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ESE 2020 : 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 : Analog Circuits-2 + Electronic Measurements and Instrumentation-2

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

Note: Answer key and solution of Q. 46 has been updated.

Detailed Explanation
Section A : Advanced Electronics + Materials Science

1. (a)

2. (b)

Given Input:	1	1	1	1	0	1	0	1	0	0	1	1	1	1
	↓	↓	↓	↓	↓	↓	↓	↓	↓					
number of ones →	(O)	(E)	(O)	(E)	(E)	(O)	(O)	(E)	(E)					
Output sequence:	0	1	0	1	1	0	0	1	1	0	0	0	0	0
										↑ two consecutive zeroes occured				

O → Odd
E → Even

So answer is (b).

3. (c)

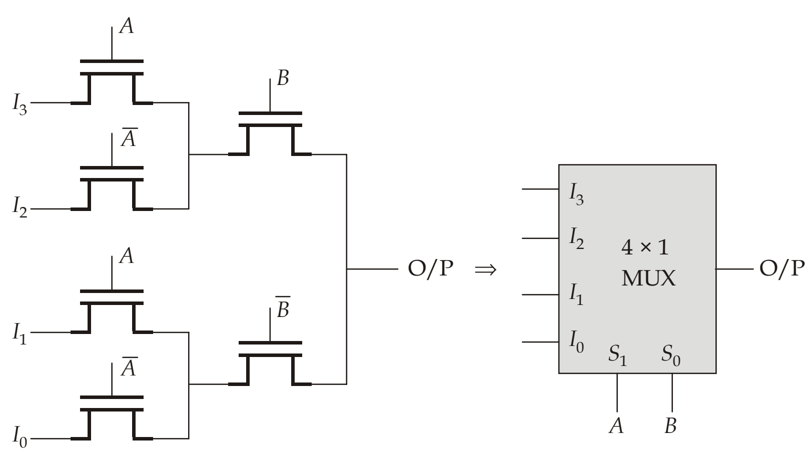
The given sequence detector can be used to detect two sequences: 01 (upper) and 10 (lower)

4. (c)

In a Mealy machine, the outputs are function of the present state and the value of the inputs. So, the outputs may change asynchronously in response to any change in the inputs.

5. (c)

6. (b)



So, minimum 6 NMOS transistors are required.

7. (d)

8. (d)

- Ingots grown using CZ process have high oxygen impurity of the order > $10^8/cm^3$.
- FZ wafers are available only in smaller diameters.

9. (b)

Since Deal-Grove equation

$$x_0^2 + Ax_0 = B(t + \tau)$$

$$\Rightarrow \quad x_0 = \frac{B(t+\tau)}{x_0} - A \quad ...(1)$$

For the given plot, $$x_0 = 0.2\frac{(t+\tau)}{x_0} - 0.5 \quad ...(2)$$

Comparing (1) and (2) we get,

$$A = 0.5;\ B = 0.2$$

So, $$\text{Linear rate constant} = \frac{B}{A} = \frac{0.2}{0.5} = 0.4\ \mu\text{m/Hour}$$

10. (c)

Dry oxidation is a slower process compared to wet oxidation. So, statement-2 is incorrect.

11. (c)

Metallization is used to provide metallic contacts, but not isolation.

12. (b)

13. (c)

When no fault occured, $$f = xy + z\overline{y}$$

Test vectors that can detect $y(s\text{–}a\text{–}1)$ fault at y are,

$$x = 1,\ y = 0;\ z = 0$$

or $$x = 0,\ y = 0;\ z = 1$$

So Boolean expression will be : $x\overline{y}\,\overline{z} + \overline{x}\,\overline{y}\,z$

14. (b)

Fault Equivalence: Two faults f_1 and f_2 are equivalent if all tests that detect f_1 can also detect f_2.

Fault Dominance: If all tests for some fault (f_1) detect another fault (f_2) but reverse relation is not true, then (f_2) is said to dominate (f_1).

For given problem:

test vector for $f_1 \rightarrow A = 0,\ B = 1,\ C = 1$

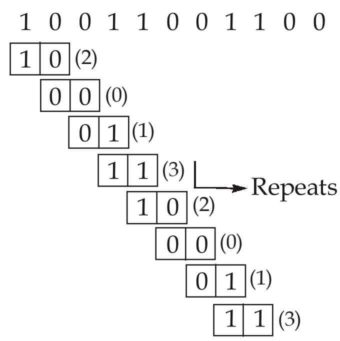
test vector for $f_2 \rightarrow$ 001, 010, 011, 100, 101, 110, 000

where 011 can defect both faults, so f_2 dominates f_1.

15. (b)

Sequence repeating in the required waveform is "1001". This sequence has 4 bits. So, minimum $\log_2(4) = 2$ bit shift register is needed.

But, it is not sufficient to select 2 as the required answer. It is also required to check whether the 2-bit shift register is compatible to produce the unique states for the given sequence.

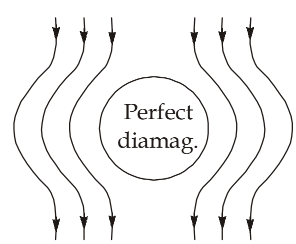


From the above figure, it is clear that, a 2-bit shift register can produce unique states for the given sequence. So, the minimum required length of the shift register is 2.

16. (b)

17. (b)

In the superconducting state, the flux lines of external magnetic field are ejected out of the superconductor.



18. (d)

Magnetic susceptibility, $\chi_m = \dfrac{C}{T}$

or $\chi_m \propto \dfrac{1}{T}$

19. (b)

Electronic polarizability is independent of temperature.

20. (a)

21. (b)

As there is a minimal temperature variation of frequency, AT-cut quartz crystal orientation is used.

22. (b)

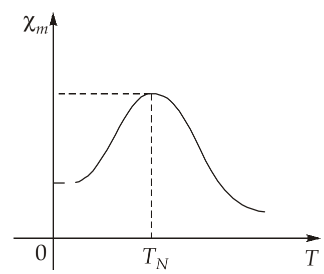
23. (a)

At high frequencies dielectric constant is a complex quantity. Its imaginary part is responsible for dielectric loss. Dielectric constant is high at power frequencies and decreases to unity at ultraviolet frequencies.

24. (d)

When an alloy is formed by adding two or more materials, the resistivity of alloy is greater than that of all those materials.

25. (d)



26. (b)

27. (b)

$$E_i = \frac{E_{applied}}{1 - \frac{1.2\alpha_e}{\pi\varepsilon_0 a^3}}$$

where a is the interatomic distance.

28. (d)

The energy gap in a superconductor is minimum at critical temperature as it enters in infinite conductive state.

29. (c)

For electronic polarization,

$$N\alpha_e = \varepsilon_0(\varepsilon_r - 1)$$

$$\therefore \quad \alpha_e = \frac{\varepsilon_0(\varepsilon_r - 1)}{N} = \frac{8.85(0.0025)\times 10^{-12}}{2.5\times 10^{25}}$$

$$\therefore \quad \alpha_e = 8.85 \times 10^{-40}\ \text{Fm}^2$$

30. (c)

- Metallic bonds are non-directional and generally weaker than ionic and covalent bonds.
- The magnitude of energy released when two atoms comes together from a large distance of separation to the equilibrium distance, called bond energy. It is related to the enthalpy of the solids.

31. (a)

Electronic polarization is the result of the displacement of the positive charged nucleus and the negative electrons of an atom in opposite directions on the application of electric field. On applying a field, the electron cloud around the nucleus readily shifts towards the positive end of the field. Hence, such a shift results in a dipole moment within the atom, as a certain distance now separates the nucleus and the centre of electron clouds.

The extent of the shift is proportional to the field strength.

32. (a)

$$\text{Uniaxial stress } (P) = Y \cdot \frac{\Delta C}{C}$$

$$q = CV$$

$\Rightarrow$ Polarization,
$$P = \frac{q}{A} = \frac{C}{A} \cdot V$$

Where A is area of the crystal capacitor.

$\therefore$
$$\Delta P = \left(\frac{V}{A}\right) \times \Delta C$$

$\Rightarrow$
$$\frac{\Delta P}{P} = \frac{\Delta C}{C}$$

$\Rightarrow$
$$\text{Stress } (P) = Y \cdot \frac{\Delta P}{P} = \frac{130 \times 20}{500} = 5.2 \text{ GPa}$$

33. (d)

$$H_C = H_0\left(1 - \left(\frac{T}{T_C}\right)^2\right)$$

For 15 K,
$$25 = H_0\left(1 - \left(\frac{15}{T_C}\right)^2\right) \quad \text{...(i)}$$

and for 30 K,
$$10 = H_0\left(1 - \left(\frac{30}{T_C}\right)^2\right) \quad \text{...(ii)}$$

from (i) and (ii),
$$\frac{25}{10} = \frac{1 - \left(\frac{15}{T_C}\right)^2}{1 - \left(\frac{30}{T_C}\right)^2}$$

$$25 - \frac{900}{T_C^2} \times 25 = 10 - \frac{2250}{T_C^2}$$

$$25 - 10 = -\frac{2250}{T_C^2} + \frac{22500}{T_C^2} = \frac{9 \times 2250}{T_C^2}$$

$$T_C^2 = \frac{9 \times 2250}{15} = 150 \times 9 = 1350$$

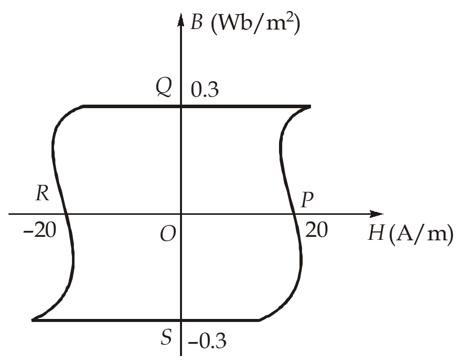
$$T_C = \sqrt{1350}\,\text{K}$$

34. (b)

$$\text{Lattice parameter of FCC} = a = \frac{4r}{\sqrt{2}}$$

$$\therefore \quad r = \frac{a\sqrt{2}}{4} = \frac{4.04 \times 1.414}{4} = 1.428\ \text{Å} \simeq 1.43\ \text{Å}$$

35. (c)



The width of the loop = $(OP + OR) = 20 + 20 = 40$ A/m

The height of the loop = $(OQ + OS) = 0.3 + 0.3 = 0.6$ Wb/m^2

$\therefore$ Area of the loop = hysteresis loss per cycle = $40 \times 0.6 = 24$ J/m^3

36. (d)

37. (c)

Carbon nanotubes exhibit varying electrical properties depending on the way the graphite structure spirals around the tube, and other factors such as doping and can be superconducting, insulating, semiconducting or conducting.

It is found that arm chair nanotubes are metallic; and chiral nanotubes are low-conducting and zigzag nanotubes are generally semi-metallic.

MWNT (Multiple Walled Nanotubes)
- Consist of 2 or more layers of carbon
- are concentrically nested

SWNT (Single Walled Nanotubes)
- Consist of just one layer of carbon
- Greater tendency to align into ordered bundles
- Used to test theory of nanotube properties

38. (b)

The surface area to volume ratio for a material or substance made of nanoparticles has a significant effect on the properties of the material. Firstly, materials made up of nanoparticles have a relative larger surface area when compared to the same volume of material made up of bigger particles.

For example, let us consider a sphere of radius r. The surface area of the sphere will be $4\pi r^2$.

The volume of the sphere = $4\pi r^3/3$.

Therefore the surface area to the volume ratio will be $4\pi r^2/(4\pi r^3/3) = 3/r$

It means that the surface area to volume ratio increases as the radius of the sphere decreases and vice versa. It also means that when a given volume of material is made up of smaller particles, the surface area of the material increases. Therefore, as particle size decreases, a greater proportion of the particles are found at the surface of the material.

Therefore, materials made of nanoparticles have a much greater surface area per unit volume ratio compared with the materials made up of bigger particles. This leads to nanoparticles being more chemically reactive.

39. (c)

In top-down technique, generally a bulk material is taken and machined to modify into the desired shape and product.

- Mechanical methods offer the least expensive ways to produce nanomaterials in bulk.
- The problem is control of quality and potential upscale.
- Some other top-down fabrication techniques are: Electrospinning, Arc discharge and Laser Ablation.

40. (d)

Primary bonds are interatomic where as secondary bonds are inter-molecular bonds.

41. (d)

Maximum optimization can be obtained with prior minimization of input Boolean functions.

42. (d)

- Verification is performed before the actual manufacturing.
- Performed by simulation tools.
- Verification can not guarantee the correctness of manufactured circuit. Testing is done on every manufactured device to verify correctness of manufactured hardware.

43. (a)

44. (a)

45. (b)

In a superconductor,

- Entropy decreases on going from normal state to superconducting state.
- There is a marked drop in the thermal conductivity when superconductivity sets in.

Section B : Electromagnetics + Computer Organization and Architecture

46. (b)

Z_L and Z_0 are purely real and $Z_L < Z_0$.

So, $$V_{min} = V_{load} = 10 \text{ V}$$

47. (b)

$$\vec{F} = I(\vec{l} \times \vec{B}) = 10(2\hat{a}_y \times 0.08\hat{a}_x)$$

$$= 10(-0.16)\hat{a}_z = -1.6\hat{a}_z \text{ N}$$

48. (b)

$$v_p = \frac{c}{\sqrt{\mu_r \varepsilon_r}} = \frac{3\times10^8}{\sqrt{9\times4}} = \frac{1}{2}\times10^8 \text{ m/s}$$

Also, $$v_p = \frac{\omega_c}{\beta}$$

or $$\omega_c = v_p \times \beta_p = 0.5 \times 10^8 \times 60\pi$$

$$f_c = \frac{0.5\times10^8\times60\pi}{2\pi} = 30 \times 0.5 \times 10^8 \text{ Hz}$$

$$= 1.5 \times 10^9 = 1.5 \text{ GHz}$$

49. (c)

50. (d)

Let us consider the force exerted an Q is $\vec{F}_1$. Since there is no externally applied field (or force), sum of all the forces in the system of charges will be zero.

$$\Sigma\vec{F} = 0$$

$$3\vec{F} + 2\vec{F} + \vec{F}_1 = 0$$

$$\vec{F}_1 = -5\vec{F}$$

51. (b)

$$|\Gamma|^2 = 0.25$$

$$\Gamma = \sqrt{0.25} = 0.5$$

$\because$ $$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{\eta_0\sqrt{\frac{\mu_{r_2}}{\varepsilon_{r_2}}} - \eta_0\sqrt{\frac{\mu_{r_1}}{\varepsilon_{r_1}}}}{\eta_0\sqrt{\frac{\mu_{r_2}}{\varepsilon_{r_2}}} + \eta_0\sqrt{\frac{\mu_{r_2}}{\varepsilon_{r_2}}}} = \pm 0.5$$

$$\frac{\varepsilon_{r_2} - \varepsilon_{r_1}}{\varepsilon_{r_2} + \varepsilon_{r_1}} = \pm 0.5$$

$$\frac{\varepsilon_{r_2}}{\varepsilon_{r_1}} = \frac{1 \pm 0.5}{1 \mp 0.5}$$

$$\Rightarrow \quad \frac{\varepsilon_{r_2}}{\varepsilon_{r_1}} = \frac{1.5}{0.5} \text{ or } \frac{0.5}{1.5} \Rightarrow 3 \text{ or } \frac{1}{3}$$

$$\therefore \quad \frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{1}{3} \text{ or } 3$$

52. (c)

$$G_t = 10$$
$$P_t = 2\text{ W}, P_r = 1\text{ W}$$
$$r = 1\text{ m}$$

$$\therefore \quad P_r = \frac{P_t}{4\pi r^2} G_t \times A_e$$

$$\therefore \quad A_e = \frac{4\pi r^2 P_r}{P_t G_t} = \frac{4\pi \times (1)^2 \times 1}{10 \times 2} = \frac{4\pi}{20} = \frac{\pi}{5}\text{m}^2$$

53. (c)

An immediate data cannot be used as the destination operand.

54. (b)

55. (b)

Sequential execution takes 1000 seconds.

After rewriting the program,

Parallel execution takes $\frac{0.76 \times 1000}{4} = \frac{760}{4} = 190$ seconds

Sequential execution takes (0.24 × 1000) = 240 seconds

Total execution time = 190 + 240 = 430 seconds.

56. (b)

Using Gantt chart,

A	B	C	D
0–3	3–9	9–13	13–15

$$\text{Average turnaround time} = \frac{(3-0)+(9-1)+(13-4)+(15-6)}{4}\text{ sec}$$

$$= \frac{3+8+9+9}{4} = 7.25\text{ sec}$$

57. **(d)**

ACID stands for

A: Atomicity

C: Consistency

I: Isolation

D: Durability

So, deadlock-freedom is not the ACID property.

58. **(c)**

Page frame number contains (11 – 1) = 10 bits

Page offset contains $\log_2(512)$ = 9 bits

So, physical address contains (10 + 9) = 19 bits

59. **(d)**

Statement (I) is wrong.

Brewster's angle occurs only for vertically polarized waves.

60. **(a)**

Section C : Analog Circuits-2 + Electronic Measurements and Instrumentation-2

61. **(b)**

$$V_0 = Av_i$$

$$\frac{dv_0}{dt} = A\frac{dv_i}{dt}$$

$$A = \frac{\text{slew rate}}{\left(\frac{dv_i}{dt}\right)} = \frac{3\times10^6\times12\times10^{-6}}{0.4} = 90 \text{ V/V}$$

62. **(c)**

$$|A| = g_m R_L$$

$$|A| \geq 29$$

$$R_L \geq \frac{29}{g_m} \geq \frac{29}{5\times10^{-3}} \geq 5.8 \text{ k}\Omega$$

thus,

$$R_L = \frac{R_D r_d}{R_D + r_d}$$

$$5.8\times10^3 = \frac{R_D(40\times10^3)}{R_D+(40\times10^3)}$$

$$5.8\times10^3 R_D + 5.8\times10^3\times40\times10^3 = R_D(40\times10^3)$$

$$\frac{5.8}{40}R_D + 5.8\times10^3 = R_D$$

$$\left(1-\frac{5.8}{40}\right)R_D = 5.8\times10^3$$

$$R_D = 6.78 \text{ k}\Omega$$

63. (d)

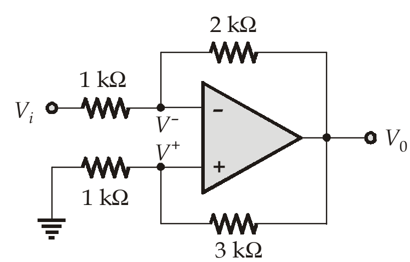
$$\frac{dA_f}{A_f} = \frac{1}{1+\beta A}\cdot\frac{dA}{A}$$

$$\frac{0.2}{100} = \frac{1}{1+\beta A}\cdot\frac{75}{1000}$$

$$1 + \beta A = 37.5$$

$$\beta = \frac{36.5}{1000} = 0.0365 \text{ (or) } 3.65\%$$

64. (b)



$$V^+ = \frac{1\text{ k}\Omega}{1\text{ k}\Omega + 3\text{ k}\Omega}V_0 = \frac{1}{4}V_0$$

$\because$ $$V^+ = V^- = \frac{1}{4}V_0$$

Applying KCL at node V^- we get,

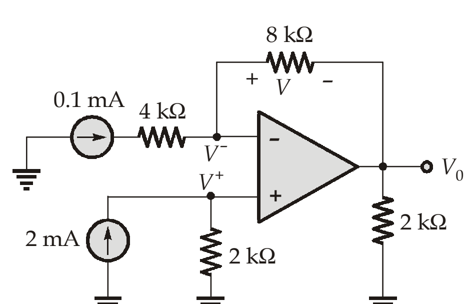
$$\frac{V^- - V_i}{1\text{ k}\Omega} + \frac{V^- - V_0}{2\text{ k}\Omega} = 0$$

so, $$V_0 = 3\,V^- - 2\,V_i$$

$$V_0 = \frac{3}{4}V_0 - 2\,V_i$$

$\therefore$ $$\frac{V_0}{V_i} = A = -8 \text{ V/V}$$

65. (a)



$$V_0 = V^- - V$$

now, $V^- = V^+ = 2\ k\Omega \times 2\ mA = 4\ V$

and $V = 0.1 \times 10^{-3} \times 8 \times 10^3 = 0.8\ V$

$\therefore$ $V_D = 4 - 0.8 = 3.2\ V$

66. (b)

Feedback resistor (R_F) is directly connected to both input and output nodes. So, voltage-shunt type of feedback.

67. (d)

68. (c)

Temperature-resistance relationship in thermistors is highly non-linear.

69. (c)

Gauge factor, $GF = \dfrac{\Delta R/R}{\text{Strain}}$

Change in resistance, $\Delta R = R \times GF \times \text{Strain}$

$= 120 \times 2 \times 10^{-5}\ \Omega$

$\Delta R = 2.4 \times 10^{-3}\ \Omega$

70. (b)

Electrostatic deflection sensitivity,

$$S_E = \frac{lL}{2dV_a}$$

given, $V_a = 2000\ V$

$d = 2\ mm = 0.2\ cm$

$l = 2\ cm$

$L = 20\ cm$

Deflection sensitivity, $S_E = \dfrac{2 \times 20}{2 \times 0.2 \times 2000} = 0.05\ cm/V$

71. (a)

Semiconductor strain gauges make use of the piezoresistive effect, but not piezoelectric.

72. (b)

73. (b)

Because of the added pair of emitter junction voltage in a darlington pair, the value of input offset voltage and drift increases.

74. (b)

75. (c)

The resistance hygrometer utilizes the principle that electrical resistance varies in a material that absorbs moisture.

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