DETAILED SOLUTIONS

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ESE 2023 : 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

1.	(b)	16.	(b)	31.	(c)	46.	(a)	61.	(c)
2.	(d)	17.	(a)	32.	(b)	47.	(c)	62.	(a)
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4.	(a)	19.	(b)	34.	(c)	49.	(b)	64.	(c)
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6.	(a)	21.	(c)	36.	(c)	51.	(d)	66.	(b)
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11.	(c)	26.	(a)	41.	(b)	56.	(a)	71.	(d)
12.	(b)	27.	(b)	42.	(b)	57.	(d)	72.	(b)
13.	(d)	28.	(c)	43.	(d)	58.	(d)	73.	(c)
14.	(c)	29.	(a)	44.	(a)	59.	(c)	74.	(c)
15.	(d)	30.	(b)	45.	(a)	60.	(b)	75.	(b)

Detailed Explanation
Section A : Advanced Electronics + Materials Science

1. (b)

The FZ grown crystal has higher breakdown voltage than CZ process.

2. (d)

We know,

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}}$$

$$\frac{\epsilon_{ox(SiO_2)}}{t_{ox(SiO_2)}} = \frac{\epsilon_{ox(HfO_2)}}{t_{ox(HfO_2)}}$$

$$\frac{3.9}{2} = \frac{25}{t_{ox(HfO_2)}}$$

$$t_{ox(HfO_2)} = \frac{50}{3.9}$$

$$t_{ox(HfO_2)} = 12.82 \text{ nm}$$

3. (c)

- Moore machines have synchronous output and state generation. Mealy machines are asynchronous as their output can change immediately with input change, independent of the clock.
- Mealy machines are faster than Moore machine. In Moore machines, more logic is required to decode the outputs resulting in more circuit delays.

4. (a)

Since, the output value is determined both by its current state and the current inputs, hence it is a Mealy machine.

State table:

Present state Q_n	Input X	Next State Q_n^+	FF Inputs T	D	Output Z
0	0	1	1	1	0
0	1	0	0	0	0
1	0	1	0	1	0
1	1	0	1	0	1

Output equation, $Z = Q_n X$

Input to T-flip flop, $T = \overline{Q_n}\,\overline{X} + Q_n X = \overline{Q_n \oplus X}$

Input to D-flip flop, $D = \overline{Q_n}\,\overline{X} + Q_n \overline{X} = \overline{X}$

6. (a)

$$d_{ox}^2 + Ad_{ox} = B(t + \tau)$$

$\tau = 0$, for initial oxide thickness

So, $$d_{ox}^2 + \sqrt{2}\, d_{ox} = 0.5(1) = 0.50$$

$$d_{ox}^2 + \sqrt{2}\, d_{ox} - 0.50 = 0$$

$$d_{ox} = \frac{-\sqrt{2} \pm \sqrt{2+2}}{2}\ \mu\text{m}$$

Since d_{ox} is a positive quantity,

$$d_{ox} = \frac{\sqrt{4}-\sqrt{2}}{2} = 1 - \frac{1}{\sqrt{2}} = 1 - 0.707 = 0.293\ \mu\text{m}$$

7. (c)

Advantages of SOI Technology in IC fabrication.

(i) Minimize leakage current

(ii) Higher speed

(iii) Low power consumption

(iv) Higher packing density

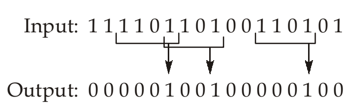
8. (a)

The minimum number of states required by Moore machine = Number of bits in the sequence +1.

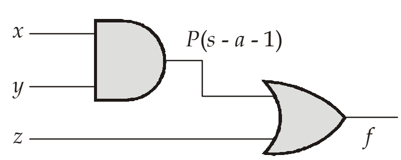
i.e., Number of states = 3 + 1 = 4

So, 2 flip-flops are required.

9. (c)



10. (a)



Step 1: Fault propagation, i.e., $f = P$,

put $z = 0$, then $f = P$

Step 2: Derive $(s - a - 0)$ at point P,

For $s - a - 0$, x and y can be 00 or 01 or 10

So, test vectors

x	y	z
0	0	0
0	1	0
1	0	0

11. (c)

If 'n' is the required number of flip-flops,

$$\max.(0\text{'s}, 1\text{'s}) \leq 2^{n-1}$$

$\Rightarrow$ $$2 \leq 2^{n-1}$$

$\Rightarrow$ $$n = 2$$

To generate 0110

1	0
1	1
⓪	1
⓪	⓪

All 4 states are different, so total 4 states are required i.e. 2FFs are required.

12. (b)

Given: $t = 15$ min $= 15 \times 60 =$ sec ; $N_s = 3 \times 10^{20}$ atoms/cm^3 ; $D = 3.14 \times 10^{-14}$ cm^2/s

Dose, $$Q = \frac{2}{\sqrt{\pi}} N_s \sqrt{Dt} = \frac{2}{\sqrt{\pi}} \times 3 \times 10^{20} \sqrt{3.14 \times 10^{-14} \times 15 \times 60}$$

$$= 2 \times 3 \times 30 \times 10^{-7} \times 10^{20} = 1.8 \times 10^{15} \text{ atoms/cm}^2$$

13. (d)

Given: $Q = 10^{15}$ cm^{-2}; $t = 45$ minutes ; $I = 0.25$ μA

We know, $$Q = \frac{I \cdot t}{q \cdot A}$$

$$A = \frac{I \cdot t}{q \cdot Q} = \frac{0.25 \times 10^{-6} \times 45 \times 60}{1.6 \times 10^{-19} \times 10^{15} \times 10^{4}} = 4.22 \times 10^{-4} \text{ m}^2$$

$$A = 4.22 \text{ cm}^2$$

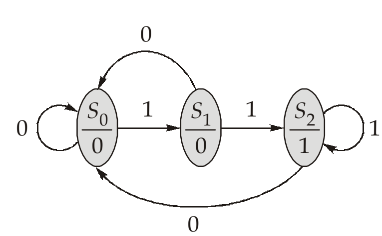
14. (c)

- FPGA is a volatile memory.
- CPLD is a non-volatile memory.

17. (a)

State table:

Present State	I/P	Next State	Output
S_0	0	S_0	0
	1	S_1	0
S_1	0	S_0	0
	1	S_1	1



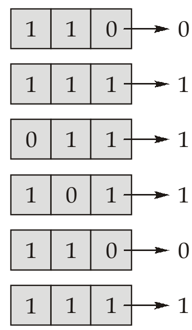
19. (b)

If n is the required number of flip-flops.

$$\max(0\text{'s}, 1\text{'s}) \le 2^{n-1}$$

$$\Rightarrow \quad 3 \le 2^{n-1}$$

$$\Rightarrow \quad n = 3$$



Number of unique states = 4 i.e. 110, 111, 011, 101.

So, number of flip-flops required is 3.

20. (a)

Number of atoms per unit cell in NaCl is 8.

$$Na^{+} : 1_{center} + 12_{edge} \times \frac{1}{4} = 4$$

$$ce^{-} : 6_{face} \times \frac{1}{2} + 8_{corner} \times \frac{1}{8} = 4$$

21. (c)

Ferroelectric materials have strong non-linear dielectric response.

22. (b)

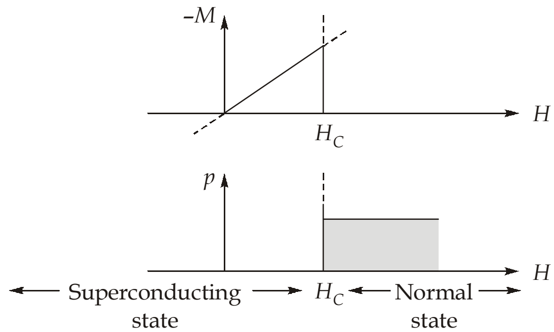
For pyroelectric materials, the field required is so high that the material undergoes dielectric breakdown before it can get polarized.

24. (b)

A material with one dimension in nano range and other two large is called quantum well. A material with two of the three dimensions in the nano range and third large is called quantum wire. When all the dimensions are in nano range, it is called quantum dot.

25. (a)

For Type-1 superconductors:



26. (a)

Number of atoms per unit cell in simple cubic is 1, BCC is 2 and FCC is 4.

27. (b)

Given, $E = 1000$ V/m; $\in_r = 6$

We know that,

$$\text{polarization, } P = \in_0(\in_r - 1)E$$
$$= 8.85 \times 10^{-12}\,(6-1) \times 1000$$
$$= 44.25 \times 10^{-9}\ \text{C/m}^2$$
$$P = 44.25 \times 10^{-13}\ \text{C/cm}^2$$

28. (c)

We know that

Electronic polarizability, $\alpha_e = 4\pi\in_0 R^3$

where R is the radius,

$$\therefore \quad R^3 = \frac{\alpha_e}{4\pi\in_0} = \frac{2.7\times10^{-46}}{4\pi\times8.85\times10^{-12}}$$
$$R^3 = 2.427 \times 10^{-36}\ \text{m}$$
$$\Rightarrow \quad R = 1.344 \times 10^{-12}\ \text{m}$$

29. (a)

The curie point is the temperature above which the material loses its ferroelectric behavior.

30. (b)

Given, magnetic field, $B = 1.6\ \text{Wb/m}^2$

magnetic intensity, $H = 1000$ A/m

$\mu_0 = 4\pi \times 10^{-7}$ Wb/A-m

$$\text{relative permeability, } \mu_r = \frac{B}{\mu_0 H}$$
$$\therefore \quad \mu_r = \frac{1.6}{4\pi\times10^{-7}\times1000} = 1273$$
$$\therefore \quad \text{Susceptibility, } \chi = \mu_r - 1 = 1273 - 1 = 1272$$

31. (c)

We know that,

$$\text{Susceptibility, } \chi \propto \frac{1}{T}$$

$$\frac{\chi_1}{\chi_2} = \frac{T_2}{T_1}$$

$$\therefore \quad T_2 = \left(\frac{\chi_1}{\chi_2}\right) T_1$$

$$\therefore \quad T_2 = \frac{1.5 \times 10^{-5}}{1.85 \times 10^{-5}} \times 400$$

$$\therefore \quad T_2 = 324.32 \text{ K}$$

34. (c)

In general, $\alpha_i = \dfrac{\alpha_e}{10}$

36. (c)

We know that,

Complex dielectric constant has relation,

$$\tan\delta = \frac{\epsilon_r''}{\epsilon_r'} = 0.006$$

$$\epsilon_r'' = \epsilon_r' \tan\delta$$

$$\epsilon_r'' = 2 \times 0.006 = 0.012$$

$\therefore$ Complex dielectric constant, $\epsilon_r^* = \epsilon_r' - j\epsilon_r''$

$$\epsilon_r^* = 2 - j0.012$$

37. (c)

The copper deposited by ECD has a lower resistivity and a better fill characteristics.

38. (c)

The carbon nano-tube may behave electrically as either a conductor or a semiconductor.

Section B : Electromagnetics + Computer Organization and Architecture

40. (c)

Comparing magnetic field intensity vector with standard form, we get,

$$\omega = 40000 \text{ rad/sec}, \quad \beta = 0.004 \text{ rad/m}$$

$$\therefore \quad \text{Phase velocity, } v_p = \frac{\omega}{\beta} = \frac{40000}{0.004} = 10^7 \text{ m/sec}$$

41. (b)

We know penetration depth (skin depth),

$$\delta = \sqrt{\frac{2}{2\pi\mu f \sigma}}$$

$$\therefore \quad \delta \propto \frac{1}{\sqrt{\mu}}$$

$$\delta \propto \frac{1}{\sqrt{f}}$$

$$\delta \propto \frac{1}{\sqrt{\sigma}}$$

42. (b)

- Quarter wave transformer is best suitable for matching purely resistive load only.
- For matching a TL to a purely reactive load, stub matching would work better than quarter wave transformer.
- Matched line works as impedance reflector because $Z_{in} = Z_L$.

43. (d)

$$\Gamma = \frac{Z_L - Z_o}{Z_L + Z_o} = \frac{120j - 50}{120j + 50}$$

$$|\Gamma| = \sqrt{\frac{120^2 + 50^2}{(120)^2 + (50)^2}} = 1$$

$$\text{SWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|} = \infty$$

$$\frac{Z_{max}}{Z_o} = \text{SWR}$$

$$Z_{max} = \infty$$

$$\frac{Z_o}{Z_{min}} = \text{SWR}$$

$$Z_{min} = 0$$

45. (a)

$\because$ $b > a$ and $f = 1$ GHz

$\therefore$ cut-off frequency, $f_c = \dfrac{c}{\sqrt{\epsilon_r}\,(2b)}$ (Dominant mode TE_{01})

$$= \frac{3 \times 10^8}{\sqrt{9} \times 2 \times 4 \times 10^{-2}} = 1.25\ \text{GHz}$$

Since, $f_c > f$

Hence, signal will not pass through the waveguide.

46. (a)

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

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

47. (c)

$$\eta = \frac{R_{\text{rad}}}{R_{\text{rad}} + R_l} = \frac{G_P}{G_D}$$

where, $G_P \rightarrow$ Power gain and $G_D \rightarrow$ Directive gain

$$G_D = \frac{G_P(R_{\text{rad}} + R_l)}{R_{\text{rad}}} = 20\times\frac{65}{60} = 21.67$$

48. (b)

Volume charge density, $\rho_v = \vec{\nabla}\cdot\vec{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z} = 0 + 4x + 0 = 4x$

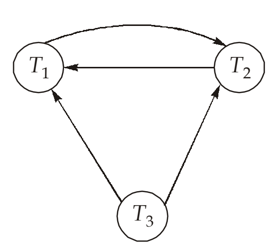
ρ_v at (1, –2 ,3) = 4 C/m^3

49. (b)

$$\text{No. of memory chips needed} = \frac{\text{Total memory size}}{\text{1 memory chip size}} = \frac{16\times2^{10}\times8}{512\times8} = 32$$

50. (d)

T_1	T_2	T_3
$r(X)$		
	$r(X)$	
$r(Z)$		
		$r(X)$
		$r(Y)$
$w(X)$		
		$w(Y)$
	$r(Y)$	
	$w(Z)$	
	$w(Y)$	



Since there is a cycle $T_3 \rightarrow T_2 \rightarrow T_1$

Hence, it is not conflict serializable.

51. (d)

Objectives of file management system:

1. Ensure that the data in the file is valid.
2. Achieve throughput and good response time.
3. Support different I/O functions for different types of storage devices.
4. Eliminate/minimize to the extent possible the potential for lost/destroyed data.
5. Provide a standardized set of I/O interface routines.
6. Provide I/O support for multiple users in a multi user system.

52. (b)

$$T_c = 50 \text{ nsec}$$
$$T_m = 1000 \text{ nsec}$$
$$T_e = T_c + \frac{T_c \times 20}{100}$$
$$T_e = 1.2\ T_c$$
$$T_e = 1.2T_c = HT_c + (1 - H)(T_c + T_m)$$
$$1.2 \times 50 = H \times 50 + (1 - H)(1050)$$
$$60 = 50\text{H} + 1050 - 1050\text{H}$$
$$1000H = 1050 - 60$$
$$H = 0.99$$

53. (d)

Gantt Chart

P_4	P_1	P_3	P_5	P_2
0 – 1	1 – 6	6 – 8	8 – 18	18 – 19

P_{id}	BT	CT	WT
P_1	5	6	1
P_2	1	19	18
P_3	2	8	6
P_4	1	1	0
P_5	10	18	8

$$\text{Average waiting time } (WT)_{\text{Avg}} = \frac{1+18+6+0+8}{5}$$
$$(WT)_{\text{avg}} = 6.6 \text{ msec}$$

55. (a)

Bubble sort is a simple sorting algorithm that works by repeatedly stepping through the list to be sorted, comparing each pair of adjacent items and swapping them if they are in wrong order.

56. (a)

Cache memory stores commonly used data, which is copied from main memory, temporarily.

57. (d)

When there is only one resource, the conditions of hold and wait and circular wait gets eliminated. Assuming that no process can use a resource for an infinite amount of time, whenever a process will finish its execution, another process can get the resource. So, deadlock can't occur.

58. (d)

Tangential component of electric field lines does not exist on a conducting surface boundary. Conducting surface always supports the normal component of the electric field.

59. (c)

In suspend ready state process is available in the secondary memory but not available for execution. It is available for execution as soon as it is loaded into main memory.

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

60. (b)

- G/T ratio is the ratio of antenna gain (G) of ground station to the total input noise temperature T. It is also sometimes called figure of merit and is denoted by M.
- When gain is maximum, then it is known as directivity.

61. (c)

- Radiated power, $P_{rad} = (P_o)_{dB} - (\text{loss})_{dB} = 30 - 2 = 28 \text{ dB}$
- Gain of dish antenna = 42 dBm = 42 – 30 = 12 dB
- EIRP = $(P_{rad})_{dB} + (\text{Gain})_{dB} = 28 + 12 = 40 \text{ dB} = 70 \text{ dBm}$

62. (a)

We have, $h_t = 144$ m, $h_r = 49$ m

The maximum distance between transmitting and receiving antenna for LOS,

$$D = 4.12[\sqrt{h_t} + \sqrt{h_r}]\,\text{km} = 4.12\,[12 + 7] = 78.28\,\text{km}$$

63. (d)

$$f_{\text{MUF}} = f_c\left(\sqrt{1 + \left(\frac{D}{2h}\right)^2}\right)$$

where, D = skip distance, h = height of ionospheric layer from earth and f_c = critical frequency.

64. (c)

We have, $h = 300$ km

$$\frac{f_{\text{MUF}}}{f_c} = 3.16 \simeq \sqrt{10}$$

$\therefore$ Skip distance $(D) = 2h\sqrt{\left(\frac{f_{\text{MUF}}}{f_c}\right)^2 - 1} = 2\times 300\sqrt{10 - 1} = 600 \times 3 = 1800\,\text{km}$

65. (c)

We know,
$$f_c = 9\sqrt{N_{max}}$$
$$N_{max} = \frac{f_c^2}{9^2} = \frac{(5\times10^6)^2}{81} = 3.08\times10^{11}\ e^-/m^3$$

66. (b)

- In geosynchronous orbit, the satellite will appear to move in the sky in analemma or figure-8 pattern in the sky but appear in the same spot every day at a certain time.
- In geostationary orbit, the satellite will appear from the earth to the fixed in same location in the sky all the time.

67. (a)

We have, Area of cellular network (A) = 196 km^2 ; Cluster size (N) = 7
Area of each cell (A_{cell}) = 4 km^2 ; ∴ Area of cluster ($A_{cluster}$) = 28 km^2

Now, number of clusters required to cover entire area is = $\frac{196}{28} = 7.$

68. (d)

Size of cluster (N) = 7
Total number of channel = 504

∴ Number of channel per cell = $\frac{504}{7} = 72$

69. (c)

We know, Deflection factor = $\frac{1}{\text{Deflection sensitivity}}$

∴ Deflection sensitivity = $\frac{1}{0.4} = 2.5\ \text{m/V}$

∵ $S = \frac{D}{E_D}$

where, D = Deflection on screen and E_D = Deflecting voltage

$$2.5 = \frac{1}{E_D} = 0.4\ \text{Volt}$$

70. (b)

Let,
C_1 = 300 pF
C_2 = 10 pF
n = 3 ------Third harmonic

Now, self-capacitance,
$$C_s = \frac{C_1 - n^2 C_2}{n^2 - 1}$$
$$C_s = \frac{300 - 9\times10}{8} = 26.25\ \text{pF}$$

71. **(d)**

Optical tachometers include an optical sensor which is used to measure the rotational speed of the wheel, motor or shaft.

72. **(b)**

In thermistor: $$R_{T2} = R_{T1} \cdot e^{\beta\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

73. **(c)**

$\because$ Gauge factor = 1 + 2γ = 1 + 2 × 2.5 = 6

But, $$\text{Gauge factor} = \frac{\frac{\Delta R}{R}}{\text{Strain}}$$

$\therefore$ $$\frac{\Delta R}{R} = (\text{G.F.}) \cdot \text{Strain} = 6 \times 0.015$$

$$\frac{\Delta R}{R} = 0.09 = 9\%$$

74. **(c)**

Digital data acquisition systems are in general, more complex than analog system, both in terms of instrumentation involved and the volume and complexity of the data they can handle.

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