ACE Engineering Academy

TEST ID: 205

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ESE- 2020 (Prelims) - Offline Test Series Test - 9

ELECTRICAL ENGINEERING

SUBJECT: Electrical Materials + Electric Circuits & Fields
SOLUTIONS

01. Ans: (a)

Sol: Miller index of a plane in the lattice can be determined by taking the reciprocal distances of the plane w.r.t X, Y, Z axes.

02. Ans: (d)

Sol: Pure silica $\rightarrow$ sodium silicate $\rightarrow$ doped silicon $\rightarrow$ nickel

$10^4 \rightarrow 2 \rightarrow 10^{-4} \rightarrow 10^{-7}$

(Resistivity value in decreasing order)

03. Ans: (d)

Sol: For BCC-Iron material, $4R = \sqrt{3}\,a$

Where, a = lattice parameter

R = radius of atom

$$\Rightarrow a = \frac{4R}{\sqrt{3}} = \frac{4\times 0.173}{\sqrt{3}} \approx 0.4 \text{ nm}$$

04. Ans: (b)

Sol: $\mu_r = \chi + 1$ for paramagnetic materials susceptibility is positive but very small hence relative permeability slightly greater than unity.

05. Ans: (b)

Sol: Metals have low ionization energies, due to loosely bounded valence electrons. The electrostatic attraction between the free electrons and the positive metal ions keeps the metal stable.

06. Ans: (c)

Sol: Permalloy is a soft magnetic material. If the temperature of material is more than curie's temperature, then the para magnetic material converts into dia magnetic material.

07. Ans: (d)

Sol: The hall coefficient, $R = \frac{1}{n.e}$ where 'n' is the carrier concentration. Hall coefficient & charge carrier concentration are inversely rated.

$$R \propto \frac{1}{n}$$

n = Charge carrier concentration

$$\frac{R_A}{R_B} = \frac{4\times10^{21}}{1\times10^{21}} = \frac{4}{1}$$

08. Ans: (a)

Sol: Atomic packing factor for SC = 52%,

BCC = 68 %, FCC = 74 % and DC = 34 %.

09. Ans: (c)

Sol: 1 mole of cu = 6.023×10^{23} atoms and cu weights 63.5 gm

$\therefore$ Mass of 1 cu atom = $\dfrac{6.35}{6.023\times10^{23}}$ gram

FCC contains 4 atoms per unit cell

For FCC, $a = 2\sqrt{2}\,r$

$$\therefore\ \rho = \frac{4\times\dfrac{63.5}{6.023\times10^{23}}\times10^{-3}\,\text{kg}}{\left(2\sqrt{2}\times1.28\times10^{-10}\right)^3 \text{m}^3}$$

$$= 8891\,\text{kg/m}^3$$

$$\simeq 8.9\times10^3\ \text{kg/m}^3$$

10. Ans: (d)

Sol:

Model	**Particle properties**	**Examples**
1. Maxwell-Boltzmann	Distinguishable unlimited particles per quantum state	Ideal gas, Molecules
2.Bose Einstein	Indistinguishable unlimited particles per quantum state	Photon, phonon
3.Fermi Dirac	Indistinguishable, identical one particle Per quantum state (Pauli exclusion principle)	Electron, protons

11. Ans: (d)

Sol: The bullet proof jacket is made up of aramid fiber reinforced polymer (AFRB) with reinforcement phase is Aramid and matrix phase is polymer.

12. Ans: (c)

Sol: If the temperature of metal increases, the lattice vibration in the crystal structure increases. Hence collision frequency increases and relaxation time decreases. Due to that resistivity of metal increases.

13. Ans: (a)

Sol: Tuning frequency $f \propto \sqrt{\dfrac{Y}{\rho}}$

Where, Y = Young’s modulus of the crystal

ρ = density of crystal

$\rho \propto M$

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

Hence, upon solving f = 8.165 kHz

14. Ans: (d)

Sol: The overall mobility of a semiconductor, the present both impurity scattering (μ_I) and phonon scattering (μ_p) is $\mu_0 = \dfrac{\mu_I \times \mu_p}{\mu_I + \mu_p}$

15. Ans: (b)

Sol: The coupling coefficient (K) = 0.42

Output mechanical energy = 9.06×10^{-3}J

= 9.06 mJ

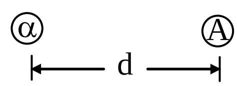
$\therefore$ The applied electric field

E = (1– 0.42) × 9.06 = 5.25mJ

16. Ans: (d)

17. Ans: (b)

Sol:



Given the atom A at a distance

$\alpha = 30A^o$ from an α -particle

The α-particle is helium molecules.

It carries 2 units of positive charge q

$= 2\times1.6\times10^{-19}$C

The electric field intensity at the site of the atom $A = \dfrac{1}{4\pi\varepsilon_0}.\dfrac{q}{d^2}$

The dipole moment induced in the atom = $\alpha.\dfrac{1}{4\pi\varepsilon_0}.\dfrac{q}{d^2}$

$$= 10^{-40} \times \frac{9\times10^9 \times 3.2\times10^{-19}}{900\times10^{-20}}$$

Dipole moment induced

$= 3.2\times10^{-32}$ coulomb-m

18. Ans: (b)

19. Ans: (a)

Sol: Stripped metal nanowires of alternative metal like Au & Ag can be used as barcode. Au as ‘0’ and Ag as ‘1’, so 0001010, 01011101, 11010001 there are all different barcodes.

20. Ans: (c)

21. Ans: (d)

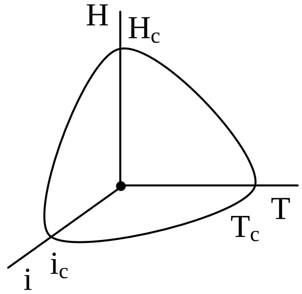
Sol: Aluminium metal matrix finds application in aerospace, thermal management areas, industrial products, and automotive applications such as engine piston, brake etc.

22. Ans: (d)

Sol: Superconductivity can not be exceeded by the application of electric field.

23. Ans: (a)

Sol: The critical current for superconductor is given as $i_c = 2\pi r\, H_c$ and $j_c = \dfrac{i_c}{\pi r^2} = \dfrac{2H_c}{r}$



So, critical current density depends on

1. Critical magnetic field
2. Temperature
3. Critical temperature also depends on penetration depth. With increasing in temperature, penetration depth increases.

24. Ans: (a)

Sol: The ceramics are high temperature super conductors. YBCO (Yithum Barium Copper Oxide) is a high temperature ceramic super conductor.

25. Ans: (b)

Sol: Given magnetic moment per atom $=2.22\mu_B$

Magnetic moment per 28 grams $=N\ 2.22\mu_B$

Where N= no.of atoms of Fe in 28 grams

56 grams of Fe contains 6.023×10^{23}atoms

28grams of Fe contains $N=\dfrac{6.023\times10^{23}}{2}=3\times10^{23}$

Magnetic moment per 28grams

$= 3\times10^{23}\times2.22\times\mu_B$

$= 3\times10^{23}\times2.22\times9.27\times10^{-24}$

$= 6.173$

26. Ans: (a)

Sol: Properties of Ferrites (Ferri magnetic materials)

1. Ferrite's possess permanent dipoles with anti parallel and unequal magnitudes they generate large magnetization.
2. Ferrites are ceramic in nature and they are high resistivity materials.

   Eg: Mn,Fe,O_4, Zn Fe_2O_4
3. Ferrite's have low eddy current losses due to high resistivity and hence there are used in high frequency transformers.

27. Ans: (d)

Sol: The hardness of a magnetic material is given by the value of the applied coercive field or even on the product of B and H_{max} called as energy product which gives area of the largest rectangle in the second quadrant of the hysteresis loop.

28. Ans: (c)

Sol: Given data:

$\chi_m = 6.8\times10^{-5}$

Relative permeability $\mu_r = 1+\chi_m$

$\mu_r = 1+6.8\times10^{-5}$

$\mu_r = 1.000068$

Permeability $\mu = \mu_r\,\mu_0 = (1.000068)(4\pi\times10^{-7})$

$= 1.256\times10^{-6}$

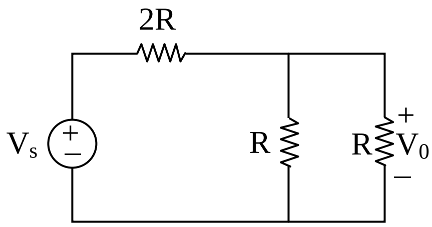
$\mu = 12.56\times10^{-7}$

29. Ans: (c)

30. Ans: (d)

Sol: Let $R_2 = R_3 = R$

So, $R_1 = 2R$ $\quad(\because R_1 = 2R_3)$



Using voltage division method,

$$V_0 = V_s \times \frac{R/2}{\frac{R}{2}+2R}$$

$$\Rightarrow \frac{V_0}{V_S} = \frac{R/2}{\frac{R}{2}+2R}$$

$$\Rightarrow \frac{V_0}{V_S} = \frac{R}{R+4R}$$

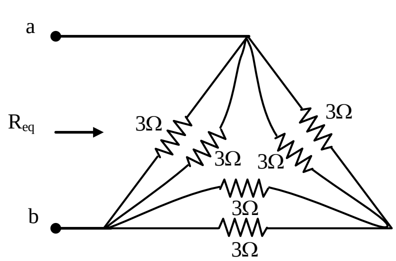
$$\Rightarrow \frac{V_0}{V_S} = \frac{1}{5} = 0.2$$

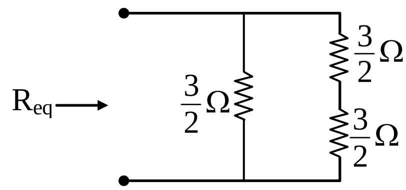
31. Ans: (d)

Sol: We know, $R_Y = \frac{R_\Delta}{3}$ (for three arms have equal resistance)

$\Rightarrow R_\Delta = 3R_Y$

The given circuit is simplified as





$$\therefore\ R_{eq} = \frac{3}{2} \parallel 3$$

$$= \frac{\frac{3}{2}\times 3}{\frac{3}{2}+3}$$

$$R_{eq} = \frac{9}{2}\times\frac{2}{9} = 1\Omega$$

32. Ans: (d)

Sol: The maximum average power transfer to the load, $P_{max} = \frac{|V_{Th}^2|}{4R_{Th}}$

$$P_{max} = \frac{(20)^2}{4\times 10} = 10W$$

33. Ans: (d)

Sol: $V(t) = 120 \cos(100\pi t - 20°)$

$\Rightarrow V = 120\angle -20°$

$i(t) = 4\cos(100\pi t + 10°) \Rightarrow I = 4\angle 10°$

$$\therefore\ Z = \frac{V}{I} = \frac{120\angle -20°}{4\angle 10°} = \frac{120}{4}\angle -30°$$

$Z = 30\angle -30°$

$Z = 30\cos(30°) - j30\sin(30°)$

$Z = 15\sqrt{3} - j15$

Resistor and capacitor connected in series

$\therefore\ R = 15\sqrt{3}\Omega$

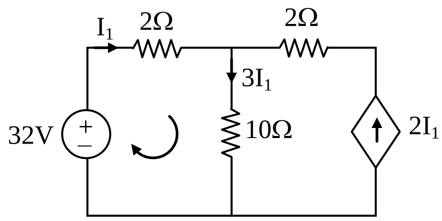
$$X_C = \frac{1}{\omega C} = 15\Omega$$

$$\Rightarrow C = \frac{1}{15 \times \omega}$$

$$C = \frac{1}{15 \times 100\pi} = \frac{1}{1500\pi} F$$

34. Ans: (d)

Sol:



By KVL, $32 - 2I_1 - 30I_1 = 0$

$\Rightarrow 32 = 32I_1 \Rightarrow I_1 = 1A$

Power dissipated in 10Ω resistor

$= (3I_1)^2 \times 10$

$= 9 \times 10$

$= 90$ watts

35. Ans: (d)

Sol: We know that for parallel resonance circuit impedance is maximum at resonance frequency.

$\therefore$ Here at 2.5 kHz the impedance is maximum.

So, $f_0 = 2.5 \times 10^3$ Hz

$\therefore \omega_0 = 2\pi f_0 = 2\pi \times 2.5 \times 10^3 = 5000\pi$ rad/sec

36. Ans: (a)

Sol: For ideal transform, $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{1}{n}$ &

$$\frac{I_1}{I_2} = \frac{-N_2}{N_1} = -n$$

$$\Rightarrow \frac{V_1}{V_2} = \frac{1}{n} \qquad \Rightarrow \frac{I_1}{I_2} = -n$$

$$\Rightarrow V_1 = \frac{1}{n} V_2 \text{----(1)} \qquad \Rightarrow I_2 = -\frac{1}{n} I_1 \text{----(2)}$$

Now compare equation (1) and (2) with the general equation of h-parameters

i.e., $V_1 = h_{11}I_1 + h_{12}V_2$

$I_2 = h_{21}I_1 + h_{22}V_2$

$\therefore h_{11} = 0,\ h_{12} = \frac{1}{n}$

$h_{21} = -\frac{1}{n}, h_{22} = 0$

$$[h] = \begin{bmatrix} 0 & 1/n \\ -1/n & 0 \end{bmatrix}$$

37. Ans: (d)

Sol: $R_{CB} = 20 + (40 \parallel 40) + 20$

$= 20 + 20 + 20$

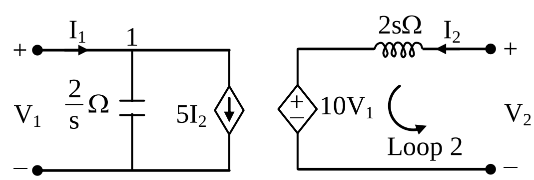
$R_{CB} = 60\ \Omega$

38. Ans: (d)

Sol: The general form of g-parameters are

$I_1 = g_{11}V_1 + g_{12}I_2$

$V_2 = g_{21}V_1 + g_{22}I_2$



Apply KCL at node '1',

$$I_1 = \frac{S}{2}V_1 + 5I_2 \qquad \text{………..} (1)$$

Apply KVL to loop '2',

$V_2 = 10V_1 + 2sI_2$ ……….. (2)

By comparing equation (1) and equation (2)

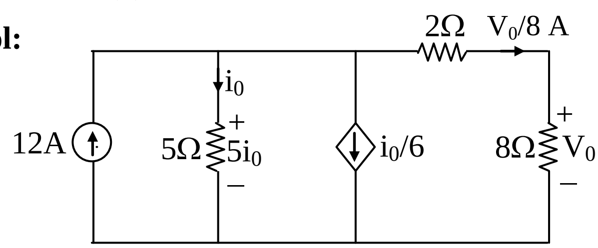
With general equation

$$\text{We get, } [g] = \begin{bmatrix} \frac{s}{2} & 5 \\ 10 & 2s \end{bmatrix}$$

39. Ans: (a)

40. Ans: (a)

Sol:



Using voltage division method,

$$V_0 = \frac{5i_0 \times 8}{8+2}$$

$$V_0 = \frac{40i_0}{10}$$

$$\Rightarrow i_0 = \frac{V_0}{4}$$

By KCL,

$$12 = i_0 + \frac{i_0}{6} + \frac{v_0}{8}$$

$$12 = \frac{V_0}{4} + \frac{V_0}{24} + \frac{V_0}{8}\left(\because i_0 = \frac{V_0}{4}\right)$$

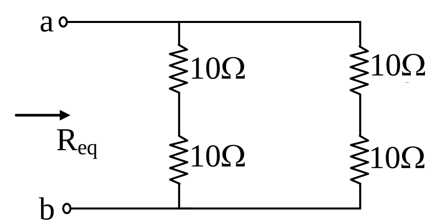
$$12 = \left(\frac{6+1+3}{24}\right)V_0$$

$$V_0 = \frac{12 \times 24}{10}$$

$V_0 = 28.8V$

41. Ans: (c)

Sol: Here the product of opposite arms are same, so using bridge balance condition the circuit can be represented as



$$R_{eq} = \frac{20}{2} = 10\Omega$$

$$G_{eq} = \frac{1}{R_{eq}} = \frac{1}{10} = 0.1℧$$

42. Ans: (b)

Sol: Using voltage division method,

$$V_0 = \frac{V_s(R_2 // 5k)}{R_1 + (R_2 // 5k)}$$

$$\Rightarrow \frac{R_2 // 5k}{R_1 + (R_2 // 5k)} = \frac{V_0}{V_s}$$

$$\Rightarrow \frac{R_2 // 5k}{R_1 + (R_2 // 5k)} = 0.8 \text{ -----(1)}$$

Here, $R_{eq} = R_1 + (R_2//5K)$

$\Rightarrow R_1 + (R_2//5K) = 50K$ -----(2)

From equation (1) and equation (2)

$$\frac{R_2 // 5K}{50K} = 0.8$$

$R_2//5K = 40K$

$$\frac{5R_2}{5+R_2} = 40$$

$5R_2 = 40\times5 + 40R_2$

$40R_2 - 5R_2 = -40\times5$

$$R_2 = \frac{-40\times5}{35} = \frac{-40}{7}$$

$$R_2 = \frac{-40}{7}\,k\Omega$$

43. Ans: (b)

Sol: We know $R_Y = \dfrac{R_\Delta}{3}$

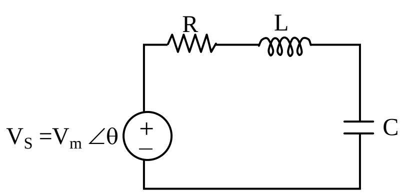
$$R_Y = \frac{R/2}{3} = \frac{R}{6}\Omega$$

44. Ans: (c)

45. Ans: (a)

46. Ans: (c)

Sol: In a series RLC circuit



At resonance condition $I_m = \dfrac{V_m}{R}$

At lower cut off frequency,

$$I = \frac{I_m}{\sqrt{2}}$$

$$\Rightarrow \frac{V_m}{\sqrt{R^2+\left(\omega L - \frac{1}{\omega C}\right)^2}} = \frac{V_m}{\sqrt{2}R}$$

$$\Rightarrow \sqrt{R^2+\left(\omega L - \frac{1}{\omega C}\right)^2} = \sqrt{2}\,R$$

$$\Rightarrow \left(\omega L - \frac{1}{\omega C}\right) = \pm R$$

At lower cut off frequency

$$\omega L - \frac{1}{\omega c} = -R$$

Power factor angle $\phi = \tan^{-1}\left(\dfrac{\omega L - \frac{1}{\omega C}}{R}\right)$

$$= -45^o$$

$\therefore$ Power factor = $\cos\phi$ = 0.707 leading

($\because$ capacitive nature)

47. Ans: (c)

Sol: Here, voltage across capacitor, voltage across resistor

$\Rightarrow V_c(t) = V_R(t) = V_0e^{-t/\tau}$ Volts

Where V_0 = 5 Volts

τ = time constant

$$i_R(t) = \frac{V_R(t)}{R} = \frac{V_0}{R}e^{-t/\tau}\text{amperes}$$

The energy absorbed by the resistor up to time t is

$$W_R(t) = \int_0^t V_R(t)\,i_R(t)dt$$

$$= \int_0^t \frac{V_0^2}{R}e^{-\frac{2t}{\tau}}dt$$

$$= -\frac{\tau V_0^2}{2R}e^{-\frac{2t}{\tau}}\Big|_0^t$$

$$\Rightarrow W_R(t) = \frac{1}{2}CV_0^2\left(1 - e^{-\frac{2t}{\tau}}\right)$$

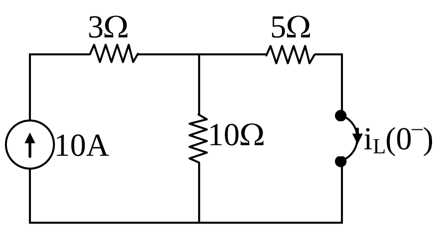
For t = 2τ

$$W_R(2\tau) = \frac{1}{2} \times 25 \times 4\left(1 - e^{-4}\right)$$

$\Rightarrow W_R\ (2\tau) = 50\ (1 - e^{-4})$ joules

48. Ans: (d)

Sol: Circuit at t = 0^-



Here, $i_L(0^-) = i_L(0^+) = \frac{10 \times 10}{10 + 5}$

$$\Rightarrow i_L(0^+) = \frac{20}{3}$$

∴ Initial energy stored in the inductor is,

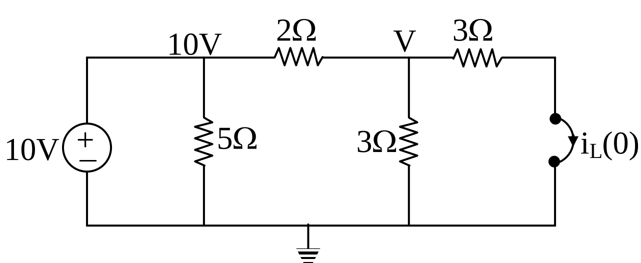
$$W_L(0) = \frac{1}{2}Li^2(0)$$

$$W_L(0) = \frac{1}{2} \times 2 \times \left(\frac{20}{3}\right)^2$$

$$\Rightarrow W_L(0) = \frac{400}{9}\text{Joules}$$

49. Ans: (b)

Sol: Circuit at t = 0^-



By nodal analysis:

$$\frac{V - 10}{2} + \frac{V}{3} + \frac{V}{3} = 0$$

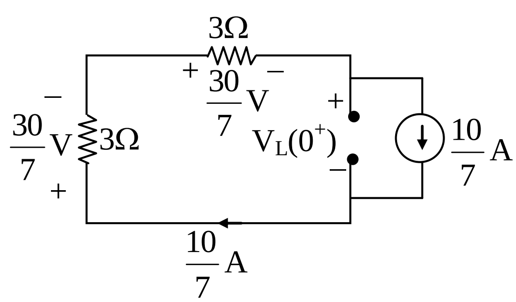
$$\Rightarrow V\left(\frac{1}{2} + \frac{2}{3}\right) = 5$$

$$\Rightarrow \frac{7V}{6} = 5$$

$$V = \frac{30}{7}$$

$$\therefore\ i_L(0^-) = i_L(0^+) = \frac{30/7}{3} = \frac{10}{7}A$$

Circuit at t = 0^+:



By KVL, $-V_L(0^+) - \frac{30}{7} - \frac{30}{7} = 0$

$$\Rightarrow V_L(0^+) = -\frac{60}{7}\text{volts}$$

50. Ans: (a)

Sol: Voltage across the capacitor at resonance

$V_c = -jQ\ V_m$

$\Rightarrow V_c = -j25 \times 20$

$= -j500$ volts.

51. Ans: (a)

Sol: Complex power, $S = \frac{1}{2}VI^*$

$$=\frac{1}{2}\times 20\angle 30^{o}\times 50\angle -60^{o}$$

$$=\frac{20\times 50}{2}\angle 30^{o}-60^{o}$$

$$=500\angle -30^{o}$$

Average real power, $P=500\cos 30^{o}$

$$=250\sqrt{3}\text{ watts}$$

52. Ans: (b)

Sol: v(t) = 225cos(5t+30^o)V

i(t) = 2cos(5t+60^o–90^o)A

= 2cos(5t–30^o)A

$\therefore$ V = 225$\angle$30^o

I = 2$\angle$–30^o

$\therefore$ Complex power, S = $\frac{1}{2}VI^*$

$$=\frac{1}{2}\times 225\angle 30^{o}\times 2\angle 30^{o}$$

Average real power, $P=\frac{225\times 2}{2}\cos 60^{o}$

$$=225\cos 60^{o}$$

$$=225\times\frac{1}{2}$$

=112.5 watts

53. Ans: (b)

Sol: For two point charge, energy stored is given by

$$W=\frac{1}{2}Q_1V_1+\frac{1}{2}Q_2V_2$$

$$=\frac{1}{2}\times Q_1\times\frac{Q_2}{4\pi\varepsilon_0 r}+\frac{1}{2}\times Q_2\times\frac{Q_1}{4\pi\varepsilon_0 r}$$

$$=\frac{Q_1Q_2}{4\pi\varepsilon_0 r}$$

$$=\frac{3\times 10^{-9}\times -3\times 10^{-9}}{4\pi\times\frac{10^{-9}}{36\pi}\times 0.2}$$

$$=-81\times\frac{10^{-9}}{0.2}=-405\text{nJ}$$

54. Ans: (d)

Sol: Given: ℓ = 100cm

A = 80cm^2

N = 250

I = 10Amp

The energy stored in a magnetic field is

$$W_M=\frac{1}{2}LI^2$$

$$L=\frac{\mu_0N^2A}{\ell}$$

$$=\frac{4\pi\times 10^{-7}\times(250)^2\times(80\times 10^{-4})}{100\times 10^{-2}}$$

$$=\frac{4\pi\times 10^{-7}\times(25\times 10)^2\times(8\times 10\times 10^{-4})}{1}$$

$= 4 \times 25 \times 8 \times 25 \times \pi \times 10^{-7} \times 10^{-3}\times 10^{2}$

$= 2\pi \times 10^{2} \times 10^{2} \times 10^{-1} \times 10^{-7}$

$L = 2\pi \times 10^{-4}$

$$W_m=\frac{1}{2}(2\pi)\times 10^{-4}\times(100)$$

$= \pi \times 10^{-2}$

$= 31.4 \times 10^{-3}$

$\therefore W_m$ = 31.40mJ

55. Ans: (c)

Sol: For any vector field, $\vec{P}$ divergence of curl of vector is always zero.

$\therefore\ \nabla.\nabla\times\vec{P}=0$

56. Ans: (d)

Sol: $W=-Q\int_{(1,3,5)}^{(2,0,3)}\vec{E}.d\vec{L}$

$\vec{E}.d\vec{L}=(x\hat{a}_y).(dx\hat{a}_x+dy\hat{a}_y+dz\hat{a}_z)=xdy$

$\therefore W=-4\int_3^0 xdy$ ----------(1)

Point of integration is (1,3,5) to (1,3,3) to (1,0,3) to(2,0,3). Between second and third point, x and z coordinates are constant where as y-coordinate varies from y=3 to y=0.Hence substitute x=1 in equation (1) ,we get

$W=-4\int_3^0 1\times dy=-4[y]_3^0=-4[0-3]=12J$

57. Ans: (a)

Sol: $\overline{p}=Q\overline{d}$, where $\overline{d}$ is a vector directed from negative charge towards positive charge.

hence $\overline{d}=(0.001\hat{a}_z)-(-0.001\hat{a}_z)$

$=0.002\hat{a}_z$

$\therefore\overline{p}=3\times10^{-6}(0.002)\hat{a}_z$

$=6\hat{a}_z\,nC-m$

58. Ans: (c)

Sol: $\rightarrow$ $\nabla^2\vec{A}=-\mu\vec{J}$ s the Poisson's equation in a static magnetic field, where the region is having non-zero current $(\vec{J}\neq0)$ distribution.

$\rightarrow$ $\nabla^2 V=0$ is the Laplace's equation, if the region is charge free (ρ_v=0).

$\rightarrow$ $\vec{H}=-\nabla V_m$ is defined if and only if $\vec{J}=0$ (current free).

Consider

$\nabla\bullet\vec{B}=0$

$\nabla\bullet\mu\vec{H}=0$

$\nabla\bullet\vec{H}=0$ (Assumed medium is homogeneous and current-free)

$\nabla.(-\nabla V_m)=0$

$\nabla^2V_m=0\rightarrow$ is Laplace's equation in a static magnetic field

$\nabla^2V=\frac{-\rho_v}{\varepsilon}$ is the Poisson's equation, only when the medium is homogeneous.

Therefore the correct matching code is P-3, Q-1, R-4, S-2

59. Ans: (c)

Sol: $\nabla.\overline{A}\neq0\Rightarrow$ The field has divergence

$\nabla.A=+ve\Rightarrow$ The divergence is outward i.e., source

$\nabla\times A\neq0\Rightarrow$ The field is non-conservative or rotational

60. Ans: (c)

Sol: The capacitance of long coaxial cable is given by

$$C = \frac{2\pi\varepsilon\ell}{\ell n\left(\frac{b}{a}\right)}(F)$$

Where l: length of the cable

ε: permittivity of medium between the conductors

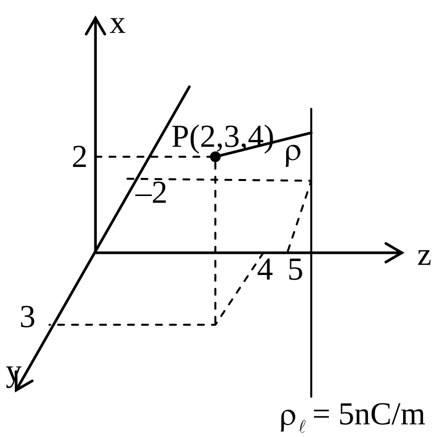
a: radius of inner conductor

b: radius of outer conductor

In general capacitance of capacitor will never depends on charge and potential applied between the two conductors. It will truly depends on physical dimensions of system of conductors and electrical permittivity.

61. Ans: (a)

Sol:



Due to infinite line charge,

$$\overline{E} = \frac{\rho_\ell}{2\pi\varepsilon\rho}\hat{a}_\rho$$

Hence, the radial distance

$$\rho = (2,3,4) - (x, -2, 5)$$

$$= 5\hat{a}_y - \hat{a}_z$$

$$E = \frac{5\times10^{-9}}{2\pi\times\frac{1}{36\pi\times10^9}\times\left(\sqrt{25+1}\right)^2}\left(5\hat{a}_y - \hat{a}_z\right)$$

$$= \frac{90}{26}\left(5\hat{a}_y - \hat{a}_z\right)V/m$$

62. Ans: (a)

Sol: $\rho_v = \nabla.\overline{D}$

$$= \frac{1}{\rho}\frac{\partial}{\partial\rho}\left[\rho\times\rho z^2\sin^2\phi\right] + \frac{1}{\rho}\frac{\partial}{\partial\phi}\left[\rho z^2\sin\phi\cos\phi\right] + \frac{\partial}{\partial z}\left[\rho^2 z\sin^2\phi\right]$$

$$= \frac{1}{\rho}\times 2\rho z^2\sin^2\phi + \frac{1}{\rho}\times\rho z^2\cos 2\phi + \rho^2\sin^2\phi$$

$$= 2z^2\sin^2\phi + z^2\cos 2\phi + \rho^2\sin^2\phi$$

$$= 2z^2\sin^2\phi + z^2\left(1 - 2\sin^2\phi\right) + \rho^2\sin^2\phi$$

$$= z^2 + \rho^2\sin^2\phi$$

63. Ans: (d)

Sol: $\Delta Q = \left[\frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}\right]_{(4,2,-3)} \times 10^{-10}$

$$= \left[12yz + 6z\right]_{(4,2,-3)}$$

$$= \left[-12\times2\times3 + 6\times-3\right]\times10^{-10} = -9nC$$

64. Ans: (b)

Sol: Given region is ϕ = constant $\left(\phi = \frac{\pi}{4}\right)$, hence

dS= rdr dθ

$$S = \int_{r=0}^{2}\int_{\theta=0}^{\frac{\pi}{2}} r\,dr\,d\theta$$

$$= \left.\frac{r^2}{2}\right|_0^2 \left.\theta\right|_0^{\frac{\pi}{2}}$$

$$\therefore S = \pi\ m^2$$

65. Ans: (d)

Sol: All statements are correct.

66. Ans: (a)

Sol: Electrical conductivity of an alloy or solid solution decreases with increasing impurity level because of disturbance in periodicity of atoms and due to that collection of e^- takes place.

67. Ans: (c)

Sol: The internal structure of a material gives the information about the arrangement of atoms in a material. Statement I is correct.

The properties of bulk matter of all kinds are dependent of the nature and distribution of imperfections. Statement II is incorrect.

68. Ans:(c)

Sol: Statement (I) is correct.

By using substitution theorem, we replace an impedance branch by another branch with different circuit components, without disturbing the voltage-current relationship in the network. So, statement (II) is wrong

69. Ans: (b)

Sol: Let the instantaneous voltage and current are

$v(t) = V_m\cos(\omega t+\theta_v)$

$i(t) = I_m\cos(\omega t+\theta_i)$

$p(t) = v(t)i(t)$

$= V_mI_m\cos(\omega t+\theta_v)\cos(\omega t+\theta_i)$

$$P(t) = \frac{1}{2}V_mI_m\cos(\theta_v-\theta_i)+\frac{1}{2}V_mI_m\cos(2\omega t+\theta_v+\theta_i) \quad \text{….(1)}$$

The 2^{nd} part of the above expression is a sinusoidal function whose frequency is 2ω (changes with time)

70. Ans: (d)

Sol: Superposition theorem is applicable to linear networks and system. The system with characteristics equation $y = x^3$ is a non-linear system. So, superposition theorem is not applicable to this system

71. Ans: (b)

72. Ans: (c)

Sol: When dielectric is subjected to alternating field, the polarization (P) varies, so the dielectric constant.

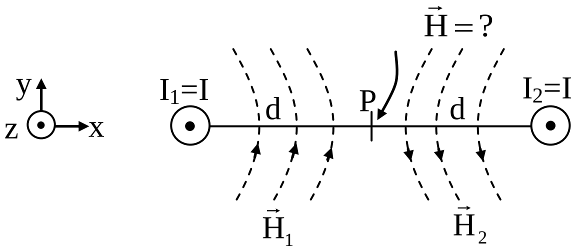
Dielectric constant $\left(\varepsilon_r^*\right) = \varepsilon_r^1 - i\varepsilon_r^{11}$

Where ε_r^{11} is measure of dielectric loss.

73. Ans: (c)

74. Ans: (a)

Sol: Consider the two long wires carrying current in the same direction (assume +z direction)

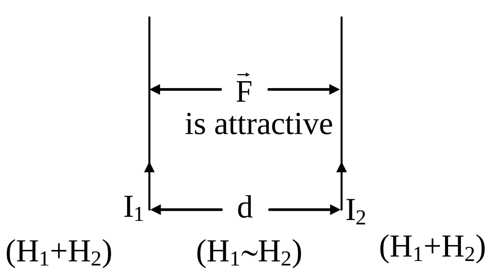


$$\vec{H} = \vec{H}_1 + \vec{H}_2$$

$$= \frac{I}{2\pi d}(+\hat{a}_y) + \frac{I}{2\pi d}(-\hat{a}_y)$$

$\therefore\ \vec{H} = 0$ (null vector)

Therefore when the two wires are carrying currents in the same direction, with equal magnitude, then the magnetic field intensity midway between then is zero. (or) null vector. This indicates there exist a weak magnetic lines of force between the two wires, due to this there is a force of attraction can exist between the wires.



If two long wires are carrying currents in the same direction with the magnitudes I_1 and I_2 and separated by a distance 'd' then the magnitude of magnetic force per unit length is given by

$$f = \frac{\mu I_1 I_2}{2\pi d}\ \text{N/m}$$

if $I_1 = I_2 = I$

Then $f = \frac{\mu I^2}{2\pi d}$; $f \alpha I^2$

Therefore both the statements S1 and S2 are individually true and S2 is the correct explanation of S1.

75. Ans: (a)

Sol: Reluctance: The opposition offered by a magnetic circuit, to flow of magnetic flux is called reluctance, which is given by

$$R = \frac{\ell}{\mu_0 \mu_r A}(\text{AT/Wb})$$

Permenace: The reciprocal of reluctance is called permeance, which indicates the conducting power of magnetic flux (ϕ).

$$P = \frac{1}{R}$$

When reluctance of a magnetic material decreases, then the permeance will increase. Therefore both S1 and S2 are individually true and S2 is the correct explanation of S1.