \approx 1 * 2^{-127}$$

(d) $\left.\begin{array}{l}\text{All 1's } BE \\ \text{All 0's } M\end{array}\right\}$ are used to represent (+∞ and –∞) distinguished by the sign bit.

Hence, option (c) represents the smallest positive number.

22. (d)

- This is a key characteristic of the Von Neumann architecture. Both instructions and data are stored in the same memory, and the CPU uses the same memory bus to access them.
- The Von Neumann architecture user a single bus for both data and instructions, which is a major limitation leading to the Von Neumann bottleneck.
- In the Von Neumann architecture, instructions are fetched and executed one at a time in a sequential manner, unless that order is altered by the control flow instructions like branches or jumps.

Hence, statements 1 and 3 are correct.

23. (d)

- The translation lookaside Buffer (TLB) is a specialized cache that stores recent page table entries to reduce the time required for virtual memory to physical memory address translation.
- When a required page table entry is not found in the TLB (a TLB miss), the system must access the page table in memory to retrieve the mapping of the virtual address to the physical address.
- TLBs are hardware-implemented and have limited storage capacity, typically much smaller than the complete page table, which could be very large in systems with extensive virtual memory.
- The TLB acts as a high-speed buffer for frequently accessed page table entries, significantly reducing the time needed for virtual-to physical address translation compared to accessing the page table in main memory.

24. (c)

$$\therefore \qquad \text{Number of lines} = \frac{\text{Cache Memory Size}}{\text{Block size}} = \frac{512\text{ K}}{64} = \frac{2^{19}}{2^6} = 2^{13}$$

$$\text{So,} \qquad \text{number of sets} = \frac{\text{Number of cache lines}}{\text{Associativity}}$$

$$\Rightarrow \qquad \text{Number of sets} = \frac{2^{13}}{2^3} = 2^{10}$$

Set offset has $\log_2(2^{10}) = 10$ bits

Since there are 64 words per block, Word offset has $\log_2 64 = 6$ bits.

40 bits

Tag	Set Offset	Word Offset
24	10	6

So, TAG size is 24 bits.

25. (c)

There are total 4 sets in the cache and each set contains 4 blocks.

Set 0	~~0~~ 48
	~~4~~ 32
	8
	~~216~~ 92
Set 1	1
	133
	129
	73
Set 2	
Set 3	~~255~~ 155
	3
	159
	63

We apply (Block Address mod 4) function to decide set.

0 mod 4 = 0; set 0
255 mod 4 = 3; set 3
1 mod 4 = 1; set 1
4 mod 4 = 0; set 0
3 mod 4 = 3; set 3
8 mod 4 = 0; set 0
133 mod 4 = 1; set 1
159 mod 4 = 3; set 3
216 mod 4 = 0; set 0
129 mod 4 = 1; set 1
63 mod 4 = 3; set 3
8 mod 4 = 0; set 0 (already in cache)
48 mod 4 = 0; set 0 (48 will replace block 0 using LRU)
32 mod 4 = 0; set 0 (32 will replace block 4)
73 mod 4 = 1; set 1
92 mod 4 = 0; set 0 (92 will replace block 216)
155 mod 4 = 3; set 3 (155 will replace 255)

After the above cache accesses, the missing block from the cache is 255 among the given options.

26. (d)

$$700 \text{ rotations} = 60 \text{ sec}$$

So,

$$1 \text{ rotation time} = \frac{60}{700} = \frac{6}{70}\text{sec}$$

$$\text{Average Rotational latency} = \frac{\text{Rotation time}}{2}$$

$$= \frac{6}{70\times 2} = \frac{3}{70}\times 1000 = \frac{300}{7}\text{ms} = 42.85 \text{ ms}$$

$$\text{Capacity of track} = \text{Number of sectors/track} \times \text{Number of bytes/sector}$$

$$= 100 \times 400 = 40000 \text{ bytes}$$

In 1 rotation, we can transfer the whole track.

$$\text{Data transfer time for 40000 bytes} = \frac{6}{70}\text{sec}$$

$$\text{Data transfer time for 250 bytes} = \frac{6}{70}\times\frac{250}{40000} = \frac{3}{5600} = 0.53 \text{ ms}$$

$$\text{Average seek time} = 249.5 \text{ ms}$$

$$\text{Average time to transfer} = \text{Average seek time} + \text{Average rotational delay}$$

$$+ \text{ Average data transfer time for transferring 250 bytes}$$

$$= 249.5 + 42.85 + 0.53 = 292.88 \text{ ms} \cong 293 \text{ ms}$$

27. (b)

Instruction execution time for non-pipelined process,

$$T_{\text{non-pipeline}} = \text{Sum of time for each state}$$

$$= (3 + 2 + 1 + 1.5 + 2.5) \text{ nsec}$$

$$= 10 \text{ nsec}$$

Instruction execution time for pipelined processor = T_p + Buffer delay

where

$$T_p = \max(\text{all stages time})$$

$$= \max(3, 2, 1, 1.5, 2.5) \text{ nsec}$$

$$= 3 \text{ nsec}$$

∴

$$T_{\text{pipeline}} = T_p + \text{Buffer delay}$$

$$= 3 + 1 = 4 \text{ nsec}$$

$$\text{speed up} = \frac{T_{\text{Non pipeline}}}{T_{\text{Pipeline}}} = \frac{10 \text{ nsec}}{4 \text{ nsec}} = 2.5$$

28. (c)

- A larger cache stores more data, reducing the likelihood of cache misses. This decreases the time needed to access data from the slower main memory, thus improving pipeline performance by avoiding stalls.
- When a cache miss occurs, the pipeline must wait for the required data to be fetched from a lower level of memory (e.g, main memory). This causes a stall, as the pipeline cannot proceed with the execution until the data is available.

- A unified cache stores both instructions and data, which can simplify the overall design. However, it can lead to contention between instruction fetches and data accesses, potentially causing pipeline stalls. Separate instruction and data caches (Harvard architecture) allow parallel access and improve pipeline throughput despite slightly increased control complexity.
- Cache replacement policies (e.g. LRU, FIFO) determine with cache block is replaced during a miss, which affects pipeline performance. A good replacement policy minimizes cache misses, enhancing pipeline performance.

29. (a)

- In memory-mapped I/O, the same address space is used for memory and I/O devices, allowing the CPU to interact with I/O devices using standard memory instructions.
- In isolated I/O (also called port-mapped I/O), a separate address space is reserved for I/O devices and special instructions (e.g. IN, OUT) are used for communication with I/O devices.
- Interrupt latency is the delay between the generation of an interrupt signal and the start of execution of the associated interrupt service routine (ISR). It depends on factors like pipeline depth, ongoing instructions and the priority of the interrupt.
- Memory-mapped I/O can allow more devices because it can utilize the entire address space available to the processor, which is typically larger than the dedicated I/O space in I/O mapped I/O. Hence, statement 4 is not correct.

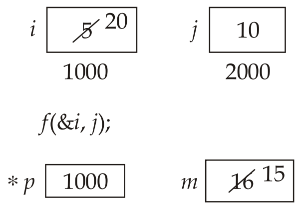
30. (c)

- In the single-precision IEEE 754 format, the exponent is stored using a bias value of 127. The actual exponent E is calculated as:

$$E = \text{Stored exponent} - 127$$

- Denormalized numbers are used to represent values closer to zero. Denormalized (or subnormal) numbers are represented with a biased exponent of all 0 bits, which represents an exponent of –126.
- For normalized number in IEEE 754, the mantissa (fraction) always has an implicit leading 1. e.g. if the mantissa is stored as xxxxx, it is interpreted as 1.xxxxx
- The sign bit in IEEE 754 represents the sign of the number, with 0 indicating positive and 1 indicating negative number.

31. (b)



When the function $f(\&i, j)$ is called, the variable 'i' is called by reference and variable 'j' is called by value. So, in function f, only value of i may change. When the function is called, $*p$ is pointing to i and $m = j = 10$. When the function is executed,

1. $m = m + 5;$ $\because m = 15$ and no change in the value of j
2. $*p = *p + m;$ $*p = 20$ i.e. $i = 20$

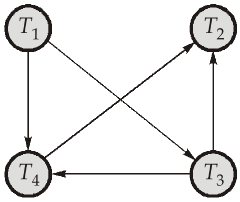
After the execution of function *f*, it returns nothing. The value of i is updated as $i = 20$ while the value of j remains at 10. Hence, the output of print *f* will be $(i + j) = 20 + 10 = 30$.

32. **(c)**

The tabular representation of the given schedule S is:

T_1	T_2	T_3	T_4
			$R(x)$
	$R(x)$		
		$R(x)$	
$R(y)$			
$W(y)$			
	$W(x)$		
		$W(y)$	
			$R(y)$

Precedence graph of schedule S:



Using topological sort, $T_1 \rightarrow T_3 \rightarrow T_4 \rightarrow T_2$ is conflict equivalent to S.

33. **(a)**

Control memory size = 512 control words

Control word size = 32 bits

Number of micro instructions in the microprogram = 100

Average cycles per microinstruction = 4

Clock speed = 2 GHz

Total cycles required to execute microprogram

$$= 100 \times 4 = 400 \text{ cycles}$$

Here,
$$\text{Clock period} = \frac{1}{\text{clock speed}} = \frac{1}{2 \times 10^9} = 0.5 \text{ ns}$$

$\therefore$
$$\text{Total execution time} = \text{Total cycles} \times \text{clock period}$$
$$= 400 \times 0.5 \text{ ns} = 200 \text{ ns}$$

34. **(b)**

- In segmentation, segments can be shared between process if they are marked as read-only (e.g., code segments like shared libraries). This allows processes to use the same segment without the risk of one process modifying it.
- Segmentation divides a process into logical units (e.g. code, data, stack) called segments. These segments can be stored in different, non-contiguous memory locations, as each segment has its own base and limit registers.
- Since segments are of variable sizes, free memory blocks may become fragmented and is too small to satisfy any application requirement. This is referred to as external fragmentation, which is a known issue in segmentation systems.

- While segmentation provides advantages like logical organization and sharing of segments, it is not inherently better than paging in terms of performance. Paging is often more efficient because it eliminates external fragmentation and provides fixed-size memory allocation, which is simpler to manage.

35. **(d)**

- When we multiply two n-bit numbers, the maximum result size can be of $2n$ bits.
  For example: For a 3-bit unsigned number, maximum value = 7. The multiplication of 3-bit unsigned numbers would result in a maximum value of $7 \times 7 = 49$ which requires 6-bits to represent that can be stored in one memory word.
  When two 16-bit unsigned numbers are multiplied, the result will be of 32-bits which can be stored in two memory words.
- Operations constituting a set of instructions are implemented by software whereas Operations with a single machine instruction are implemented by hardware.

Thus, statements 1, 3 and 4 are not correct.

36. **(c)**

- A full binary tree has all its nodes with either 0 or 2 children, meaning no node has only one child.
- In a binary tree, at each level, the maximum number of nodes is 2^i. Hence, the maximum number of nodes in a binary tree of height 'h' is
  $$N = 1 + 2^1 + 2^2 + ... + 2^{h-1} = 2^{h-1}$$
- A complete binary tree is defined as a binary tree in which all levels except the last are fully filled, and all nodes in the last level are as left-aligned as possible. This is different from a perfect binary tree, where all levels are fully filled.
- A binary search tree maintains the property where the left subtree contains nodes with values smaller than the parent node, and the right subtree contains nodes with values greater than the parent node.

37. **(a)**

- Associative mapping allows any block of memory to be placed in any cache line, thus avoiding fixed mappings that can cause cache conflicts.
- Associative mapping works by associating memory blocks with any cache line, as opposed to direct mapping, which fixes memory blocks to specific cache lines.

38. **(c)**

- The radiation resistance of a small loop antenna is indeed significantly lower than that of a half-wave dipole antenna because small loop antennas are inefficient radiators.
  Their radiation resistance is proportional to the fourth power of the loop circumference relative to the wavelength (C/λ), which makes it very small compared to a dipole.
- For a half-wave dipole, the radiation resistance is approximately 73 ohms.
- The radiation resistance is not directly proportional to the effective aperture. Instead, the radiation resistance depends on the physical size and geometry of the antenna and how efficiently it can radiate electro-magnetic energy.

Section B : Advanced Comm.-1 + Electronic Measurements & Instrumentation-1

39. (d)

Linear velocity of a satellite in the circular orbit can be given by,

$$V = \frac{\text{Circumference of the orbit}}{\text{Orbital period}} = \frac{2\pi a}{T}$$

where Radius of the orbit (a) = 29600 + 6400 = 36000 km

From Kepler's third law,

$$T^2 = \frac{4\pi^2 a^3}{\mu}$$

$$T = \frac{2\pi a\sqrt{a}}{\sqrt{\mu}}$$

So,

$$V = \frac{2\pi a}{T} = \frac{2\pi a}{\left(2\pi a\sqrt{a}/\sqrt{u}\right)} = \sqrt{\frac{\mu}{a}}$$

$$= \sqrt{\frac{4\times 10^5\,\text{km}^3/\text{s}^2}{36000\text{ km}}} = \frac{20}{6}\text{ km/s}$$

40. (c)

Number of cells in a cluster,

$$N = i^2 + ij + j^2 = 3^2 + (3\times 2) + 2^2 = 19$$

Now, number of clusters in the system

$$= \frac{\text{area of the system}}{\text{area of each cluster}}$$

Area of each cluster = number of cells in a cluster × 4 km^2

= 19 × 4 = 76 km^2

∴ Number of clusters $= \frac{1250}{76} = 16.45 \simeq 17$

41. (b)

Cluster size, N = 5

Total number of cell clusters $= \frac{25}{5} = 5$

Voice channels available = Voice channels per cluster

= 1200

Thus, system capacity = 5 × 1200 = 6000 channels

42. (c)

$$\text{LOS} = 4.12\left(\sqrt{h_t} + \sqrt{h_r}\right)$$

$$= 4.12\left(\sqrt{120} + \sqrt{16}\right)$$

$$= 4.12(10.954 + 4) = 61.61\text{ km}$$

43. (a)

- Fresnel zone clearance ensure minimal diffraction loss.
- Rain attenuation affects microwave frequencies.
- In terrestrial LOS microwave links, reflections from the ground or other obstacles can cause multipath fading which impacts received signal strength.
- Dopler shift is negligible in terrestrial LOS where the antennas are stationary.

Thus, statements 1, 2 and 4 are correct.

44. (d)

The relation between the refractive index and the frequency of propagation is given by

$$\mu = \sqrt{1 - \frac{81N}{f^2}},$$

where N = electron density in D-region and f is the frequency of the wave. For $\mu = 0.6$,

$$(0.6)^2 = \sqrt{1 - \frac{81N}{f^2}}$$

$$0.36 = 1 - \frac{81N}{f^2}$$

$$\frac{81N}{f^2} = 1 - 0.36 = 0.64$$

Given electron density in D-region, $N = 500\ \text{cm}^{-3}$. Substituting the value of N, we get

$$f^2 = \frac{81 \times 500}{0.64}$$

$$f = \sqrt{\frac{81 \times 500}{0.64}} = \frac{9 \times 10}{0.8} \times \sqrt{5} = \frac{900}{8} \times 2.23$$

$$f = 250.8 \cong 251\ \text{kHz}$$

45. (c)

- Handoff occurs when the user crosses $0.7 \times R = 0.7$ km in a cell
- Time to handoff, $$t = \frac{\text{Cell coverage distance}}{\text{speed}} = \frac{0.7}{30} \times 60\ \text{minutes}$$ $$= 1.4\ \text{minutes per handoff}$$
- $$\text{Handoff rate} = \frac{60}{1.4} \cong 43\ \text{handoffs per hour}$$

46. (a)

- Larger cluster size increases separation between co-channel cells and thus, reduces interference.
- Directional antennas focus energy in the required direction, reducing interference outside the main lobe.
- Lower transmitter power reduces interference to co-channel cells.
- Increasing beamwidth spreads power, potentially increasing interference.

Thus, statements 1, 2 and 3 are correct.

47. (b)

Observational error occurs due to improper observational techniques and is a systematic error. An example of this is the error due to parallax. It is a Non-permanent constant repetitive error, meaning it is not permanent but consistently repeats under similar conditions. Observational errors can be minimized by being more careful and attentive while taking measurements.

48. (d)

The given input signal is:

$$x(t) = \underset{\displaystyle f_1 = \frac{50\pi}{2\pi} = 25\text{ Hz}}{\underset{\Downarrow}{\frac{4}{\pi}\sin(50\pi t)}} + \underset{\displaystyle f_2 = \frac{100\pi}{2\pi} = 50\text{ Hz}}{\underset{\Downarrow}{\frac{2\pi}{3}\sin(100\pi t)}} + \underset{\displaystyle f_3 = \frac{75\pi}{2\pi} = 37.5\text{ Hz}}{\underset{\Downarrow}{3\sin(75\pi t)}}$$

Thus, the signal consists of three frequencies: 25 Hz; 50 Hz, 37.5 Hz.

A Wein Bridge is a frequency-selective circuit that provides a null indication at its resonant frequency. Since, the given signal has frequencies, 25 Hz, 50 Hz and 37.5 Hz and the problem specify the resonant frequency as 100 Hz, thus null indication will not occur.

Hence, option (d) is correct answer.

49. (a)

We have, $I_1 = 300 \pm 1\% = 300 \pm \left(300 \times \frac{1}{100}\right)\text{A}$

$I_1 = (300 \pm 3)\text{A}$

and $I_2 = (400 \pm 4)\text{A};$

Now, $I = I_1 + I_2$

$I = (300 \pm 3) + (400 \pm 4)$

$I = (300 + 400) \pm (3 + 4) = (700 \pm 7)\text{A}$

$$I = \left[700 \pm \left(\frac{7}{700} \times 100\right)\%\right]\text{A} = (700 \pm 1\%)\text{A}$$

Thus, we can write $I = (700 \pm 7)\text{A}$ or $I = (700 \pm 1\%)\ \text{A}$

Therefore, option (a) is correct.

50. (d)

The precision of instrument refers to the degree of consistency or repeatability in the measurements when the same quantity is measured multiple times under similar conditions.

51. (c)

- In terms of accuracy, the order of instruments are:
  Electrodynamometer (Highly accurate), permanent magnetic moving coil instrument
  Moving iron instrument (least accurate)
- In terms of sensitivity, the order of instruments are:
  Permanent magnetic moving coil instrument (Highly sensitive), moving iron instrument, electro dynamometer (least sensitive)

52. (d)

At balance, $$\left(R_1 + r_1 + \frac{1}{j\omega C_1}\right)R_4 = \left(R_2 + r_2 + \frac{1}{j\omega C_2}\right)R_3$$

On equating real parts,

$$(R_1 + r_1)R_4 = (R_2 + r_2)R_3$$

$$\Rightarrow \quad \left(\frac{R_1 + r_1}{R_2 + r_2}\right) = \frac{R_3}{R_4}$$

On equating imaginary parts,

$$\frac{R_4}{C_1} = \frac{R_3}{C_2} \quad \Rightarrow \quad \frac{C_1}{C_2} = \frac{R_4}{R_3}$$

53. (c)

Rate of change of inductance with deflection is,

$$\frac{dL}{d\theta} = \frac{d}{d\theta}(5 + \theta - 0.5\theta^2) = 1 - (0.5 \times 2)\theta = (1 - \theta)\mu\text{H/rad}$$

The deflection is, $$\theta = \frac{1}{2}\frac{I^2}{K}\frac{dL}{d\theta}$$

Given, $K = 15 \times 10^{-6}$ Nm/rad. Thus,

$$\theta = \frac{1}{2}\frac{(10)^2}{15 \times 10^{-6}}[1 - \theta] \times 10^{-6} = \frac{100}{30}[1 - \theta]$$

$$30\theta = 100 - 100\theta$$

$$\Rightarrow \quad \theta = \frac{100}{130} = 0.77 \text{ rad}$$

54. (a)

Number of full digits on a $4\frac{1}{2}$ digit display = 4

$$\therefore \quad \text{Resolution} = \frac{1}{10^4} = 0.0001 \quad \text{(or)} \quad 0.01\%$$

Resolution on 1 V range = 1 × 0.0001 = 0.0001 V

Therefore, on 1 V range, any reading can be displayed to 4th decimal place.
Hence, 0.2025 V will be displayed as 0.2025 on 1 V range.

55. (a)

In electrodynamometer type instrument, the magnetic field in which the coil moves is provided by the two coils and it uses the current under measurement to produce the necessary field flux which results in high power consumption.

56. (c)

In the graded index fiber, the profile of the refractive index is parabolic and due to this refocusing of the signal within the core is increased which eventually increases data rate.

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

57. (d)

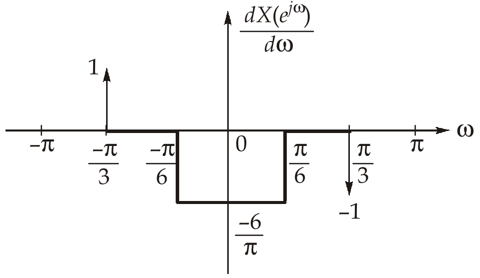
We know, $$X(e^{j\omega}) = \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n}$$

Using the multiplication by 'n' property of DTFT,

$$j\frac{dX(e^{j\omega})}{d\omega} = \sum_{n=-\infty}^{\infty} [nx[n]]e^{-j\omega n}$$

$$\Rightarrow \quad \sum_{n=-\infty}^{\infty} nx[n] = j\left.\frac{dX(e^{j\omega})}{d\omega}\right|_{\omega=0} \qquad \text{...(i)}$$

On differentiating the given graph $X(e^{j\omega})$,



∴ Using equation (i),

$$\sum_{n=-\infty}^{\infty} nx[n] = j\left[\frac{-6}{\pi}\right] = \frac{6}{j\pi}$$

58. (c)

We have, $z[n] = x[n] \cdot y[n]$

Using multiplication property of DTFS, Multiplication in time domain leads to convolution in Fourier series domain. We get,

$$Z_k = \sum_{r=\langle N\rangle} X_r Y_{k-r} = \sum_{r=0}^{5} X_r Y_{k-r}$$

$$\Rightarrow \quad Z_k = X_0Y_k + X_1Y_{k-1} + X_2Y_{k-2} + X_3Y_{k-3} + X_4Y_{k-4} + X_5Y_{k-5}$$

For k = 2:

$$Z_2 = X_0Y_2 + X_1Y_1 + X_2Y_0 + X_3Y_{-1} + X_4Y_{-2} + X_5Y_{-3} \qquad \text{...(i)}$$

We have, $$x[n] = 1+\cos\left(\frac{2\pi}{6}n\right) = 1+\frac{1}{2}e^{j\frac{2\pi}{6}n}+\frac{1}{2}e^{-j\frac{2\pi}{6}n}$$

∴ $$X_0 = 1,\ X_1 = \frac{1}{2},\ X_5 = X_{-1} = \frac{1}{2}$$

Similarly, $$y[n] = \sin\left(\frac{2\pi}{6}n+\frac{\pi}{4}\right)$$

$$= \frac{1}{2j}e^{j\frac{\pi}{4}}\cdot e^{j\frac{2\pi}{6}n} - \frac{1}{2j}e^{-j\frac{\pi}{4}}\cdot e^{-j\frac{2\pi}{6}n}$$

$\therefore$
$$Y_1 = \frac{1}{2j}e^{j\frac{\pi}{4}}, Y_5 = Y_{-1} = \frac{-1}{2j}e^{-j\frac{\pi}{4}}$$

Using equation (i),

$$Z_2 = X_1Y_1\left(\frac{1}{2}\right)\cdot\left(\frac{1}{2j}e^{j\frac{\pi}{4}}\right) = \frac{1}{4j}e^{j\frac{\pi}{4}}$$

59. (d)

Given,
$$x[n] = 1 + \sin\left(\frac{3\pi}{8}n + \frac{\pi}{4}\right)$$

$\Rightarrow$
$$\omega = \frac{3\pi}{8}$$

$\Rightarrow$
$$\frac{2\pi}{\omega} = \frac{2\pi}{\left(\frac{3\pi}{8}\right)} = \frac{16}{3} = \frac{N}{m} \rightarrow \text{a rational number}$$

$\therefore$ $x[n]$ is periodic with period $N = 16$

$\Rightarrow$
$$x[n] = 1 + \frac{e^{j\left(\frac{3\pi}{8}n+\frac{\pi}{4}\right)} - e^{-j\left(\frac{3\pi}{8}n+\frac{\pi}{4}\right)}}{2j}$$

$$= e^{j0\left(\frac{2\pi}{16}\right)n} + \frac{1}{2j}e^{j\frac{\pi}{4}}e^{j\left(\frac{2\pi}{16}\right)3n} - \frac{1}{2j}e^{-j\frac{\pi}{4}}e^{-j\left(\frac{2\pi}{16}\right)3n}$$

$$= X_0e^{j0\left(\frac{2\pi}{16}\right)n} + X_3e^{j\left(\frac{2\pi}{16}\right)3n} + X_{-3}e^{-j\left(\frac{2\pi}{16}\right)3n}$$

$\therefore$ The DTFS coefficients are,

$$X_0 = 1$$

$$X_3 = \frac{1}{2j}e^{j\frac{\pi}{4}}$$

$$X_{-3} = \frac{-1}{2j}e^{-j\frac{\pi}{4}}$$

We know,
$$X_k = X_{k+N}$$

$\Rightarrow$
$$X_{-3} = X_{-3+16} = X_{13} = \frac{-1}{2j}e^{-j\frac{\pi}{4}} = \frac{j}{2}e^{-j\frac{\pi}{4}}$$

60. (d)

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

Applying final value theorem,

$$\lim_{n\to\infty} x[n] = \lim_{z\to 1}(z-1)X(z)$$

$$= \lim_{z\to 1}(z-1)\frac{2z^{-1}(1-z^{-4})}{(1-z^{-1})^2}$$

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

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

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

$$= 2 \times 2 \times 2 = 8$$

61. (d)

Let $$X_1(z) = e^z = \sum_{n=0}^{\infty}\frac{z^n}{n!} = \sum_{n=-\infty}^{0}\frac{z^{-n}}{(-n)!} = \sum_{n=-\infty}^{\infty}\frac{1}{(-n)!}u[-n]z^{-n} \qquad \text{...(i)}$$

We know, $$X_1(z) = \sum_{n=-\infty}^{\infty} x_1[n]z^{-n} \qquad \text{...(ii)}$$

On comparing equations (i) and (ii),

$$x_1[n] = \frac{u[-n]}{(-n)!}$$

Similarly, consider $$X_2(z) = \frac{-z^{-1}}{1-z^{-1}}; \quad \text{ROC } |z| < 1$$

$\Rightarrow$ $$x_2[n] = u[-n]$$

$\therefore$ $$X(z) = e^z - \frac{z^{-1}}{1-z^{-1}} \longleftrightarrow x[n] = \frac{u[-n]}{(-n)!} + u[-n]$$

$\Rightarrow$ $$x[n] = \left[1 + \frac{1}{(-n)!}\right]u[-n]$$

62. (a)

Given, causal signal $$g[n] = \begin{cases}1; & n \text{ even}\\ 0; & n \text{ odd}\end{cases}$$

For a causal signal, $g[n] = 0$ for $n < 0$,

$\Rightarrow$ $$g[n] = \begin{cases}1, & n = 0, 2, 4, ...\\ 0, & \text{elsewhere}\end{cases}$$

$\Rightarrow$ $$g[n] = u\left[\frac{n}{2}\right]$$

We know, $$u[n] \longleftrightarrow \frac{1}{1-z^{-1}}; |z| > 1$$

Using the time-scaling property,

$$x(n/k) \longleftrightarrow X(z^k); \text{ROC}^{1/k}.$$

We get,

$$u\left[\frac{n}{2}\right] \longleftrightarrow \frac{1}{1-z^{-2}}; \quad |z| > 1$$

63. (c)

Correlation property of z-transform

$x_1[n] \longleftrightarrow X_1(z)$; ROC = R_1

$x_2[n] \longleftrightarrow X_2(z)$; ROC = R_2

Correlation sequence, $r_{x_1x_2}(m) = x_1(m) * x_2(-m)$

The convolution in time domain leads to multiplication in frequency domain.

$$\therefore \quad r_{x_1x_2}(m) \longleftrightarrow X_1(z)\cdot X_2(z^{-1})$$

with ROC: $R_1 \cap \dfrac{1}{R_2}$

64. (c)

Type	Symmetry	Length
I	Even symmetric	Odd
II	Even symmetric	Even
III	Odd symmetric	Odd
IV	Odd symmetric	Even

65. (d)

The N-point DFT of a signal $x[n]$ is given by

$$X(k) = \sum_{n=0}^{N-1} x[n]\cdot e^{-jk\frac{2\pi}{N}n}; k = 0, 1...., N-1$$

For direct calculation of N-point DFT, we require 'N^2' complex multiplications and '$N(N-1)$' complex additions.

$$\Rightarrow \quad A = N^2$$

$$B = N(N-1)$$

$$\therefore \quad \frac{B}{A} = \frac{N(N-1)}{N^2} = \frac{N-1}{N}$$

For $N = 8$:

$$\frac{B}{A} = \frac{8-1}{8} = \frac{7}{8}$$

66. (c)

Using Parseval's relation for DFT, $P = \sum_{n=0}^{N-1} |x[n]|^2 = \frac{1}{N}\sum_{k=0}^{N-1} |X(k)|^2$

$$\Rightarrow \quad P = \frac{1}{4}\sum_{k=0}^{3} |X(k)|^2$$

$$\Rightarrow \quad P = \frac{1}{4}\left\{|6|^2 + |2j-2|^2 + |-2|^2 + |-2-2j|^2\right\}$$

$$\Rightarrow \quad P = \frac{1}{4}\{36+8+4+8\} = \frac{56}{4}$$

$$\Rightarrow \quad P = 14 \text{ Watts}$$

67. (c)

The transformer takes a power of 440 VA at no load and rated voltage.Thus,

Input power, $V_1 I_0 = 440$ VA

As $V_1 = 220$ V

$$I_0 = \frac{440}{V_1} = \frac{440}{220} = 2\text{A}$$

We know that, Core loss $= V_1 I_0 \cos\phi_0$

$$220 = 440 \cos\phi_0$$

$$\cos\phi_0 = 0.5$$

As $\vec{I}_0 = \vec{I}_W + \vec{I}_\mu$

where Core loss component of no-load current,

$$I_W = I_c \cos\phi_0 = 2 \times 0.5 = 1 \text{ A}$$

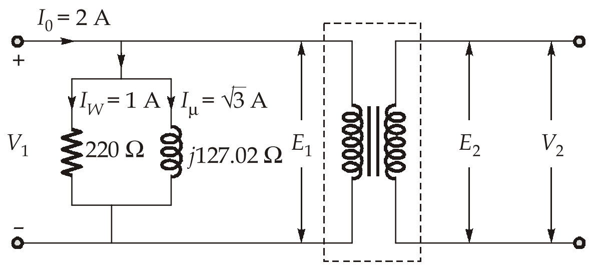
Magnetising component of no-load current,

$$I_\mu = \sqrt{I_0^2 - I_W^2} = \sqrt{2^2 - 1^2} = \sqrt{3} \text{ A}$$

And, $$|R_0| = \frac{V_1}{I_W} = \frac{220}{1} = 220\ \Omega$$

$$|X_0| = \frac{V_1}{I_\mu} = \frac{220}{\sqrt{3}} = 127.02\ \Omega$$

Thus, no load equivalent circuit for the transformer is given as



68. (a)

We know that,
$$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + P_c}$$

At maximum efficiency,

$$\text{variable copper loss} = \text{constant iron loss}$$
$$P_c = P_i = 300 \text{ W; it implies } P_i + P_c = P_i + P_i = 600 \text{ W}$$
$$\%\eta_{\max} = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + P_i} \times 100 = \frac{(25\times 10^3 \times 1)}{(25\times 10^3 \times 1) + 600} \times 100$$
$$\%\eta_{\max} = \frac{25000}{25600} \times 100 = 97.66\%$$

69. (a)

Instrument transformers, specifically current transformers (CTs) and voltage transformer (VTs), are used to step down the high currents and voltages respectively in a power system to a safe, measurable levels for instruments and protective devices.

70. (d)

- Autotransformers use a single winding instead of separate primary and secondary windings, which reduces the amount of copper required. Thus, autotransformers are efficient, compact and cost-effective for many applications where electrical isolation between primary and secondary is not required.
- They offer the advantages of using less copper and thus, providing higher efficiency.

71. (b)

Given,
$$V = 200 \text{ V}$$
$$I = 10 \text{ A}$$
$$\cos\phi = 0.8 \text{ lagging}$$
$$\text{Total 3-}\phi \text{ input power, } P_i = \sqrt{3} \times VI\cos\phi = \sqrt{3} \times 200 \times 10 \times 0.8 = 1.73 \times 2000 \times 0.8$$
$$= 2768 \text{ W}$$
$$\text{Stator losses, } P_{st} = 100 \text{ W}$$
$$\text{Total air gap power, } P_g = P_i - P_{st} = 2768 - 100 = 2668 \text{ W}$$
$$\text{Rotor copper loss, } P_{cu} = 106.72 \text{ W}$$
$$\therefore \quad \text{slip, } s = \frac{P_{cu}}{P_g} = \frac{106.72}{2668} = 0.04$$
$$\text{Rotor leakage reactance, } X_2' = 0.8\ \Omega$$
$$\text{For maximum torque at } s_{T\max} = s = 0.04$$
$$s = \frac{R_2'}{X_2'}$$
$$0.04 = \frac{R_2'}{0.8}$$
$$\Rightarrow \quad R_2' = 0.032\ \Omega$$

72. (a)

$$T_{\max} = 150 \text{ N-m}$$

slip at maximum torque, $s_{T\max} = 0.15$

Full load slip, $s_{fl} = 3\% = 0.03$

We have,
$$\frac{T}{T_{\max}} = \frac{2s\, s_{T\max}}{s_{T\max}^2 + s^2}$$

At $T = T_{fl}$, $s = s_{fl}$

$$\Rightarrow \quad \frac{T_{fl}}{T_{\max}} = \frac{2s_{fl}s_{T\max}}{s_{T\max}^2 + s_{fl}^2} = \frac{2\times 0.03\times 0.15}{0.15^2 + 0.03^2}$$

$$\frac{T_{fl}}{150} = 0.385$$

$$T_{fl} = 57.75 \text{ N-m}$$

73. (d)

Given, *sfl* = 0.02, *Tst* = 0.5 *Tfl*.

At starting, slip = 1. The ratio of starting torque to full load torque is given by,

$$\frac{T_{st}}{T_{fl}} = \left(\frac{I_{st}}{I_{fl}}\right)^2 \times s_{fl}$$

$$\frac{0.5T_{fl}}{T_{fl}} = \left(\frac{I_{st}}{I_{fl}}\right)^2 \times 0.02 \qquad (\because s_{fl} = 2\% = 0.02)$$

$$\left(\frac{I_{st}}{I_{fl}}\right)^2 = \frac{0.5}{0.02} = 25$$

$$\frac{I_{st}}{I_{fl}} = 5$$

$$\Rightarrow \quad I_{st} = 5 \times I_{fl}$$

74. (c)

- slip at maximum torque, $s_{T\max} = \dfrac{R_2}{X_2}$

  As rotor resistance R_2 increases, $s_{T\max}$ also increases.
- speed at maximum slip,

  $$N = (1 - s_{T\max})N_s$$

  As $s_{T\max}$ increases with increase in R_2, speed decreases.
- The maximum torque is given by,

  $$T_{\max} = \frac{kE_2^2}{2X_2}$$

  Hence, Maximum torque, $T_{\max}$ is unaffected by the rotor resistance.

75. (d)

The voltage regulation of a transformer is the percentage difference between its no-load voltage and full-load voltage relative to the full-load voltage. It occurs because the full load draws current that causes a voltage drop in the transformer due to its internal impedance. It is given as,

$$\text{Regulation} = \frac{I_2 R_{02} \cos\phi_2 \pm I_2 X_{02} \sin\phi_2}{E_2}$$

+ sign is used for lagging loads and –ve sign for leading loads. Hence, voltage regulation can be negative for the leading loads. Therefore, Statement (I) is false but Statement (II) is true.

❍❍❍❍