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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 16

Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials [All Topics]
Section B : Systems and Signal Processing + Communication Systems [All Topics]
Section C : BEE-2 + Analog Electronics-2 + Electrical & Electronic Measurements-2 [Part Syllabus]

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

DETAILED EXPLANATIONS

Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials

1. (c)

When the spheres are brought in contact with each other the total charge on them gets redistributed equally since they are identical. Therefore the resultant charge on each sphere is

$$Q = \frac{Q_A + Q_B}{2} = \frac{2.0}{2} = 1.0 \text{ nC}$$

$$F = \frac{1.0\times10^{-9}\times1.0\times10^{-9}}{4\pi\varepsilon_0\times(50\times10^{-2})^2} = 3.6 \times 10^{-8} \text{ N}$$

3. (b)

$$\rho_V = \nabla\cdot D = \frac{\partial D_z}{\partial z} = \rho\cos^2\phi$$

$$Q = \int_v \rho_v dV = \int_v \rho\cos^2\phi\rho d\phi\, d\rho dz$$

$$= \int_{z=-2}^{2} dz \int_{\phi=0}^{2\pi} \cos^2\phi d\phi \int_{\rho=0}^{1} \rho^2 d\rho$$

$$= 4\times\pi\times\frac{1}{3} = \frac{4\pi}{3}C$$

4. (c)

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

5. (b)

The field $\vec{H}$ at the centre of a circular wire carrying a current of I is given by,

$$H = \frac{I}{2a},$$

Where, 'a' is the radius of the circular wire.

6. (d)

For spherical volume charge distribution for distances less than radius of spherical charge distribution is uniform in its volume.

∴ Charge in concentric sphere with radius ($r < a$) is proportional to its volume

$$\left(\frac{Q_r}{Q_t}\right) = \left(\frac{r}{a}\right)^3$$

Q_t, Q_r is charge enclosed in spherical distribution of radius a and r respectively

$$(Q_r) = Q_t\left(\frac{r}{a}\right)^3 = Q\left(\frac{r}{a}\right)^3 \quad \text{(Since } Q_t = Q\text{)} \quad \text{...(i)}$$

We know,

$$\text{Electric field, } \vec{E} = \frac{Q_r}{4\pi \epsilon_0 r^2}\hat{a}_r$$

Using equation (i),

$$\vec{E} = \frac{Q_t}{4\pi \epsilon_0}\frac{r^3}{a^3 r^2}\hat{a}_r = \frac{Q_t r}{4\pi \epsilon_0 a^3}\hat{a}_r \qquad (\text{for } r \le a)$$

For $r > a$, distances greater than radius 'a'

Total charge $Q_t = Q$

So electric field, $$\vec{E} = \frac{Q}{4\pi \epsilon_0 r^2}\hat{a}_r$$

∴ Hence option (d) is correct.

7. (a)

$$I = \int J \cdot ds$$

Where, $$ds = r^2 \sin\theta \, d\phi \, d\theta \, \hat{a}_r$$

$$I = \int_0^{\frac{\pi}{2}} \int_0^{2\pi} \frac{1}{r^3} 2\cos\theta r^2 \sin\theta \; d\phi \; d\theta \Big|_{r=0.2}$$

$$= \frac{2}{r} 2\pi \int_{\theta=0}^{\frac{\pi}{2}} \sin\theta\cos\theta d\theta \Big|_{r=0.2}$$

$$= \frac{4\pi}{0.2} \frac{\sin^2\theta}{2}\Bigg|_0^{\pi/2} = 10\pi = 31.4 \text{ A}$$

8. (c)

Coulomb's law of force states that,

$$F = \frac{Q_1 Q_2}{4\pi \epsilon_0 r^2}\hat{a}_R$$

9. (c)

$$J = \sigma E = (5 \times 10^7) \times (10 \times 10^{-3})$$
$$= 500 \text{ kA/m}^2$$

10. (c)

$$B = \nabla \times A = \frac{-\partial A_z}{\partial \rho}\hat{a}_\phi = \frac{\rho}{2}\hat{a}_\phi$$

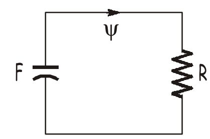
$$dS = d\rho \, dz \, \hat{a}_\phi$$

Hence, $$\psi = \int_s B \cdot dS = \frac{1}{2}\int_{z=0}^{5}\int_{\rho=1}^{2} \rho\, d\rho\, dz$$

$$= \frac{1}{4}\rho^2\Big|_1^2 (5) = \frac{15}{4} = 3.75 \text{ Wb}$$

11. (a)

Equivalent electric circuit analog,



The toroidal core is analogous to the electric circuit,

$$\mathcal{F} = NI = \psi\mathcal{R} = \psi\frac{l}{\mu S} = \frac{\psi 2\pi\rho_0}{\mu_0\mu_r \pi a^2}$$

$$I = \frac{2\rho_0\psi}{\mu_0\mu_r N a^2} = \frac{2\times(10\times10^{-2})\times(0.5\times10^{-3})}{4\pi\times10^{-7}(1000)(200)(1\times10^{-4})}$$

$$= \frac{100}{8\pi} = 3.979 \text{ A}$$

12. (a)

This is the case of motional emf :

$$V_{\text{emf}} = \int_L (U\times B)dl = \int_{x=l}^{0}\left(U\hat{a}_y \times B\hat{a}_z\right)\cdot dx\,\hat{a}_x = UBl$$

$$= -20\ (4\times10^{-3})\times 0.06 = -4.8 \text{ mV}$$

13. (a)

$$D = \varepsilon E = \varepsilon\frac{V}{d}$$

$$J_d = \frac{\partial D}{\partial t} = \frac{\varepsilon\, dV}{d\, dt}$$

Hence, $$I_d = J_d \cdot S = \frac{\varepsilon S}{d}\frac{dV}{dt} = C\frac{dV}{dt}$$

Which is the same as the conduction current given by,

$$I_C = \frac{dQ}{dt} = S\frac{d\rho_s}{dt} = S\frac{dD}{dt} = \varepsilon S\frac{dE}{dt}$$

$$= \frac{\varepsilon S}{d}\frac{dV}{dt} = C\frac{dV}{dt}$$

$$I_d = 2\times\frac{10^{-9}}{36\pi}\times\frac{5\times10^{-4}}{3\times10^{-3}}\times10^3\times50\cos10^3 t = 147.4\cos 10^3 t \text{ nA}$$

14. (c)

For a multiprogrammed system, several jobs are kept in main memory at the same time and the CPU is multiplexed. This increases CPU utilization. Also, in multiprogramming system the operating system switches and executes jobs and never sit idle unlike any non-multiprogrammed system.

15. (c)

- Address generated by a segmented program is called logical address.
- DRAM need more power consumption and special circuitry.
- Associative memory is expensive than RAM as each must have storage capability and logic circuits.

16. (b)

$$\text{Seek time} = 4 \text{ ms}$$

$$\text{Revolution time} = \frac{60}{15000}\text{sec} = 4 \text{ msec}$$

$\therefore$ Average rotational latency,

$$= \frac{1}{2}\times\text{Revolution time} = 2 \text{ msec}$$

$$\text{Transfer time} = 4 \text{ msec} + (2 + 4) \times 4 \text{ msec}$$
$$= (4 + 24) \text{ m sec}$$
$$= 0.028 \text{ sec}$$

17. (d)

No. of bits to determine which byte within a cache line an address is pointing to

$$\text{word offset} = \log_2 128$$
$$= 7 \text{ bits}$$

18. (c)

Prefetching : Method of overlapping the I/O of job with that of job's own computation.
Spooling : CPU overlaps the input of one job with the computation and output.

19. (a)

Program counter is incremented by 1 at the end of instruction fetch cycle.

20. (a)

Process chart using round robin scheduling,

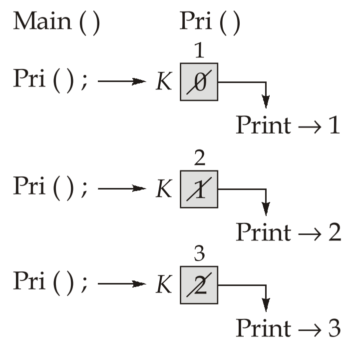
P_1	P_2	P_3	P_4	P_5	P_1	P_2	P_3	P_4	P_5	P_1	P_3	P_4	P_1

0 2 4 6 8 10 12 14 16 18 19 21 23 24 30

Pid	*AT*	*BT*	*CT*	*TAT*	*WT*
P_1	0	12	30	30	18
P_2	2	4	14	12	8
P_3	3	6	23	20	14
P_4	4	5	24	20	15
P_5	5	3	19	14	11

$$\text{Average } WT = \frac{18+8+14+15+11}{5} = 13.2 \text{ ms}$$

22. (c)



25. (a)

Thrashing is the term used whenever a process is busy swapping pages in and out.

26. (d)

$$(110XY)_2 * (101)_2 = \begin{array}{cccccccc} & & & 1 & 1 & 0 & X & Y \\ & 1 & 1 & 0 & X & Y & & \\ \hline 1 & 0 & 0 & 0 & 0 & Z & 1 & 1 \\ \hline \end{array}$$

$\therefore$ $Y = 1$

$X = 1$

Also, $Z = Y$

$\therefore$ $Z = 1$

27. (a)

$$\text{sign bit} = 1$$

$$(12.25)_{10} = (1100.01)_2$$

$$= (1.10001) \times 2^3$$

$$\therefore \quad (12.25) \times 2^{10} = (1.10001) \times 2^{13}$$

$$BE = AE + \text{Bias}$$

$$\text{Bias in excess 3} = \frac{2^7}{2} = 2^6 = 64$$

$$\therefore \quad BE = 64 + 13 = 77$$

$$(77)_{10} = (1001101)_2$$

$$\therefore \quad -12.25 \times 2^{10} = 1100\ 1101\ 1000\ 1000\ 0000$$

$$= (CD880)_H$$

30. (b)

Glass ceramic materials should have low coefficient of thermal expansion.

31. (a)

$$\rho = \frac{1}{\sigma} = \frac{1}{ne\mu_n}$$

$$n = \frac{1}{\rho e\mu_n} = \frac{1}{0.25 \times 1.6 \times 10^{-19} \times 0.3}$$

$$n = 8.3 \times 10^{19}/\text{m}^3$$

32. (b)

Ferrites have low eddy current loss even at high frequencies.

33. (d)

- Susceptibility of Anti-ferro magnetic material is positive and small.
- Susceptibility of diamagnetic material is independent of temperature.

34. (d)

All these angular momentum corresponds to a permanent dipole moment.

35. (d)

Magnetization, $M = \chi H$

$= -5 \times 10^{-5} \times 10^{5}$ A/m

$= -5$ A/m

Magnetic flux density, $B = \mu_0(H + M)$

$= 12.57 \times 10^{-7}(10^5 - 5)$

$= 0.126$ Wb/m^2

36. (a)

Current in semiconductors does not obey Ohm's law and are non-linear devices.

37. (c)

Ferrites have low dielectric loss and low saturation magnetization compared to ferromagnetic materials.

38. (b)

Carbon nanotube displays require less power than CRT.

39. (c)

Both statements are correct.

40. (a)

- Polarization of a pyroelectric material changes on heating.
- Every pyroelectric material is piezoelectric material but converse is not true.

41. (d)

Assertion is not true because the Laplacian operator (∇^2) of a scalar function ϕ can be defined as "Divergence of the gradient of the scalar ϕ". i.e. $\nabla.\nabla\phi$.

42. (d)

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

44. (c)

Photon with lower wavelength than threshold wavelength are required for photo conductivity as lower wavelength implies higher energy of photon.

45. (c)

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

Section B : Systems and Signal Processing + Communication Systems

46. (a)

$$h[n] = 3\delta[n-1] + 2\delta[n-2] + \delta[n-3]$$
$$H(z) = 3z^{-1} + 2z^{-2} + z^{-3}$$
$$H(1) = 3 \times 1 + 2 \times 1 + 1 = 6$$

48. (b)

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

and using time reversal property

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

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

49. (b)

Since,
$$x(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(\omega)e^{j\omega n}\,d\omega$$

$$x(0) = \frac{1}{2\pi}\int_{-\omega_0}^{\omega_0} (1)\,d\omega = \frac{\omega_0}{\pi}$$

50. (b)

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

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

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

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

51. (b)

$$y'(t) - 4y(t) = x(t)e^{-4t}; \text{ (where } x(t) = u(t))$$

by taking Fourier transform, we get

$$j\omega Y(j\omega) - 4Y(j\omega) = \frac{1}{4+j\omega}$$

$$\Rightarrow \qquad Y(j\omega) = \frac{1}{(4+j\omega)(j\omega-4)} = -\frac{1}{4^2+\omega^2}$$

and $$Y(j\omega) \xrightarrow{IFT} -\frac{1}{8}e^{-4|t|}$$

53. (a)

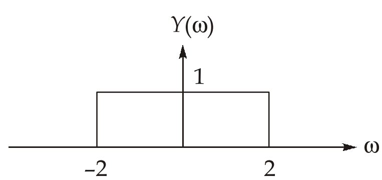
Since, $$y(t) = x(t)\cos t$$

Taking Fourier transform,

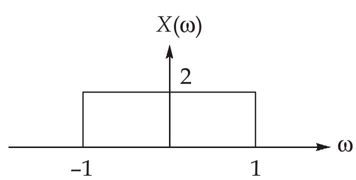
$$Y(\omega) = \frac{1}{2}[X(\omega-1)+X(\omega+1)]$$

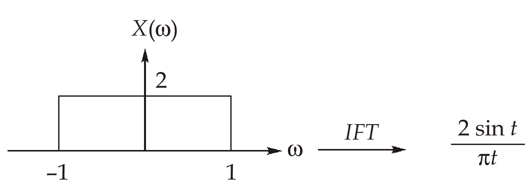
[using modulation property of Fourier transform]

and also given that,



so, $X(\omega)$ will be





54. (c)

The modulation efficiency of an AM signal can be given as,

$$\%\eta = \frac{P_{SB}}{P_{total}} \times 100 = \frac{\mu^2}{2+\mu^2} \times 100$$

Where, μ = modulation index

For a multi-tone modulation,

$$\mu = \sqrt{\mu_1^2 + \mu_2^2}$$

For the given AM signal, $\mu_1 = 0.5$ and $\mu_2 = 0.4$

So, $$\mu^2 = \mu_1^2 + \mu_2^2 = (0.5)^2 + (0.4)^2 = 0.41$$

$$\%\eta = \frac{0.41}{2+0.41} \times 100 \approx 17\%$$

55. (d)

The modulation index of an FM signal can be given as,

$$\beta_{FM} = \frac{(\Delta f)_{max}}{f_m} = \frac{A_m k_f}{f_m} \quad ...(i)$$

The modulation index of a PM signal can be given as,

$$\beta_{PM} = (\Delta\phi)_{max} = A_m k_p \quad ...(ii)$$

From equations (i) and (ii), option (d) can be selected as the correct one.

56. (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,

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

57. (b)

To eliminate slope-overload distortion,

$$\frac{\Delta}{T_s} \geq \left|\frac{dx(t)}{dt}\right|_{max}$$

$$\left|\frac{dx(t)}{dt}\right|_{max} = \left|\frac{10-0}{1-(1.5)}\right| = \frac{10}{0.5} = 20 \text{ V/sec}$$

$$T_s = \frac{1}{f_s} = 10^{-4} \text{ sec} \qquad \because \text{Given that, } f_s = 10 \text{ kHz}$$

So, $\Delta \geq T_s \left|\frac{dx(t)}{dt}\right|_{max}$

$$\Delta \geq (10^{-4})\,(20) \text{ V}$$

$$\Delta_{min} = 2 \text{ mV}$$

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

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. (d)

Granular noise cannot be eliminated. It can be only minimized by selecting relatively small step-size.

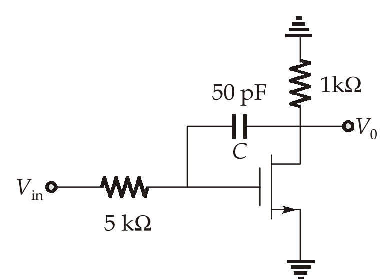
Section C : BEE-2 + Analog Electronics-2 + Electrical & Electronic Measurements-2

61. (c)

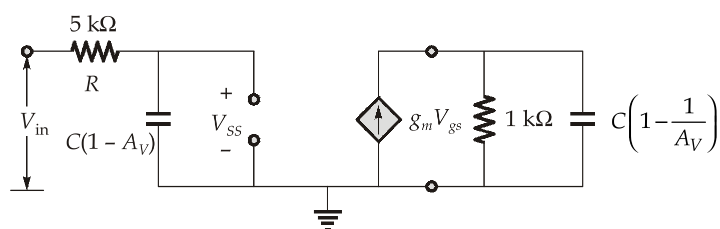
- Loaded voltage gain of an amplifier is always less than the no-load gain.
- Smaller the internal resistance of the signal source, greater is the overall gain.

64. (a)

With respect to AC



Taking Miller's equivalent and assume $r_0 = \infty$



$$A_V = -g_m R_D = -0.01 \times 10^3$$
$$= -10$$

Small signal input pole frequency,

$$f = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 5 \times 10^3 \times 50 \times 10^{-12}(1+10)} = 57.87 \text{ kHz}$$

65. (c)

- It result in reduced output impedance.
- Reduced gain is a disadvantage and not improvement.

66. (d)

$$\omega = \frac{1}{\sqrt{LC_{eq}}}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$= \frac{500 \times 500 \times 10^{-12} \times 10^{-12}}{1000 \times 10^{-12}} = 25 \times 10^{-11} \text{ F}$$

$$\omega = \frac{1}{\sqrt{40 \times 10^{-6} \times 25 \times 10^{-11}}}$$

$$= \frac{1}{2 \times 5 \times 10^{-3} \times 10^{-5}} = \frac{10^8}{10} = 10^7 \text{ rad/sec}$$

$$\omega = 10 \times 10^6 \text{ rad/sec}$$

67. (b)

In order to sustain the oscillations

$$\frac{R_3}{R_4} = \frac{R_1}{R_2} + \frac{C_2}{C_1} = \frac{5}{2.5} + \frac{1}{0.5} = 4$$

Only option (b) satisfies the given condition.

68. (a)

$$V_0 = V_Z - V_{BE}$$
$$= 12 - 0.7$$
$$= 11.3 \text{ V}$$

$$I_R = \frac{20 - 12}{220} = \frac{8}{220} = 36.4 \text{ mA}$$

$$I_L = \frac{V_0}{R_L} = \frac{11.3 \text{ V}}{1 \text{ k}\Omega} = 11.3 \text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{11.3 \text{ mA}}{50} = 226 \text{ } \mu\text{A}$$

$$I_Z = I_R - I_B = 36.4 \text{ mA} - 0.226 \text{ mA} = 36.174 \text{ mA}$$

69. (b)

Capacitance transducers have high input impedance and hence have small loading effect.

70. (a)

$$\text{Percentage linearity} = \pm \frac{0.002}{2} \times 100 = \pm 0.1\%$$

71. (a)

$$\text{Nominal ratio, } K_n = \frac{200}{1} = 200$$

Actual transformation ratio,

$$R = \frac{I_P}{I_S} = \frac{100}{0.495} = 202.02$$

$$\text{Ratio error} = \frac{\text{Nominal ratio} - \text{Actual ratio}}{\text{Actual ratio}} \times 100$$

$$= \frac{200 - 202.020}{202.02} \times 100 = -1\%$$

72. (b)

Delay line is introduced between Y-inputs and Y-plate to synchronize the output of both horizontal and vertical deflection system.

73. (d)

$$\text{Deflection sensitivity, } S = \frac{D}{E_d} = \frac{Ll_d}{2dE_a}$$

∴ No relation between sensitivity and deflection voltage.

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