DETAILED SOLUTIONS

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ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 16

Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials [All Topics]

Section B : Systems & Signal Processing + Communication Systems [All Topics]

Section C : BEE-2 + Analog Electronics-2 + Elec. & Electro. Measurements-2 [Part Syllabus]

ANSWER KEY

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

DETAILED EXPLANATIONS
Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials

1. (c)

The divergence in spherical coordinate system is given as

$$\vec{\nabla}\cdot\vec{V} = \frac{1}{\rho^2}\frac{\partial}{\partial\rho}(\rho^2 V_\rho) + \frac{1}{\rho\sin\theta}\frac{\partial}{\partial\theta}(V_\theta\cdot\sin\theta) + \frac{1}{\rho\sin\theta}\frac{\partial V_\phi}{\partial\phi}$$

$$= \frac{1}{\rho^2}\frac{\partial}{\partial\rho}(\rho^3\cos\theta) + \frac{1}{\rho\sin\theta}\frac{\partial}{\partial\theta}\left(-\frac{1}{\rho}\sin^2\theta\right) + \frac{1}{\rho\sin\theta}\frac{\partial}{\partial\phi}(2\rho^2\sin\theta)$$

$$= 3\cos\theta - \frac{1}{\rho^2\sin\theta}(2\sin\theta\cdot\cos\theta)$$

$$= \left(3-\frac{2}{\rho^2}\right)\cos\theta$$

$$(\vec{\nabla}\cdot\vec{V})_\rho = \left[3-\frac{2}{(\sqrt{2})^2}\right]\cos 60^\circ = 2\times\frac{1}{2} = 1$$

2. (c)

For *ABCD* surface

$$\vec{ds} = \rho\cdot d\phi\cdot dz\,, \qquad \rho = 5$$

Hence, area $ABCD = \int\vec{ds} = \int_{\phi=0}^{\pi/2}\int_{z=0}^{10}\rho\cdot d\phi\cdot dz$

$$= 5\int_{\phi=0}^{\pi/2}d\phi\int_{z=0}^{10}dz = 25\pi$$

3. (a)

Using stokes theorem,

$$\oint\vec{A}\cdot\vec{dl} = \iint_s(\vec{\nabla}\times\vec{A})\cdot\vec{ds}$$

$\vec{ds}$ for the following surface is given by

$$\vec{ds} = \rho\cdot d\rho\cdot d\phi\,\hat{a}_z$$

Calculating, $\vec{\nabla}\times\vec{A} = \frac{1}{\rho}\begin{vmatrix}\hat{a}_\rho & \rho\,\hat{a}_\phi & \hat{a}_z\\ \frac{\partial}{\partial\rho} & \frac{\partial}{\partial\phi} & \frac{\partial}{\partial z}\\ A_\rho & \rho\cdot A_\phi & A_z\end{vmatrix}$

Calculate only $\hat{a}_z$ term

$$\vec{\nabla} \times \vec{A} = \frac{1}{\rho}\left[\frac{\partial}{\partial \rho}(A_\phi \cdot \rho) - \frac{\partial}{\partial \phi}(A_\rho)\right]\hat{a}_z$$

$$= \frac{1}{\rho}\left[\frac{\partial}{\partial \rho}(\rho \sin\phi) - \frac{\partial}{\partial \phi}(\rho \cos\phi)\right]\hat{a}_z$$

$$= \frac{1}{\rho}[\sin\phi + \rho\sin\phi] = \frac{(1+\rho)}{\rho}\sin\phi\,\hat{a}_z$$

As we know,

$$\oint \vec{A} \cdot \vec{dl} = \iint (\vec{\nabla} \times \vec{A})ds = \iint_s \frac{(1+\rho)}{\rho} \cdot \sin\phi(\rho \cdot d\rho \cdot d\phi)$$

$$= \int_2^5 (1+\rho) \cdot dp \int_{30°}^{60°} \sin\phi \cdot d\phi$$

$$= \left[\rho + \frac{\rho^2}{2}\right]_2^5 [-\cos\phi]_{30°}^{60°}$$

$$= \frac{27}{4}\left[\sqrt{3} - 1\right] = 4.94$$

4. (c)

By using Gauss's law

$$\vec{\nabla} \cdot \vec{D} = \rho_v$$

$$P_v = \frac{\partial}{\partial x}[A_x] + \frac{\partial}{\partial y}\left[A_y\right] + \frac{\partial}{\partial z}[A_z]$$

$$= \frac{\partial}{\partial x}[2y^2 + z] + \frac{\partial}{\partial y}[4xy] + \frac{\partial}{\partial z}[x]$$

$$= 0 + 4x + 0$$

$$(\rho_v)_{-1,\,0,\,3} = -4 \text{ C/m}^3$$

5. (a)

Since V is known,

$$W = -Q\int_A^B \vec{E} \cdot \vec{dl} = Q \cdot V_{AB}$$

$$= Q(V_B - V_A)$$

$$= 10\times10^{-6}\left[\frac{10}{4^2}\sin 90^\circ\cos 60^\circ - \frac{10}{1}\sin 30^\circ\cos 120^\circ\right]$$

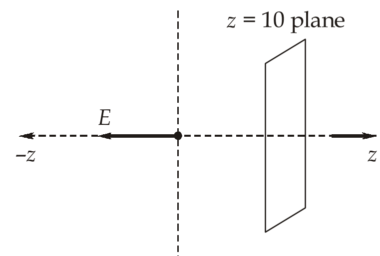
$$= 10\left[\frac{10}{16}\times\frac{1}{2} - 10\times\frac{1}{2}\left(-\frac{1}{2}\right)\right]\times10^{-6}$$

$$= 10\left[\frac{10}{32}+\frac{5}{2}\right]\times10^{-6}$$

$$W = 28.125\ \mu\text{J}$$

6. (d)

Electric field intensity is given by



$$E = \frac{\rho_s}{2\varepsilon_0}[-\hat{a}_z]$$

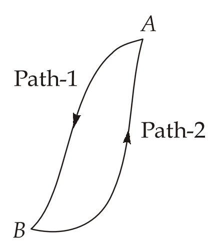
$$= \frac{20\times10^{-9}}{2\times\varepsilon_0}(-\hat{a}_z)$$

$$= 10\times10^{-9}\times36\pi\times10^{9}(-\hat{a}_z)$$

$$\vec{E} = -360\pi\hat{a}_z\ \text{V/m}$$

7. (b)

As we know,



$$\oint \vec{E}\cdot\vec{dl} = 0$$

By applying stokes theorem,

$$\vec{\nabla}\times\vec{E} = 0$$

and we know the relation

$$V = -\int \vec{E}\cdot\vec{dl} \quad \text{(Not closed path integration)}$$

$$E = -\nabla V$$

8. (a)

Since $\hat{a}_z$ is normal to the boundary plane, we obtain the normal component as -

$$E_{1n} = E_1\cdot\hat{a}_n = E_1\cdot\hat{a}_z = 3$$

$$= 3\cdot\hat{a}_z$$

and $$\vec{E}_1 = \vec{E}_{1t}+\vec{E}_{1n}$$

(Where $E_{1t}\rightarrow$ tangential component of $\vec{E}_1$ and $E_{1n}\rightarrow$ Normal component of $\vec{E}_1$)

$$\vec{E}_{1t} = \vec{E}_1-\vec{E}_{1n}$$

$$= 5\hat{a}_x-2\hat{a}_y+3\hat{a}_z-3\hat{a}_z$$

$$\vec{E}_{1t} = 5\hat{a}_x-2\hat{a}_y\ \text{kV/m}$$

Using boundary condition,

$$\vec{E}_{2t} = \vec{E}_{1t} = 5\hat{a}_x - 2\hat{a}_y \text{ kV/m}$$

Using 2nd boundary condition,

$$D_{2n} = D_{1n}$$

$$\vec{\varepsilon}_{r2} \cdot \vec{E}_{2n} = \vec{\varepsilon}_{r1} \cdot \vec{E}_{1n}$$

$$\vec{E}_{2n} = \frac{4}{3}[3\hat{a}_z]$$

$$= 4\hat{a}_z \text{ kV/m}$$

Now, $$\vec{E}_2 = \vec{E}_{2t} + \vec{E}_{2n}$$

$$\vec{E}_2 = 5\hat{a}_x - 2\hat{a}_y + 4\hat{a}_z \text{ kV/m}$$

9. (b)

V_m is magnetic scalar potential,

$$\vec{H} = -\nabla V_m$$

$$\vec{H} = -\left(\frac{\partial}{\partial x}V_x \cdot \hat{a}_x + \frac{\partial}{\partial y}V_y \cdot \hat{a}_y + \frac{\partial}{\partial z}V_z \cdot \hat{a}_z\right)$$

$$= -(2xy + y^2)\hat{a}_x - (x^2 + 2xy)\hat{a}_y - (t)\hat{a}_z$$

$$\vec{H}(1, 1, 1) = -3\hat{a}_x - 3\hat{a}_y - \hat{a}_z$$

$$|\vec{B}| = \mu_0 \mu_r \cdot |H|$$

$$= 4\pi \times 10^{-7} \times \sqrt{3^2 + 3^2 + 1}$$

$$= 5.5 \ \mu\text{T}$$

10. (b)

Using ampere's circuit law

$$\oint \vec{H} \cdot \vec{dl} = I_{\text{enc}}$$

The loop direction is anti clockwise, the currents which will produce ACW magnetic field will be considered +ve

$$\oint \vec{H} \cdot \vec{dl} = 10 - 30 = -20 \text{ A}$$

11. (d)

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

and $$\nabla^2 A = -\mu_0 J$$

12. (a)

As,
$$J = \vec{\nabla}\times\vec{H} = \vec{\nabla}\times\left(\frac{B}{\mu_0\mu_r}\right)$$
$$= \frac{1}{4\pi\times10^{-7}}\left[\frac{\partial B_y}{\partial x}-\frac{\partial B_x}{\partial y}\right]\hat{a}_z\times\frac{1}{2.5}\hat{a}_z$$
$$= \frac{10^6}{\pi}(-5-10)\times10^{-3}\hat{a}_z$$
$$J = -4.775\hat{a}_z \text{ KA/m}^2$$

13. (b)

Self inductance per meter,
$$L = \frac{N^2(\mu_0\mu_r)A}{l} = (4000)^2 \times 4\pi \times 10^{-7} \times 1000 \times 4 \times 10^{-4}$$
$$= 256\pi \times 10^{-2} \text{ H/m}$$

Energy stored,
$$E = \frac{1}{2}LI^2 = \frac{1}{2}\times256\pi\times10^{-2}\times0.25$$
$$= 128\pi \times 0.25 \times 10^{-2} = 32\pi \times 10^{-2} \approx 1 \text{ J/m}$$

14. (a)

Capacitance when air is dielectric is C_1 and charge Q_1
$$C_1 = \frac{\varepsilon_0\cdot A}{d} \quad \text{...(i)}$$
Capacitance when dielectric is given is C_2 and charge Q_2
$$C_2 = \frac{\varepsilon_0\cdot\varepsilon_{r2}\cdot A}{d} \quad \text{...(ii)}$$
Given, $Q_2 = 2Q_1$ $\{Q \propto C\}$

Means $C_2 = 2C_1$
$$\frac{\varepsilon_0\cdot\varepsilon_r\cdot A}{d} = 2\times\frac{\varepsilon_0\cdot A}{d}$$
$$\varepsilon_r = 2$$
Susceptibility of dielectric,
$$\chi_e = \varepsilon_r - 1$$
$$= 2 - 1$$
$$\chi_e = 1$$

16. (c)

The electric field lines and equipotential surfaces are perpendicular to each other for any electric charge.

17. (a)

For a sphere, potential $= \dfrac{Q}{4\pi\varepsilon_0 R}$ (where, R = radius of sphere)

For two metallic spheres; $\dfrac{Q_1}{4\pi\varepsilon_0 R_1} = \dfrac{Q_2}{4\pi\varepsilon_0 R_2}$

$$\frac{Q_1}{Q_2} = \frac{R_1}{R_2} = 4$$

Surface area of sphere $= 4\pi R^2$

Hence, $\dfrac{\text{Area}_1}{\text{Area}_2} = \dfrac{R_1^2}{R_2^2} = (4)^2 = 16$

18. (a)

Process chart using round robin scheduling,

P_1	P_2	P_1	P_3	P_4	P_2	P_5	P_1	P_3	P_4	P_5	P_1	P_3	P_4	P_1

0 2 4 6 8 10 12 14 16 18 19 21 23 25 26 30

Pid	*AT*	*BT*	*CT*	*TAT*	*WT*
P_1	0	12	30	30	18
P_2	2	4	12	10	6
P_3	3	6	25	22	16
P_4	4	5	26	22	17
P_5	5	3	21	16	13

$$\text{Average } WT = \frac{18+6+16+17+13}{5} = 14 \text{ ms}$$

20. (d)

$(110XY)_2 * (101)_2 =$

```
      1 1 0 X Y
  1 1 0 X Y
---------------
1 0 0 0 0 Z 1 1
```

$\therefore$ $Y = 1$

$X = 1$

Also, $Z = Y$

$\therefore$ $Z = 1$

21. (a)

Trap is non-maskable edge and level triggered interrupt.

22. (b)

$$(0.11)_2 = 2^{-1} + 2^{-2} = (0.75)_{10}$$

$$0.75 \times 8 = 6.0 \rightarrow (\text{carry } 6)$$

$$(0.75)_{10} = (0.60)_8$$

23. (d)

The state of CPU at the end of the exclusive cycle (when the interrupt is recognized) is determined from:

1. the content of the program counter.
2. the content of all processor registers.
3. the content of certain status conditions.

25. (b)

Little endian (little and first) : First location can hold least significant byte.

Example: Intel uses little endian

little endian format (little end first).

26. (c)

The content at the memory location 30 after the execution of the following instructions:

- PUSH 10 will PUSH the value at location $(80)_{16}$ onto stack.
- PUSH 20 will PUSH the value at location $(4A)_{16}$ onto stack.
- ADD will add the value and push the result onto stack.

$$\begin{array}{r} 80 \\ +4A \\ \hline CA_{16} \\ \hline \end{array}$$

- POP 30 will POP the value which is $(CA)_{16}$ from stack and store the result at location 30.

27. (b)

$$\text{Average CPI} = \Sigma(ICi \times CPi)$$
$$= 1 \times 0.1 + 2 \times 0.2 + 4 \times 0.3 + 8 \times 0.4$$
$$= 4.9$$

28. (d)

$$\text{Magnetization, } \vec{M} = \chi\vec{H}$$
$$= -5 \times 10^{-5} \times 10^{5} \text{ A/m}$$
$$= -5 \text{ A/m}$$

$$\text{Magnetic flux density, } \vec{B} = \mu_0(\vec{H} + \vec{M})$$
$$= 12.57 \times 10^{-7}(10^5 - 5)$$
$$= 0.126 \text{ Wb/m}^2$$

30. (a)

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

$$\text{Charge, } q = CV$$

Now, $\text{Polarization; } P = \frac{q}{A} = \frac{C}{A} \cdot V$

Where A is area of the crystal capacitor.

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

$$\text{So,} \qquad \frac{\Delta P}{P} = \frac{\Delta C}{C}$$

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

31. (c)

The electrical conductivity of materials can be controlled by

- Controlling the number of charge carries in the materials.
- Controlling the mobility or ease of movement of the charge carriers.

32. (d)

The energy losses in a dielectric material are due to

1. Ionization
2. Leakage current
3. Polarization
4. Structural in homogeneity

33. (d)

Applications of Hall effect:

- It is used to determine whether a semiconduction is n-type or p-type.
- It is also used to determine.
- The carrier concentration.
- The mobility.
- The drift velocity.
- The conductivity of specimen.

It is also used in manufacturing of magnetic-flux meter and Hall-effect multiplier.

34. (d)

The diamagnetic substances include:

- organic solids like naphthalene, benzene etc.
- metals like gold, silver and copper.
- Rare gases like He, Ne and Ar.

35. (d)

Soft magnetic materials are materials having

1. high permeability
2. low hysteresis loss
3. low coercive force

36. (c)

Number of atoms in a unit cell of BCC crystal = 2

Number of atoms in a unit cell of FCC crystal = 4

$$\text{Required ratio} = \frac{2}{4} = 0.50$$

37. (a)

Ionic crystal are hard and brittle because of strong ionic bonding.

38. (d)

- The crystal structure of diamond is equivalent to a face-centrad cubic (FCC) lattice.
- In diamond each carbon atom is at the centre of a tetrahedron formed by four other carbon atoms, so the coordination number is four.
- In diamond, each atom can be thought of as a sphere with a radius of $\frac{1}{8}$ of the cubic body diagonal.

Therefore, Packing fraction $= \dfrac{8\times\frac{4}{3}\pi r^3}{a^3}$, Here, $r = \dfrac{a\sqrt{3}}{8}$

$$= \frac{8\times\frac{4}{3}\pi\left(\frac{a\sqrt{3}}{8}\right)^3}{a^3} \approx 0.34$$

39. (a)

A good insulating materials should have:

- a low dissipating factor.
- high insulation resistance.
- good dielectric strength.
- high mechanical strength.
- high thermal conductivity.

40. (c)

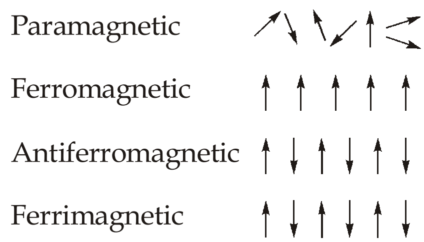
$$\text{Capacitance, } C = \frac{\in A}{d}$$ (where A is the area of plate)

So, $C \propto A$

New capacitance, $C_{new} = \dfrac{5\times 5}{20\times 20}\times C_1 = \dfrac{C_1}{16}$

41. (b)

The arrangement of dipole moments in different magnetic materials is shown below:



42. (c)

When an alloy is formed adding two or more metals the resistivity at alloy is greater than that of all those metals.

$$\rho_r = \rho_{al} + \rho_{cu}$$

43. (d)

If ρ = 0, Poisson's equation reduces to Laplace equation but solution of Poisson's equation is not same as that of Laplace equation.

44. (a)

Routers are used at Network layer to perform the routing function. With the help of routing tables find the best route for all the data sent to them by the previous router or at the end station of the LAN.

45. (c)

The imaginary part of the dielectric constant is a measure of the dielectric loss in the substance.

Section B : Systems & Signal Processing + Communication Systems

46. (d)

$y(t)$ will be written as

$$y(t) = x(t - t_0)$$
$$y(t) = (t - t_0)\, u(t - t_0)$$
$$L[y(t)] = \frac{1}{s^2} e^{-st_0}$$

47. (b)

- Causal or non-causal

$$y(t)\big|_{t=-\pi} = x(\sin(-\pi))$$
$$y(-3.14) = x(0)$$

In this case of present output dependens on figure input,

So system is non-causal.

- Linear or nonlinear,

$$x_1(t) \rightarrow y_1(t) = x_1(\sin(t))$$
$$x_1(t) \rightarrow y_1(t) = x_1(\sin(t))$$
$$= x_1(\sin(t)) + x_2(\sin(t)) = \text{L.H.S.}$$
$$x_1(t) + x_2(t) \rightarrow y_3(t) = x_1(\sin(t)) + x_2(\sin(t)) = \text{R.H.S.}$$

Since, L.H.S = R.H.S

It follows additivity, so system is linear.

48. (d)

$$\frac{d^2y(t)}{dt^2} + 2t\,y(t) = t^2\,x(t)$$

Let an input $x_1(t)$ produce an output $y_1(t)$ then

$$\frac{d^2y_1(t)}{dt^2} + 2t\,y_1(t) = t^2\,x_1(t)$$

Similarly, $\frac{d^2y_2(t)}{dt^2} + 2t\,y_2(t) = t^2\,x_2(t)$

linear combination of above equation gives

$$= a\cdot\frac{d^2y_1(t)}{dt^2} + a\cdot 2t\,y_1(t) + b\cdot\frac{d^2y_2(t)}{dt^2} + b\cdot 2ty_2(t)$$
$$= at^2\,x_1(t) + bt^2\,x_2(t)$$

that is

$$\frac{d^2}{dt^2}\left[ay_1(t) + by_2(t)\right] + 2t\left[ay_1(t) + by_2(t)\right] = t^2[ax_1(t) + bx_2(t)]$$

This shows that weighted sum of inputs to the system produces an output which is equal to weighted sum of outputs to each of the individual inputs.

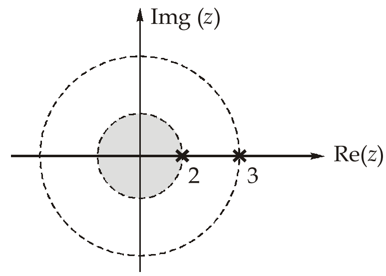
49. (a)

Given, $X(z) = \frac{z}{(z-2)(z-3)}, \quad |z| < 2$

$$\frac{X(z)}{z} = \frac{1}{(z-2)(z-3)}$$
$$= \frac{1}{(z-3)} - \frac{1}{(z-2)}$$
$$X(z) = \frac{z}{(z-3)} - \frac{z}{(z-2)}$$

Poles of $X(z)$ are $z = 2$ and $z = 3$.

For ROC : $|z| < 2$



Since ROC is inside the innermost pole of $X(z)$, both the terms in equation corresponds to anticausal signal -

$$x(n) = -3^n\, u(-n-1) + 2^n\, u(-n-1)$$
$$= (2^n - 3^n)\, u(-n-1)$$

50. (b)

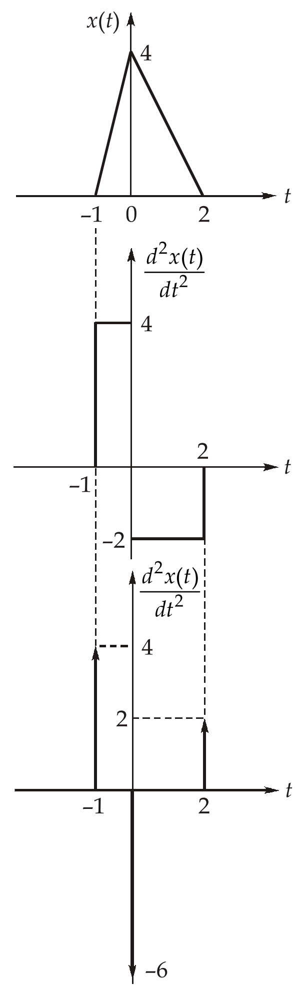
$$u(n) \overset{ZT}{\longleftrightarrow} \frac{1}{1-z^{-1}} \qquad \text{ROC}|\,z\,| > 1$$

and using time reversal property

$$x(-n) \overset{ZT}{\longleftrightarrow} X(z^{-1})$$

we get,
$$u(-n) \overset{ZT}{\longleftrightarrow} \frac{1}{1-z} \qquad \text{ROC}|\,z\,| < 1$$

51. (b)



52. (b)

Given, $x(t) = \delta(2t + 1)$

$$\delta(t) \xleftrightarrow{\text{LT}} 1$$

$$\delta(t + 1) \xleftrightarrow{\text{LT}} e^s$$

$$\delta(2t + 1) \xleftrightarrow{\text{LT}} \frac{1}{2}e^{s/2} = 0.5e^{0.5s}$$

53. (b)

There are three practical methods of generating the SSB signal:

(i) Filter method.

(ii) The phase shift method.

(iii) The third method.

54. (a)

Image frequency, $f_{si} = f_s + 2\,IF$

$$(f_{si})_{min} = 4 + 2(1.8) = 7.6 \text{ MHz}$$

$$(f_{si})_{max} = 10 + 2(1.8) = 13.6 \text{ MHz}$$

Image frequency range 7.6 MHz - 13.6 MHz

55. (b)

Flicker noise sometimes called as $\frac{1}{f}$ noise.

56. (c)

Slope overload distortion will occur if

$$\frac{\partial m(t)}{\partial t} > \frac{\Delta}{T_s}$$

$$a > \frac{\Delta}{T_s}$$

$$\Delta < aT_s$$

57. (d)

Input PSD, $S_X(\omega) = \frac{N_0}{2}$

$$h(t) = 2e^{-2t}u(t)$$

$$H(\omega) = \frac{2}{2 + j\omega}$$

$$|H(\omega)|^2 = \frac{4}{4 + \omega^2}$$

Output PSD, $S_Y(\omega) = S_X(\omega)\,|H(\omega)|^2 = \frac{2N_0}{4 + \omega^2}$

58. (c)

The phase deviation of the given modulated signal is,

$$\Delta\phi(t) = 12\sin(5000\pi t) + 5\cos(5000\pi t) \text{ rad}$$

$$= \sqrt{(12)^2 + (5)^2}\,[\cos(5000\pi t - \alpha)] \text{ rad} = 13\cos(5000\pi t - \alpha) \text{ rad}$$

Where, $\alpha = \tan^{-1}\left(\frac{12}{5}\right)$

Maximum phase deviation of the signal $s(t)$ is,

$$\Delta\phi_{max} = |\phi(t)|_{max} = 13 \text{ rad}$$

59. (d)

Statement (I) is not correct in general for any continuous time periodic signal. Some cases may take an infinite number of spectral components.

60. (c)

An invertible system is one which have a unique relation between its input and output.

Section C : BEE-2 + Analog Electronics-2 + Elec. & Electro. Measurements-2

61. (c)

Open loop gain, $A = -100$

Negative feedback, $\beta = \frac{-8}{100}$

Closed loop gain, $A_f = \frac{A}{1+A\beta} = \frac{-100}{1+(-100)\left(\frac{-8}{100}\right)} = \frac{-100}{9} = -11.11$

62. (b)

Emitter follower properties are

- it is a voltage series feedback circuit.
- its voltage gain is less than unity.
- its output impedance is very low.

63. (a)

The circuit is Wien bridge oscillator

The frequency of oscillation is

$$\omega = \frac{1}{RC}$$

$$f = \frac{1}{2\pi RC}$$

$$C = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 10^3 \times 10^3} = \frac{1}{2\pi}\mu F$$

64. (d)

In crystal, frequency depends on

- Thickness of crystal.
- Angle of cut.
- Physical size of crystal.

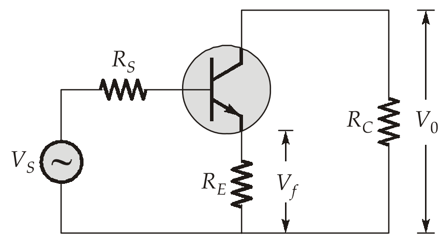
65. (a)

In current shunt, $R_{if} = \frac{R_i}{1+A\beta}$

$$R_{of} = R_0(1 + A\beta)$$

66. (b)

The equivalent in ac analysis



$$\beta = \text{Feedback factor} = \frac{-I_C R_E}{I_C R_C} = \frac{-R_E}{R_C}$$

68. (a)

Magnitude of the limiting error is,

$$0.018 \times 100 = 1.8 \text{ V}$$

Percentage error at meter indication of $\frac{3}{4}$th of its full scale, i.e. 75 V is

$$\%\varepsilon_r = \frac{1.8}{75} \times 100 = 2.4\%$$

69. (a)

Given, $4\frac{1}{2}$ digit DVM

Resolution, $R = \frac{1}{10^4} = 10^{-4}$

Sensitivity, $S = (\text{Full scale})_{\min} \times R$

$= 10 \times 10^{-3} \times 10^{-4} = 10^{-6}$

$\therefore$ $S = 1\ \mu\text{V}$

70. (b)

Given time base is set at 1 ms per division. Also, given for one complete cycle, the given sinusoidal signal occupies five horizontal division.

i.e. the frequency of the sinusoidal will be

$$f = \frac{1}{5 \times 10^{-3}} = 200 \text{ Hz}$$

71. (a)

When signals to X and Y plates are of equal magnitude and in-phase, the display is straight line inclined at 45°.

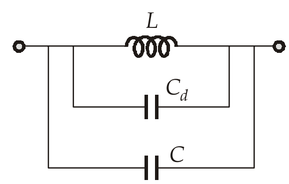
72. (c)

$$\text{Sensitivity of LVDT} = \frac{\text{Output voltage}}{\text{Displacement}} = \frac{1.5\text{ V}}{10} = 0.15\text{ V/mm}$$

$$\text{Sensitivity of instrument} = \text{Amplification factor} \times \text{Sensitivity of LVDT}$$
$$= 300 \times 0.15\text{ V/mm} = 45\text{ V/mm}$$

73. (b)

Let the self distributed capacitance be C_d



$$\therefore \text{ Resonance frequency, } f_0 = \frac{1}{2\pi\sqrt{L(C+C_d)}}$$

Given,
$$f_1 = 4\text{ MHz};$$
$$C_1 = 400\text{ pF}$$
$$f_2 = 8\text{ MHz}$$
$$C_2 = 80\text{ pF}$$

$$f_1 = \frac{1}{2\pi\sqrt{L(C_1+C_d)}};$$

and
$$f_2 = \frac{1}{2\pi\sqrt{L(C_2+C_d)}}$$

so,
$$\frac{f_2}{f_1} = \sqrt{\frac{C_1+C_d}{C_2+C_d}}$$

$$\frac{8}{4} = \sqrt{\frac{400+C_d}{80+C_d}}$$

$$4 = \frac{400+C_d}{80+C_d}$$

$$80 + C_d = 100 + \frac{C_d}{4}$$

$$3\frac{C_d}{4} = 20$$

$$C_d = \frac{80}{3}\text{pF} = 26.67\text{ pF}$$

74. (d)

The unbypassed emitter resistor gives negative feedback which reduces the voltage gain.

75. (d)

Two sinusoidal waveforms of same frequency and same magnitude produces lissajous pattern which may be a straight line, a circle or an ellipse.