DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 16

Section A : Advanced Electronics + Materials Science

Section B : Electromagnetics + Computer Organization and Architecture

Section C : Advanced Comm.-2 + Electronic Measurements & Instrumentation-2

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Detailed Explanation
Section A : Advanced Electronics + Materials Science

1. (c)

- The use of CMOS results in zero or extremely low static power dissipation.
- CMOS inherently has a wider noise margin because the logic levels are closer to the supply rails (V_{DD} and GND), making it less susceptible to noise and voltage fluctuations.
- Option (c) is not a primary advantage. While CMOS is fast, the primary reason for its speed is related to device scaling and superior performance at lower V_{DD}. The statement that CMOS has shorter switching times for all logic gates due to minimal intrinsic capacitance is generally incorrect.
- In CMOS, the pMOS pulls the output completely upto V_{DD} and the nMOS pulls it completely down to GND, achieving full-swing logic levels and excellent signal integrity.

2. (d)

- LVS stands for Layout Versus Schematic.
- The LVS tool extracts the electrical netlist (components and their inter connections) from the physical layout data and compares it with the intended electrical netlist derived from the design's schematic (circuit diagram).

3. (c)

- Thermal CVD methods (such as low pressure CVD and atmospheric-pressure CVD) rely on high thermal energy to drive the chemical reactions, typically requiring temperatures well above 500°C.
- Plasma-enhanced CVD (PECVD) addresses this limitation by using radio-frequency (RF) power to create a glow discharge (plasma). The plasma-enhanced CVD operates at much lower temperatures (200°C to 400°C), making it ideal for deposition after critical high-temperature processing steps.

4. (a)

Statement 1 is correct because clock gating eliminates unnecessary switching activity in idle blocks, which directly reduces dynamic power. The dynamic power dissipation is given as

$$P_{\text{dynamic}} = \alpha C V^2 f$$

Statement 2 is correct because MTCMOS (or multi V_t design) is a standard leakage reduction technique.

The high-V_t transistors used on Non-critical path in MTCMOS has low leakage while low-V_t transistors are used on critical paths which is fast but has leakage.

Statement 3 is incorrect because parallelism at the same supply voltage increases the total switched capacitance per cycle and may increase the operating frequency and hence the energy per operation may remain the same or even increase. Energy reduces significantly only when parallelism is combined with voltage scaling. Thus, only statements 1 and 2 are correct.

5. (b)

The Czochralski (CZ) or Float-Zone (FZ) processes which grow single-crystal silicon ingots, require ultra-pure polycrystalline silicon as the input material. This ultra-pure polysilicon is known as Electronic Grade Silicon (EGS) or Semiconductor Grade Silicon (SGS).

Process flow:

- MGS (Metallurgical Grade Silicon) → First stage
- After purification → Electronic Grade Silicon → Fed into CZ/FZ puller
- Final ingot → Single-Crytal Silicon Wafer

Float-zone silicon is a refining and crystal-growth method, not the starting raw material.

6. (c)

- Level-sensitive scan design was IBM's original scan method, which used level-sensitive latches.
- Modern industry-standard scan uses edge-triggered muxed-D-flip-flops and is widely referred to as scan design.
- The technique that incorporates both level-sensitive principles and scan-path using shift registers in production VLSI is full scan design using muxed D flip-flops.

7. (b)

- Virtually all modern smartphones, tablets, and battery-constrained embedded systems use ARM-based cores.
- x86 architectures are power-hungry and primarily oriented toward desktop and server applications.
- MIPS has largely lost its share of the mobile market.
- Although RISC-V is an open ISA, its low-power mobile ecosystem and implementations are still far behind ARM in terms of maturity as of 2025.

8. (c)

Under constant-field scaling, the power dissipation of a MOS device scales as:

$$P_{\text{scaled}} = \frac{P}{S^2}$$

9. (b)

If a system is built from N components, each of which must function correctly, then the yield of the system Y_t is the product of the yields Y_C of the components:

$$Y_t = Y_C^N$$

For a 16-core processor, if each core has a yield of 0.9, then

$$\text{Yield of chip} = (0.9)^{16}$$

10. (d)

All the given statements are correct.

11. (c)

Given:

$$A = 60.2$$
$$\rho = 6250 \text{ kg/m}^3$$
$$N_A = 6.02 \times 10^{26}\text{/kg-mole}$$

⇒
$$\frac{n}{V_c} = \frac{N_A \rho}{A}$$
$$= \frac{6.02\times10^{26}\times6250}{60.2}$$

$$\Rightarrow \qquad \frac{n}{V_c} = 625 \times 10^{26}$$

For an FCC Lattice, $n = 4$

$$\Rightarrow \qquad V_c = \frac{n}{625\times10^{26}} = \frac{4}{625\times10^{26}} = a^3$$

$$a = 4 \times 10^{-10}\text{ m}$$

12. (c)

For a cubic unit cell with edge length 'a' and a plane with Miller indices h, k, l, the inter-planar spacing 'd_{hkl}' is given as

$$d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

Given: $(h\ k\ l) = (2\ 3\ 1)$

FCC structure with atomic radius,

$$R = 0.125\text{ nm}$$

For an FCC structure, $a = 2\sqrt{2}R = 2\sqrt{2}\times0.125\text{ nm}$

$$= 0.353\text{ nm}$$

Hence, $d_{231} = \dfrac{0.353\text{ nm}}{\sqrt{2^2+3^2+1^2}} = 0.094\text{ nm}$

13. (b)

Statement 1:

APF of BCC (0.68) > APF of SC (0.52) $\rightarrow$ Correct

APF of BCC (0.68) < APF of FCC (0.74) $\rightarrow$ Correct

$\therefore$ Statement 1 is correct.

Statement 2:

Coordination number of HCP = 12

Coordination number of FCC = 12

Coordination number of BCC = 8

Thus, HCP has the same coordination number as FCC and a higher coordination number than BCC.

$\therefore$ Statement 2 is correct.

Statement 3:

Among SC, BCC and FCC, the APFs are:

SC = 0.52, BCC = 0.68, FCC = 0.74

Clearly, the simple cubic structure has the lowest APF, not the highest.

$\therefore$ Statement 3 is incorrect.

14. (a)

Statement 1

- A substitutional impurity replaces a host atom at its normal lattice site. Since the size difference is usually small, the resulting lattice strain is moderate.

- A self-interstitial atom (the same metal atom forced into an interstitial void) must squeeze into a space much smaller than a normal atom site, causing very large local distortion. Hence, statement 1 is correct.

Statement 2

- Vacancies are thermodynamic equilibrium defect.
- The equilibrium concentration of vacancies:

$$N_V = Ne^{-\frac{Q_V}{kT}}$$

where Q_V is vacancy formation energy.
At T = 0 K, $N_V \rightarrow 0$ (theoretically zero in a perfect crystal).
Hence, vacancy concentration increases exponentially with temperature.
So, statement 2 is correct.

Statement 3

The size of the largest interstitial sites (relative to atom radius r) is:

- BCC tetrahedral site: ~0.291r
- BCC octahedral site : ~0.155r
- FCC/HCP octahedral site : ~0.414r
- FCC/HCP tetrahedral site : ~0.225r

The largest interstitial sites occur in FCC and HCP structures, not in BCC. In BCC, interstitial sites are smaller. Hence, statement 3 is incorrect.
Therefore, the correct option is '*a*'.

15. (c)

Dielectric strength is the potential gradient required to cause breakdown in a material.
Thus,

$$\text{Dielectric strength} = \frac{\text{Breakdown voltage}}{\text{Thickness}}$$

$$\Rightarrow \quad \text{Thickness} = \frac{\text{Breakdown voltage}}{\text{Dielectric strength}}$$

$$= \frac{33\times10^3 \text{ Volt}}{40000 \text{ V/mm}} = 0.825 \text{ mm}$$

16. (a)

- P → Large particle reinforced → Concrete (gravel in cement)
- Q → Dispersion strengthened → Very fine oxide particles (Al_2O_3 in SAP, ThO_2 in TD-Ni)
- R → Continuous fiber reinforced → Carbon/epoxy, glass/epoxy
- S → Laminar composites → Plywood, bimetallics, sandwich panels

∴ Correct matching: P – 2, Q – 4, R – 1, S – 3

17. (c)

- Glass fibers in polyester : $\frac{l_c}{d} \approx 40 - 100$

- Carbon fibers in epoxy : $\frac{l_c}{d} \approx 60-140$
- Boron fibers in aluminium : $\frac{l_c}{d} \approx 80-120$

Commercial composites typically use fiber lengths that are 10-50 times the critical length for safety. Therefore, the critical length itself is usually 50-150 times the fiber diameter.

Hence, the correct option is (c).

18. (a)

- Orbital and electron-spin angular momentum associated with electronic motion give rise to permanent magnetic moment and also contribute to permanent electric dipole moments in molecules with unpaired electrons or asymmetric charge distributions (e.g., polar molecules, paramagnetic substances).
- Nuclear spin contributes to the nuclear magnetic moment but does not produce any significant permanent electric dipole moment because the nucleus is centrally located and its charge distribution is symmetric.

∴ Only 1 and 2 contribute to the permanent electric dipole moment.

Hence, the correct option is (a).

19. (a)

- Cordierite has the exact composition:
  $2MgO.\ 2Al_2O_3\ .\ 5\ SiO_2$.
- $BaTiO_3 \rightarrow$ Barium titanate (ferroelectric).
- $MgO + Al_2O_3 \rightarrow$ Magnesium aluminate spinel.
- YSZ $\rightarrow$ Yttria–stabilized zirconia

Hence, the correct option is (a)

20. (b)

$$\text{Force density} = \frac{B^2}{2\mu_0} = \frac{1}{2}\times\frac{1.6\times1.6}{4\pi\times10^{-7}}$$
$$= 1.01 \times 10^6\ \text{N/m}^2$$

21. (d)

$$\text{Density of atoms (N)} = \frac{N_A\rho}{M_{at}} = \frac{6.023\times10^{23}\times8.4}{63.5}$$

The density of vacancies at 1000°C is given by,

$$N_v = Ne^{-\frac{Q_v}{kT}}$$
$$Q_v = \text{Activation energy} = 0.9\ \text{eV}$$
$$N_v = 8\times10^{22}\, e^{-\frac{0.9\ \text{eV}}{8.62\times10^{-5}\,\text{eV/K}\times1273\text{K}}}\ \text{cm}^{-3}$$
$$= 2.2 \times 10^{19}\ \text{vacancies/cm}^3$$
$$= 2.2 \times 10^{25}\ \text{vacancies/m}^3$$

22. (d)
- High dielectric strength
- High volume resistivity
- Very low dissipation factor

23. (b)
- Fe_3O_4 (Magnetite) $\rightarrow$ Ferrimagnetic
- NiO $\rightarrow$ Rock-salt structure, classic antiferromagnetic below the Neel temperature (i.e. 523 K)
- γ-Fe_2O_3 (Maghemite) $\rightarrow$ Ferrimagnetic.
  It is used in magnetic recording.
- CrO_2 $\rightarrow$ Ferromagnetic
  $\therefore$ Only NiO is purely antiferromagnetic.

24. (c)
- Change in length during magnetization is called the Joule effect. Joule effect is also known as magnetostriction.
- Change in magnetization due to applied stress is called the Villari effect. Villari effect is also called as Inverse magnetostriction.
- The twist produced when longitudinal and circular magnetic fields are applied is called Wiedemann effect.

$\therefore$ The basic dimensional change (extension/contraction) is the Joule effect.
Hence, the correct option is (c).

25. (a)

P. Gadolinium $\rightarrow$ Rare-earth ferromagnet,
- $T_c = 293$ K
- Ferromagnetic at room temperature

Q. Copper $\rightarrow$ Diamagnetic material

R. α-Manganese
- Has a complex non-collinear antiferromagnetic structure.
- Has no net magnetic moment.
- Effectively behaves like a paramagnetic material above the Neel temperature, but at room temperature it behaves as a weakly paramagnetic/antiferromagnetic material.

S. Aluminium $\rightarrow$ Typical paramagnetic material.

26. (b)

Given:
$$l = 100 \text{ m}$$
$$R = 2\ \Omega$$
$$\rho = 1.7 \times 10^{-8}\ \Omega\text{-m}$$

We know, Resistance, $R = \dfrac{\rho l}{A}$

$$\Rightarrow \quad A = \frac{\rho l}{R} = \frac{1.7 \times 10^{-8} \times 100}{2}$$
$$A = 8.5 \times 10^{-7} \text{ m}^2$$

also, $A = \frac{\pi d^2}{4}$

$$d^2 = \frac{4A}{\pi} = \frac{4 \times 8.5 \times 10^{-7}}{\pi} = 1.0823 \times 10^{-6}$$

$$d = 1.04 \times 10^{-3} \text{ m}$$

27. (d)

The resistance-temperature relation is given by:

$$R_T = R_0(1 + \alpha T)$$

$$\frac{R_{25}}{R_{70}} = \frac{50}{57.2} = \frac{R_0(1+\alpha\times 25)}{R_0(1+\alpha\times 70)}$$

$$\Rightarrow \quad 50 + \alpha \times 50 \times 70 = 57.2 + \alpha \times 25 \times 57.2$$

$$\Rightarrow \quad \alpha(3500 - 1430) = 7.2$$

$$\alpha = \frac{1}{287.5}$$

28. (b)

The variation of transition temperature (T_c) with isotopic mass is given by,

$$T_c \propto \frac{1}{\sqrt{M}}$$

$$\Rightarrow \quad \frac{T_{c_2}}{T_{c_1}} = \sqrt{\frac{M_1}{M_2}}$$

$$\Rightarrow \quad T_{c_2} = \sqrt{\frac{M_1}{M_2}} \cdot T_{c_1}$$

$$T_{c_2} = \sqrt{\frac{202}{200}} \times 4.153 \text{ K}$$

$$T_{c_2} = 4.17 \text{ K}$$

$$T_{c_2} \simeq 4.2 \text{ K}$$

29. (b)

A Type-I superconductor has very large conductivity below a critical temperature. Therefore, statement I is incorrect.

30. (c)

Since different electrons have the same mass but different kinetic energies, the velocities of all electrons cannot be equal. Hence, statement 1 is wrong. The average velocity of the electron gas is proportional to $\sqrt{T}$. Hence statement 4 is wrong.

31. (b)

The repulsion of magnetic flux lines from the interior of a magnetic material below the critical temperature is known as Meissner effect.

32. (a)

The statement given in option (a) correctly describes the required components and their roles.

Donor = Planar organic molecule

Acceptor = Non-organic Anion

These form a stable charge-transfer salt that exhibits super conductivity.

33. (b)

The phenomenon in which a material is driven from the superconducting state (zero resistance) to the normal state (resistive) by exceeding either the critical current density (J_c) or the critical magnetic field (H_c) is called a Quench.

34. (d)

- Silsbee's rule → Applies universally to both Type-I and Type-II superconductor; hence, it is not specific to soft superconductors.
- Curie-Weiss law → Completely unrelated to superconductivity.
- Meissner effect → A perfect (complete) Meissner effect is the defining property of soft (Type-I) superconductors.
- Faraday rotation → A well-known magneto-optical effect historically used to visualize the intermediate state in Type-I (soft) superconductors.

35. (c)

- Dry etching (Plasma-based) achieves highly directional etching, which is essential for creating deep, straight sidewalls required for sub-micron and nanoscale features in modern VLSI circuits. Anisotropy means that the etch rate is much faster in the vertical (downward) direction than in the lateral (sideways) direction.
- Statement (II) is false. Wet etching uses liquid chemicals and is typically isotropic (etches equally in all directions), leading to undercutting of the mask. This undercutting makes wet etching unsuitable for defining tiny, high-precision sub-micron features of modern VLSI circuits, which require anisotropic etching control.

36. (a)

The depletion width in a region decreases as the doping concentration in that region increases. Since the concentration of acceptor atoms is higher, the depletion region will not extend significantly into the p^+ substrate.

37. (a)

An alloy has a less regular structure than a pure metal, which increases electron scattering. As a result, the conductivity of the alloy decreases with an increase in alloy content, and the resistivity of the alloy increases in comparison to that of a pure metal.

38. (c)

- Statement (I) is true because pure elemental metals such as Hg(T_c = 4.15 K), Pb(T_c = 7.2 K), Nb(T_c = 9.25 K) etc. exhibit superconductivity below a well-defined critical temperature (T_c) that is characteristic of each metal.
- Statement (II) is false because superconductivity is a cooperative phenomenon of the entire compound or alloy. It is not necessary for the constituent elements themselves to be superconducting.

Section B : Electromagnetics + Computer Organization and Architecture

39. (b)

$$\frac{m\pi}{a} = 40\,\pi \quad \Rightarrow \quad m = 40 \times 5 \times 10^{-2} = 2$$

$$\frac{n\pi}{b} = 100\,\pi \quad \Rightarrow \quad n = 100 \times 3 \times 10^{-2} = 3$$

$\Rightarrow$ $$\text{mode} = TE_{23}$$

$$\beta_g = 52.9\,\pi \text{ rad/m}$$

40. (d)

$$(Z_{in})_{max} = Z_0 \times \text{VSWR}$$

$\Rightarrow$ $$\text{VSWR} = \frac{(Z_{in})_{max}}{Z_0} = \frac{200}{100} = 2$$

41. (d)

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{200\times10^6} = 1.5 \text{ m}$$

The standing-wave magnetic field has a null starting at $\frac{\lambda}{4}$ from the conducting surface, and the distance between adjacent nulls is $\frac{\lambda}{2}$.

So, the second null occurs at:

$\therefore$ $$\text{Distance} = \frac{\lambda}{4} + \frac{\lambda}{2} = 3\frac{\lambda}{4} = \frac{3}{4}\times1.5 = 1.125 \text{ m}$$

42. (b)

$$\text{Guide wavelength, } \lambda_g = \frac{\lambda_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{\frac{(3\times10^{10})}{2f_c}}{\sqrt{1-\left(\frac{f_c}{2f_c}\right)^2}} \text{ cm} \quad \left(f_c = \frac{3\times10^{10}}{2\times2} = 7.5 \text{ GHz and } f = 2f_c\right)$$

$$= \frac{\frac{(3\times10^{10})}{(2\times7.5\times10^9)}}{\sqrt{1-\frac{1}{4}}} = \frac{2}{\sqrt{3}}\times2 = \frac{4}{\sqrt{3}} \text{ cm}$$

43. (a)

Since $U(\theta)$ is independent of ϕ, the beam is symmetrical about $\theta = 0$.

Setting $U(\theta) = 0.5$, we have $e^{(-20\theta^2)} = 0.5$

$$-20\theta^2 = \ln(0.5)$$

$\Rightarrow \quad 20\theta^2 = \ln 2 \quad \Rightarrow \quad \theta^2 = \frac{\ln(2)}{20}$

$\Rightarrow \quad \theta = \pm 0.186$ rad

$\Rightarrow$ Half-power beamwidth, HPBW = 2 × θ = 0.372 rad or 21.31°

44. (a)

The Laplacian in cylindrical coordinates is:

$$\nabla^2 D = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho \frac{\partial D}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 D}{\partial \phi^2} + \frac{\partial^2 D}{\partial z^2}$$

$$= \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho \cdot 20\rho \sin 2\phi) + \frac{1}{\rho^2}\cdot 10\rho^2(-4\sin 2\phi)$$

$$= \frac{1}{\rho}\times 40\rho \sin 2\phi - 40 \sin 2\phi = 0$$

45. (b)

$$\vec{E}_1 = 60\sin\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_z \text{ V/m}$$

$$\vec{H}_1 = H_1 \sin\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_{H_1}$$

Where, $H_1 = \frac{60}{120\pi} = \frac{1}{2\pi}$ A/m

and $\hat{a}_{H_1} = \hat{a}_x \times \hat{a}_z = -\hat{a}_y$

$\Rightarrow \quad \vec{H}_1 = -\frac{1}{2\pi}\sin\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_y$ A/m

$$\vec{E}_2 = 40\cos\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_y \text{ V/m}$$

$$\vec{H}_2 = H_2 \cos\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_{H_2}$$

Where, $H_2 = \frac{40}{120\pi} = \frac{1}{3\pi}$ A/m

$$\hat{a}_{H_2} = \hat{a}_x \times \hat{a}_y = \hat{a}_z$$

$\Rightarrow \quad \vec{H}_2 = \frac{1}{3\pi}\cos\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_z$ A/m

$\therefore \quad \vec{H} = \frac{1}{6\pi}\left[2\cos\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_z - 3\sin\left(2\pi\times 10^6 t - \beta x\right)\hat{a}_y\right]$ A/m

46. (b)

$$V = -\int_{r=2}^{r=1} \vec{E}\cdot \vec{dr}$$

$$= -\int_2^1 \frac{10}{r^2} dr = \left[\frac{10}{r}\right]_2^1 = 10 - 5 = 5 \text{ V}$$

47. (b)

Statement 1 – True

For a rectangular waveguide with $a > b$, the lowest (dominant) mode is TE_{10}. Its cutoff wavelength for mode indices (m, n) is:

$$\lambda_{c_{mn}} = \frac{2}{\sqrt{(m/a)^2 + (n/b)^2}} \quad \Rightarrow \quad \lambda_{c_{10}} = 2a$$

so statement 1 is correct (for air-filled guide)

Statement 2 - True

By definition, TE (transverse electric) modes have no longitudinal electric field component, $E_z = 0$. However, they do have a longitudinal magnetic field component H_z which is non-zero for TE modes. So statement 2 is correct.

Statement 3 - True

If $f < f_c$, the axial propagation constant becomes purely imaginary (β is imaginary), and the field decays exponentially along the guide (evanescent mode). The time-average real power transmitted along the guide in propagation direction is essentially zero for a purely evanescent wave (only reactive energy oscillation occurs, with no net transmitted power transmission). So statement 3 is correct.

Statement 4 - False

For a guided propagating mode ($f > f_c$), the phase velocity is

$$v_p = \frac{\omega}{\beta} = \frac{c}{\sqrt{1-(f_c/f)^2}}$$

which is always greater than c (since denominator < 1). The group velocity is $v_g = c\sqrt{1-(f_c/f)^2}$, which is < c. Therefore, the claim that v_p is always less than c is false. Hence 4 is incorrect.

So, the correct statements are 1, 2 and 3 → (option b)

48. (b)

$$\text{Reflection coefficient, } \Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

If $Z_L = Z_0$, then $\Gamma = 0$

Hence, no reflection occur, and the line appears as an infinitely long line.

49. (d)

- A micro program is a program for the control unit of a processor.
- A micro program is a set of instructions for primitive operations in a system.

50. (c)

Using the Least Recently Used (LRU) technique, the page replacement process is shown below:

				6	7	10	4	8
		5	7	7	6	7	10	4
	7	7	5	5	5	6	7	10
4	4	4	4	4	4	5	6	7
4-m	7-m	5-m	7-Hit	6-Hit	7-Hit	10-m	4-m	8-m

5	8	6	8	11	4	9	5	9
8	5	8	6	8	11	4	9	5
4	4	5	5	6	8	11	4	4
10	10	4	4	5	6	8	11	11
5-m	8-Hit	6-m	8-Hit	1-m	4-m	9-m	5-m	9-Hit

6	9	12	4	7	5	7
9	6	9	12	4	7	5
5	5	6	9	12	4	4
4	4	5	6	9	12	12
6-m	9-Hit	12-m	4-m	7-m	5-m	7-Hit

Total misses (Page faults) = 18

51. (b)

It is not always necessary that a BCNF relation be dependency-preserving.

52. (c)

4800 revolutions —— 60 sec

1 revolution —— $\frac{60}{4800} = \frac{1}{80}$ sec

Let each sector contain 'x' bytes.

- Data per track = $400 \times x$ bytes
- Time for one revolution = $\frac{1}{80}$ s.

Therefore,

$$\text{Data rate} = 400 \times x \times 80 = 20 \times 10^6 \text{ B/s}$$

$$\Rightarrow \quad x = \frac{20\times10^6}{400\times80} = 625 \text{ bytes}$$

53. (a)

To create the precedence graph:

(a) Create a node T in the graph for each participating transaction in the schedule.

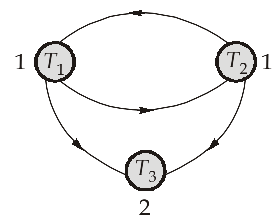
(b) For the conflicting operations read (X) and write (X): If a transaction T_j executes a read (X) after T_i executes a write (X), draw an edge from T_i to T_j in the graph.

(c) For the conflicting operations write (X) and read (X): If a transaction T_j executes a write (X) after T_i executes a read (X), draw an edge from T_i to T_j in the graph.

(d) For the conflicting operations write (X) and write (X): If a transaction T_j executes a write (X) after T_i executes a write (X), draw an edge from T_i to T_j the graph.

The schedule S is serializable if there is no cycle in the precedence graph.

Precedence graph:



54. (d)

$$32 \text{ kB} = 2^{15} \times 8\text{-bits}$$

Required pins:

- 15 address lines
- 8 data lines
- 1 chip-enable pin
- 1 read/write pin

Thus, Minimum pin required = 25 pins

Maximum unused pins = 40 – 25 = 15

55. (b)

Cache is used along with main memory to speed up execution → Cache → High speed RAM (1).
DMA I/O is used for data transfers between memory and secondary storage (disks) taking control from the CPU while using main memory.
DMA I/O → Disk (2)

56. (d)

- For $d = \frac{\lambda}{2}$, no grating lobes occur. Hence, statement (I) is incorrect.
- Grating lobes indeed appear only when the element spacing exceeds λ.

57. (a)

$$\text{Directivity} = \frac{\text{Maximum radiation intensity}}{\text{Average radiation intensity}}$$

For an isotropic radiator, both quantities are equal $\Rightarrow$ Directivity = 1
Hence, both the statements are correct and statement II is the correct explaination of statement (I).

58. (a)

In pipelining, the concept of overlapped execution of instructions is used, which improves performance and helps reduce the effective memory requirements of programs.

59. (b)

Both the statements are true. But statement (II) is not the explanation of statement (I).

Section C : Advanced Comm.-2 + Electronic Measurements & Instrumentation-2

60. (b)

LEO
- Low altitude
- High Resolution
- Low delay
- Low free space loss

MEO
- Lower delay than GEO (acceptable for navigation)
- Large coverage

Examples: GPS, GlONASS, GALILEO

HEO (Molniya/Tundra)
- Target regions: Russia and polar regions, where GEO satellites appear too low in the sky.

61. (b)
- Disaster monitoring requires rapid revisit $\Rightarrow$ LEO
- Global broadband internet with low latency $\Rightarrow$ LEO (starlink, oneweb)
- Fixed weather observation of the Indian subcontinent $\Rightarrow$ GEO
- Polar region communication $\Rightarrow$ HEO (Molniya)

62. (c)

We know that,

$$\text{Radio maximum LOS, } d_{\text{radio}} = 4.123\left[\sqrt{h_t} + \sqrt{h_r}\right]$$
$$= 4.123\left[\sqrt{h_1} + \sqrt{16}\right]$$
$$d_{\text{radio}} = 4.123\left[\sqrt{h_1} + 4\right] \quad \text{...(i)}$$

Similarly,

$$\text{Geometric maximum LOS, } d_{\text{Geo}} = 3.57\left[\sqrt{h_1} + \sqrt{h_2}\right]$$
$$= 3.57\left[\sqrt{h_1} + \sqrt{16}\right]$$
$$= 3.57\left[\sqrt{h_1} + 4\right] \quad \text{...(ii)}$$

According to the given condition:

$$d_{\text{radio}} - d_{\text{Geo}} = 4.123\left[\sqrt{h_1} + 4\right] - 3.57\left[\sqrt{h_1} + 4\right]$$
$$3.871 = 4.123\sqrt{h_1} - 3.57\sqrt{h_1} + 4[4.123 - 3.57]$$
$$\frac{3.871 - 4[4.123 - 3.57]}{4.123 - 3.57} = \sqrt{h_1}$$
$$\frac{3.871}{4.123 - 3.57} - 4 = \sqrt{h_1}$$
$$7 - 4 = \sqrt{h_1}$$
$$h_1 = 9 \text{ m}$$

63. **(b)**

A wide band satellite signal before being transmitted to the satellite, is amplified by a Travelling Wave Tube (TWT).

64. **(c)**

Three geosynchronous satellite can give 100% global coverage. Therefore statement 4 is incorrect.

65. **(c)**

Rount-trip propagation delay,

$$t = \frac{2d}{c}$$

where, $d \approx 36000$ km

So, $$t = \frac{2 \times 36000}{3 \times 10^5} = 240 \text{ msec}$$

66. **(d)**

We know that,

$$p = 3, q = 11, e = 3$$
$$z = (p - 1)(q - 1)$$
$$z = (3 - 1)(11 - 1)$$
$$z = 20$$
$$(e \times d) \text{mod } z = 1$$
$$(3 \times d) \text{mod } z = 1$$
$$(3 \times d) \text{mod } 20 = 1$$
$$3d = 20 \times 1 + 1$$
$$d = 7$$

67. **(d)**

- Measurement of non-electrical quantities (such as force, pressure, temperature, displacement, etc.) often relies on mechanical, thermal or chemical principles that are highly susceptible to environmental and physical factors.
  Hence, statement 1 is correct.
- The sequence accurately describes the typical functional blocks in a measurement system. Hence, statement 2 is correct.
- Piezoelectric sensors (such as accelerometers and force sensors) generate an electric charge when mechanical stress is applied. They have excellent frequency response and are very sensitive, making them ideal for measuring dynamic phenomenona such as vibrations, impacts and rapidly changing forces. Hence, statement 3 is correct.

Therefore, all of the above statements are correct.

68. **(c)**

A DVM having a $4\frac{1}{2}$ digit display will read the 1 volt range as 1.9999. Therefore, statement 1 is wrong.

69. (c)

- A Bourden tube is used for the measurerment of medium and high pressure.
- Pirani and McLeod gauges are used for the measurement of vaccum pressure.
- A Doppler Vibrometer is used for the measurement vibration, not pressure.

70. (a)

- Real thermistors do not follows a perfectly exponential relationship.
  The Steinhart-Hart equation provides the best-fit model:
  $$\frac{1}{T} = A + B \ln R + C(\text{In } R)^3$$
  Thus, statement 1 is correct.
- For an NTC thermistor:
  As Temperature$\uparrow \Rightarrow$ Resistance $\downarrow$
  The curve becomes flatter at higher temperatures, which implies that $\left|\frac{dR}{dT}\right|$ decreases at high temperatures. Hence, the sensitivity magnitude decreases, not increases. Therefore, statement 2 is incorrect.
- Self-heating error:
  $$\Delta T = \frac{P}{\delta}$$
  where δ is the dissipation constant.
  A higher δ results in a smaller temperature rise and hence less self-heating error. Therefore, statement 3 is correct.
- The β depends only on the material, not on the specific temperature points used for callibration. This is why manufacturers quotes a single β-points. Hence, statement 4 is correct.

71. (c)

We know that:

$$\text{Charge, } Q = \text{Charge sensitiity} \times \text{Applied Pressure}$$
$$Q = 400 \text{ pC/bar} \times 12 \text{ bar}$$
$$Q = 4800 \text{ pC}$$
$$\text{Output voltage, } V_0 = Q \times \text{gain}$$
$$V_0 = 4800 \times 5 \times 10^{-3}$$
$$V_0 = 24 \text{ V}$$

72. (b)

$$\frac{f_x}{f_y} = \frac{\text{Points of tangency to the verticle line}}{\text{Points of tangency to the horizontal line}} = \frac{1}{2}$$

or $$f_x : f_y = 1 : 2$$

73. (c)

Both statements are correct.

74. (d)

Both the X and Y inputs are of the same frequency and in phase. Hence, the waveform will be a straight line.

75. (b)

A CRO is capable of measuring of high frequencies and uses high-gain amplifiers for its operation. However, the use of high-gain amplifiers is not the correct explanation for its ability to measure high frequencies.

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