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ESE 2017 - PRELIMS

ELECTRICAL ENGINEERING

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SET - A

UPSC Engineering Services - 2017 (Prelims)

Electrical Engineering [SET - A]

01. If a square matrix order 100 has exactly 15 distinct eigen values, then the degree of the minimal polynomial is

(a) At least 15 (b) At most 15 (c) Always 15 (d) Exactly 100

01. Ans: (a)

02. The solution of the differential equation $y\sqrt{1-x^2}\,dy + x\sqrt{1-y^2}\,dx = 0$ is

(a) $\sqrt{1-x^2} = c$ (b) $\sqrt{1-y^2} = c$

(c) $\sqrt{1-x^2} + \sqrt{1-y^2} = c$ (d) $\sqrt{1+x^2} + \sqrt{1+y^2} = c$

02. Ans: (c)

Sol: $y\sqrt{1-x^2}\,dy + x\sqrt{1-y^2}\,dx = 0$

$y\sqrt{1-x^2}\,dy = -x\sqrt{1-y^2}\,dx$

$\Rightarrow \frac{y dy}{\sqrt{1-y^2}} + \frac{x\,dx}{\sqrt{1-x^2}} = 0$

Integrating both sides

$\int \frac{y\,dy}{\sqrt{1-y^2}} + \int \frac{x\,dx}{\sqrt{1-x^2}} = 0$

$\Rightarrow -\sqrt{1-y^2} - \sqrt{1-x^2} = 0$

$\therefore \sqrt{1-x^2} + \sqrt{1-y^2} = k$

03. The general solution of the differential equation

$\frac{d^4y}{dx^4} - 2\frac{d^3y}{dx^3} + 2\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + y = 0$ is

(a) $y = (c_1 - c_2x)e^x + c_3\cos x + c_4\sin x$ (b) $y = (c_1 + c_2x)e^x - c_3\cos x + c_4\sin x$

(c) $y = (c_1 + c_2x)e^x - c_3\cos x + c_4\sin x$ (d) $y = (c_1 + c_2x)e^x + c_3\cos x - c_4\sin x$

03. Ans: (c)

Sol: The auxiliary equation is

$D^4 - 2D^3 + 2D^2 - 2D+1 = 0$

$\Rightarrow D^4 - 2D^3 + D^2 + D^2 - 2D + 1 = 0$

$\Rightarrow D^2 (D^2 - 2D+1)+(D^2 - 2D+1) = 0$

$\Rightarrow (D^2+1)(D^2 - 2D + 1) = 0$

$\Rightarrow D^2 + 1 = 0$ & $D^2 - 2D + 1 = 0$

$\Rightarrow D = 1,1, i, -i$

$\therefore$ The general solution is

$Y=(C_1 + C_2x)e^x + C_3 \cos x + C_4 \sin x$

04. Given the Fourier series in $(-\pi, \pi)$ for $f(x) = x\cos x$, the value of a_0 will be

(a) $-\frac{2}{3}\pi^2$ (b) 0 (c) 2 (d) $\frac{(-1)^n 2n}{n^2-1}$

04. Ans: (b)

Sol: $f(x) = x \cos x$ is an odd function defined on $[-\pi,\pi]$. It's fourier series contains only sine terms since $a_0 = a_n = 0$

05. The Fourier series expression of the saw-toothed waveform

$f(x) = x$ in $(-\pi, \pi)$ of period 2π gives the series, $1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+....$

The sum is equal to

(a) $\frac{\pi}{2}$ (b) $\frac{\pi^2}{4}$ (c) $\frac{\pi^2}{16}$ (d) $\frac{\pi}{4}$

05. Ans: (d)

Sol: Fourier series is

$$f(x) = \sum_{n=1}^{\infty} b_n \sin\left(\frac{n\pi}{2}k\right) = \sum_{n=1}^{\infty} \frac{2(-1)^{n+1}}{n}\sin(nx)$$

$$\Rightarrow f(x) = 2\left[\frac{1}{1}\sin(x) + \frac{(-1)}{2}\sin(2x) + \frac{1}{3}\sin(3x) + \frac{(-1)}{4}\sin(4x) + ...\right]$$

put $x = \frac{\pi}{2}$

$$\Rightarrow f\left(\frac{\pi}{2}\right) = 2\left[\frac{1}{1} + 0 - \frac{1}{3} + 0 + \frac{1}{5} + ...\right]$$

$$\therefore \left[\frac{1}{1} - \frac{1}{3} + \frac{1}{5} .... = \frac{\pi}{4}\right]$$

06. What is the value of m for which $2x - x^2 + my^2$ is harmonic?

(a) 1 (b) –1 (c) 2 (d) 2

06. Ans: (a)

Sol: A function u(x,y) is said to be harmonic function if $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{2y^2} = 0$

Let $u(x,y) = 2x - x^2 + my^2$

Then $\frac{\partial^2}{\partial x^2}\left(2x - x^2 + my^2\right) + \frac{\partial^2}{\partial y^2}\left(2x - x^2 + my^2\right) = 0 \Rightarrow -2+2m = 0$

$\therefore m = 1$

07. Evaluate $\int_c \frac{dz}{z\sin z}$, where is $x^2 + y^2 = 1$.

(a) 1 (b) 2 (c) 0 (d) −1

07. Ans: (c)

Sol: $I = \int_C \frac{1}{z\sin(z)} dz$

Where 'C' is $x^2+y^2=1$

The singular points of $\frac{1}{z\sin(z)}$ are given by z. sin(z) =0

$\Rightarrow z = 0$ and $z = 0, \pm\pi, \pm 2\pi, \ldots\ldots$

But only z = 0 lies inside the unit circle 'C' Here z = 0 is a pole of order '2'

$\therefore\ R_1 = \frac{1}{(2-1)!} \underset{z\to 0}{Lt}\left[\frac{d}{dz}\left\{(z-0)^2 \frac{1}{z\times\sin(z)}\right\}\right]$

$\therefore R_1 = \frac{1}{1} \underset{z\to 0}{Lt}\left[\frac{d}{dz}\left(\frac{z}{\sin z}\right)\right]$

$R_1 = \underset{z\to 0}{Lt}\left[\frac{\sin(z) - z\cos z}{(\sin z)^2}\right]$

$R_1 = \underset{z\to 0}{Lt}\left[\frac{\cos(z) - (-z\sin z + \cos z}{2\sin(z)\cos(z)}\right]$

$\therefore$ The residue of $\frac{1}{z\sin z}$ at a singular point is zero (i.e $R_1 = 0$)

Hence by canchy's residue theorem, we have $\int_C \frac{1}{z\sin(z)} dz = 2\pi i(R_1) = 2\pi i(0) = 0$

08. The sum of residues of $f(z) = \frac{2z}{(z-1)^2(z-2)}$ at its singular point is

(a) −8 (b) −4 (c) 0 (d) 4

08. Ans: (c)

Sol: Given $f(z) = \frac{2z}{(z-1)^2(z-2)}$

F(z) has singular points at z = 1 and z =2

$\Rightarrow$ z = 1 is a pole of order two and z = 2 is a pole of order one.

$r_1 = \text{res}(f(z) : z = 2)$

$$= \underset{z\to 2}{\text{Lt}}\left[(z-2).\frac{2z}{(z-1)^2(z-2)}\right] = 4$$

$R_2 = \text{Res}(f(z) : z = 1)$

$$= \frac{1}{(m-1)!}\ \underset{z\to z_0}{\text{Lt}}\left[\frac{d^{m-1}}{dz^{m-1}}\left\{(z-z_0)^m f(z)\right\}\right]$$

$$= \frac{1}{(2-1)!}\ \underset{z\to 1}{\text{Lt}}\left[\frac{d}{dz}\left\{(z-1)^2.\frac{2z}{(z-1)^2(z-2)}\right\}\right]$$

$$= \underset{z\to 1}{\text{Lt}}\left[\frac{(z-2)(2)-(2z)(1)}{(z-2)^2}\right] = -4$$

$\therefore$ Sum of residues of f(z) = $R_1 + R_2 = 4 - 4 = 0$

09. A bag contains 7 red and 4 white balls. Two balls are drawn at random. What is the probability that both the balls are red?

(a) $\frac{28}{55}$ (b) $\frac{21}{55}$ (c) $\frac{7}{55}$ (d) $\frac{4}{55}$

09. Ans: (b)

Sol: $P(E) = \frac{{}^7C_2}{{}^{11}C_2} = \frac{21}{55}$

10. A random variable X has the density function f(x) = $K\frac{1}{1+x^2}$. Where $-\infty < x < \infty$. Then the value of K is

(a) π (b) $\frac{1}{\pi}$ (c) 2π (d) $\frac{1}{2\pi}$

10. Ans: (b)

Sol: $\int_{-\infty}^{\infty} f(x)dx = 1$ ($\because$ total probability is unity)

$$\int_{-\infty}^{\infty} \frac{k}{1+x^2}\,dx = 1$$

$$2k\int_{0}^{\infty} \frac{dx}{1+x^2} = 1$$

$$\because \frac{1}{1+x^2} \text{ is an even function)}$$

$$\Rightarrow 2k\left(\text{Tan}^{-1}x\right)_0^{\infty} = 1$$

$$\Rightarrow 2k\,(\tan^{-1}\infty - \tan^{-1}0) = 1$$

$$2k\left(\frac{\pi}{2}\right) = 1$$

$$\therefore\ k = \frac{1}{\pi}$$

11. A random variable X has a probability density function

$$f(x) = \begin{cases} kx^n e^{-x}; x \geq 0 \\ 0; \quad \text{otherwise} \end{cases} \quad \text{(n is an integer)}$$

with mean 3. The values of {k, n} are

(a) $\left\{\frac{1}{2}, 1\right\}$ (b) $\left\{\frac{1}{4}, 2\right\}$ (c) $\left\{\frac{1}{2}, 2\right\}$ (d) {1, 2}

11. Ans: (c)

Sol: $f(x) = kx^n e^{-x}, x \geq 0$

$= 0$, otherwise

$$\int_0^\infty f(x)dx = 1$$

($\because$ total probability is unity)

$$\Rightarrow \int_0^\infty kx^n e^{-x} dx = 1$$

$\Rightarrow kn! = 1$

$$\Rightarrow k = \frac{1}{n!}$$

Now, $f(x) = kx^2 e^{-x} = \frac{1}{2}x^2 e^{-x}$

Mean is $E(x) = \int_0^\infty x f(x)dx$

$$= \int_0^\infty \frac{x^3}{2} e^{-x} dx$$

$$= \frac{1}{2}\left\{-x^3e^{-x} - 3x^2e^{-x} - 6xe^{-x} - 6e^{-x}\right\}_0^\infty$$

$= 3$

$$\therefore k = \frac{1}{2}, n = 2$$

12. What is the probability that at most 5 defective fuses will be found in a box of 200 fuses, if 2% of such fuses are defective?

(a) 0.82 (b) 0.79 (c) 0.59 (d) 0.52

12. Ans: (b)

Sol: n = 200, p = 2%, λ = np

$$= 200 \times \frac{2}{100} = 4$$

Poission propability function is

$$p(x) = \frac{e^{-\lambda} \times \lambda^x}{x!}$$

P(x≤5) = p(x=0)+p(x=1)+p(x=2)+p(x=3)+ p(x=4)+p(x=5)

$$= \frac{e^{-4} \times 4^0}{0!} + \frac{e^{-4} \times 4^1}{1!} + \frac{e^{-4} \times 4^2}{2!} + \frac{e^{-4} \times 4^3}{3!} + \frac{e^{-4} \times 4^4}{4!} + \frac{e^{-4} \times 4^5}{5!}$$

$$= e^{-4}\left[1 + 4 + \frac{16}{2} + \frac{4^3}{3!} + \frac{4^4}{4!} + \frac{4^5}{5!}\right]$$

$$= e^{-4}\left[\frac{643}{15}\right] = 0.785 = 0.79$$

13. If X is a normal variate with mean 30 and standard deviation 5, what is probability (26 ≤ X ≤ 34), given A(z = 0.8) = 0.2881?

(a) 0.2881 (b) 0.5762 (c) 0.8181 (d) 0.1616

13. Ans: (b)

Sol: $\mu = 30, \sigma = 5$

$$p(26 \le x \le 34) = p\left(\frac{26-30}{5} \le \frac{x-30}{5} \le \frac{34-30}{5}\right) = p\,(-0.8 \le z \le 0.8)$$

$$= 2p\,(0 \le z \le 0.8)$$

$$= 2 \times 0.2881 = 0.5762$$

14. For high speed reading and storing of information in a computer, the core shall be of

(a) Ferrite (b) Piezoelectric

(c) Pyroelectric (d) Ferromagnetic above 768° C

14. Ans: (a)

Sol: For high speed reading and storing of information in a computer, the core shall be of "FERRITE". Ferro magnetic materials alone are capable of storing large amount of information. A ferromagnetic alone 768°C, it becomes a paramagnetic. Hence it is not useful similarly piezoelectric and pyroelectric.

15. Soft magnetic materials should have

(a) Large saturation magnetization and large permeability

(b) Low saturation magnetization and large permeability

(c) Large saturation magnetization and low permeability

(d) Low saturation magnetization and low permeability

15. Ans: (b)

16. Gauss's theorem states that total electric flux ϕ emanating from a closed surface is equal to

(a) Total current density on the surface

(b) Total charge enclosed by that surface

(c) Total current on the surface

(d) Total charge density within the surface

16. Ans: (b)

Sol: Gauss's Law:

The total electric flux leaving through any closed surface is equal to the total charge enclosed by that surface

$$\phi = \phi_{enc}$$

17. Orbital magnetic moment of an electron, in an atom, is of the order of

(a) 0.1 Bohr magneton (b) 1.0 Bohr magneton

(c) 10 Bohr magneton (d) 100 Bohr magneton

17. Ans: (b)

Sol: An electron revolving around a nucleus is equivalent to current carrying loop. The electron current $=e\nu$,

e = electron charge and

ν = frequency of revolution of electrons

The magnetic moment of the orbiting electron = $(e\nu)\,\pi r^2$

Where r = radius of the electron orbit.

According to Bohr postulate the angular momentum of the electron is given by

$mvr = n.\frac{h}{2\pi}$, n = quantum number

h = Planck's constant

or $m\omega r^2 = n.\frac{h}{2\pi}$

where ω = angular frequency

$\therefore m.2\pi\nu r^2 = n.\frac{h}{2\pi}$

$\Rightarrow \pi r^2\nu = \frac{nh}{4\pi m}$

$\therefore$ The magnetic moment $e\nu\pi r^2 = n.\left(\frac{he}{4\pi m}\right)$.

Hence orbital magnetic moment is measured in units $\left(\frac{he}{4\pi m}\right)$ which is called Bohr magneton.

18. When the temperature of ferromagnetic material exceeds the Curie temperature, it behaves similar to a

(a) Diamagnetic material
(b) Ferromagnetic material
(c) Paramagnetic material
(d) Antiferromagnetic material

18. Ans: (c)

Sol: Ferromagnetic materials possess a transition temperature called curie temperature T_C, for $T < T_C$ it remains ferromagnetic and for $T > T_C$, it transforms to paramagnetic.

19. Photoconductivity is a characteristic of semiconductors. When light falls on certain semiconductors, it

(a) Sets free electrons from some of the atoms, increasing the conductivity

(b) Ejects electrons into space

(c) Establishes a potential difference creating a source of EMF

(d) Produces heat raising the temperature

19. Ans: (a)

Sol: Photoconductivity is the phenomenon in which a semiconductor when exposed to light radiation, exhibits electric conductivity.

When the energy of the incident photon hν is greater than or equal to energy gap E_g, it is absorbed by the valence band electron and it gets excited to conduction bond. This results in the generation of electron hole pairs. This increases the conductivity of the semiconductor.

This does not create EMF. In the photovoltaic effect, the absorption of the photons results in the creation of EMF, which is used in solar cells.

20. The resistivity of intrinsic germanium at 30° C is 0.46 Ω-m. What is the intrinsic carrier density n_i at 30° C, taking the electron mobility μ_n as 0.38 m^2V-s and hole mobility μ_p as 0.18 m^2/V-s?

(a) 2.4×10^{19} /m^2 (b) 4.2×10^{19}/m^2 (c) 2.4×10^{10} m^3 (d) 4.2×10^{10} /m^3

20. Ans: (a)

Sol: Given data:

$\rho = 0.46\Omega\text{-m}$, $\mu_n = 0.38\text{m}^2/\text{V-s}$ and

$\mu_p = 0.18\text{m}^2/\text{V-s}$

Consider $\rho = \dfrac{1}{ne\mu_n + pe\mu_p}$

$= \dfrac{1}{n_i[\mu_n + \mu_p]e}$ ……(1) [∵ In intrinsic semiconductor $n = p = n_i$]

$n_i = \dfrac{1}{\rho[\mu_n + \mu_p]e} = \dfrac{1}{0.46\Omega - m[0.56m^2/V - s]\times 1.602\times 10^{-19}C}$ …….(2)

$\therefore n_i = 2.42\times 10^{19}/m^3$……(3)

21. For intrinsic gallium arsenide, conductivity at room temperature is 10^{-6} $(\Omega\text{-m})^{-1}$, the electron and hole mobilities are, respectively 0.85 and 0.04 m^2/V-s. The intrinsic carrier concentration n at room temperature is

(a) 7.0×10^{12} m^{-3} (b) 0.7×10^{12} m^{-3} (c) 7.0×10^{-12} m^{-3} (d) 0.7×10^{-12} m^{-3}

21. Ans: (a)

Sol: Given data:

$\sigma = 10^{-6}/\Omega\text{-m}$, $\mu_n = 0.85\text{m}^2/\text{V-s}$ and

$\mu_p = 0.04\text{m}^2/\text{V-s}$

Consider $\sigma = (n\mu_n+p\mu_p)e = n_i[\mu_n+\mu_p]e$….(1)

[$\because$ In an intrinsic semiconductor , n =p =n_i]

$$n_i = \frac{\sigma}{[\mu_n + \mu_p]e} = \frac{10^{-6}\Omega - m}{[0.89m^2/V-s]\times 1.602\times 10^{-19}C} \text{ ……(2)}$$

$\therefore n_i = 7.0137\times10^{12}/m^3$…..(3)

22. A copper conductor has a resistance 15.5 Ω at 0° C. What is its percentage conductivity at 16° C (to nearest unit value) assuming the temperature coefficient of copper 0.00428 per °C at 0°C?

(a) 54% (b) 68% (c) 94% (d) 98%

22. Ans: (c)

Sol: The resistance of a conductor varies with temperature as

$R = R_0(1+\alpha t)$ where R_0 = resistance at 0°C,

R = resistance at t°C,

α = temperature coefficient of resistance.

$\therefore$ The conductivity varies with temperature as

$$\frac{1}{R} = \frac{1}{R_0(1+\alpha t)}$$

or $\frac{1}{R} = \left(\frac{1}{R_0}\right)(1-\alpha t)$ [by Binomial approximation]

Percentage conductivity = $\frac{(1/R)}{(1/R_0)}\times 100$

$= (1-\alpha t)\times 100$

$= [1- 0.00428 \times 16] \times 100 = [1 - 0.06848] \times 100 = 93.2\%$

23. At temperature above a limiting value, the energy of lattice vibrations, in a conductor, increases linearly with temperature so that resistivity increases linearly with temperature. In this region, this limiting value of temperature is called

(a) Bernouli temperature (b) Curie temperature

(c) Debye temperature (d) Neel temperature

23. Ans: (c)

Sol: The energy of lattice vibrations are significant at low temperature upto a temperature called Debye temperature (θ_D). For T > θ_D, the energy varies linearly with temperature. This is the basis of the Debye's theory.

24. Consider the following statements:

1. The critical magnetic field of superconductor is maximum at absolute zero
2. Transition temperature of a superconductor is sensitive to its structure.
3. The critical magnetic field of a superconductor is zero its critical temperature.
4. Superconductors show very high conductivity below the critical temperature.

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 2 and 4 only

(c) 2, 3 and 4 only (d) 1, 3 and 4 only

24. Ans: (d)

Sol: The superconductivity can be destroyed with the applications of magnetic field and it depends upon the temperature as

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

H_C = critical magnetic field at T°k

H_0 = critical magnetic field at 0°k.

Hence H_C is maximum at 0°k and $H_C = 0$ at $T = T_C$

The superconductors remain in the state of super conduction for $T < T_C$

Critical temperature is independent of the crystal structure of the material.

25. What is the correct sequence of the following materials in ascending order of their resistivity?

1. Iron
2. Silver
3. Constantan
4. Mica
5. Aluminimum

Select the correct answer using the codes given below.

(a) 2, 5, 1, 3 and 4
(b) 4, 5, 3, 1 and 2
(c) 2, 3, 1, 5 and 4
(d) 4, 5, 1, 3 and 2

25. Ans: (a)

Sol: The correct ascending order of the resistivity of Fe, Ag, Constantan, Mica and Aluminium.

	Metal	resistivity(in μΩ-cm)
1	Fe	8.85
2	Ag	1.51
3	Constantan	49
4	Mica	$\sim 10^{21}$
5	Aluminium	2.62

26. In the first Cauer network, with a pole at infinity, the first element must be

(a) Series capacitor (b) Series inductor

(c) Shunt inductor (d) Shunt inductor

26. Ans: (b)

Sol: Pole of infinity means 's' term by synthetic division is inductor

27. The total magnetic moment

1. is called saturation magnetization
2. depends on the number of magnetic dipoles per unit volume, the instant electric current and the area of the current loop.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only (c) Bothe 1 and 2 (d) Neither 1 nor 2

27. Ans: (b)

Sol: Total magnetic moment is the sum of the moments of all the magnetic dipoles and the atomic magnetic moments due to orbital motion of electrons.

Saturation magnetization is the magnetic moment per unit volume of the specimen.

28. Which of the following statements are correct regarding dot product of vectors?

1. Dot product is less than or equal to the product of magnitudes of two vectors.
2. When two vectors are perpendicular to each other, then their dot product is non-zero.
3. Dot product of two vectors is positive or negative depending whether the angle between the vectors is less than o greater than $\frac{\pi}{2}$.
4. Dot product is equal to the product of one vector and the projection of the vector on the first one.

Select the correct answer using the codes given below:

(a) 1, 2 and 3 only (b) 1, 3 and 4 only (c) 1, 2 and 4 only (d) 2, 3 and 4 only

28. Ans: (b)

Sol: 1. $\overline{A}.\overline{B} = |A||B|\cos\theta$

$\overline{A}.\overline{B} \le |A||B|$ [correct]

2. $\theta = \frac{\pi}{2}$

A.B = 0 [wrong]

3. $\overline{A}.\overline{B} = |A||B|\cos\theta$

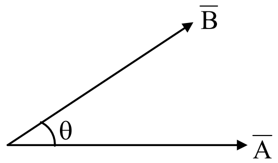
$0 < \theta < \frac{\pi}{2}$

$\cos\theta = +ve$

$\theta > \frac{\pi}{2}$

$\cos\theta = -ve$ [correct]

4.



The projection at $\overline{B}$ along $\overline{A}$ is $|B| \cos\theta$

$|A|\,|B|\cos\theta = \overline{A}.\overline{B}$ [correct]

29. Susceptibility of a diamagnetic material is

1. Negative
2. Positive
3. Dependent on the temperature
4. Independent of the temperature

Select the correct answer using the codes given below:

(a) 1 and 3 only
(b) 2 and 3 only
(c) 1 and 4 only
(d) 2 and 4 only

29. Ans: (c)

Sol: A diamagnetic material is characterized by a very small and negative susceptibility which is independent of temperature.

30. Consider the following statements:

1. The susceptibility χ of diamagnetic materials is small and negative.
2. The susceptibility of para and anti ferromagnetic materials is small but positive
3. The susceptibility has a finite value for free space or air.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

30. Ans: (d)

Sol: All the three statements are true.

31. Eddy current losses in transformer cores can be reduced by the use of

1. Solid cores
2. Laminated cores
3. Ferrites

Select the correct answer using the codes given below:

(a) 2 and 3 only (b) 1 and 2 only (c) 1 and 3 only (d) 1, 2 and 3

31. Ans: (a)

Sol: Eddy current losses in a transformer can be reduced by the following two methods.

1. To minimize eddy current losses and maintain high flux density, the core can be **made of laminated sheet** with thin coating of iron oxide and varnish. This increases the resistance and decreases eddy current.
2. **Ferrites** are ceramics and hence the eddy current loss is minimum.

32. The phenomenon of magnetostriction occurs when a ferromagnetic substance is magnetized resulting in

(a) Heating
(b) Small changes in its dimensions
(c) Small changes in its crystal structure
(d) Some change in its mechanical properties

32. Ans: (b)

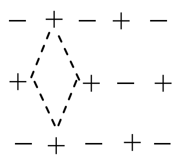
Sol: Magnetostriction is the phenomenon of changes in the dimensions of a ferromagnetic material when subjected to a magnetic field.

33. What type of defect causes F-centres in a crystal?

(a) Stoichiometric defect
(b) Metal excess defect due to anion vacancies
(c) Metal excess defect due to extra cations
(d) Frenkel defect

33. Ans: (b)

Sol: F-centre: The simplest colour centre is the F-centre. The name comes from german word for colour, "Farbe". It is usually produced by heating crystal in excess alkali vapour or by x-irradiation.



F-centre has been identified by electron spin resonance as an electron bound at a negative iron vacancy.

34. Consider the following statements:

1. Superconductors exhibit normal conductivity behaviour above a transition temperature Tc.
2. Superconductors lose their superconducting nature in an external magnetic field, provided the external magnetic field is above critical value.
3. High T_c superconductors have T_c values in the range 1 to 10 K.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

34. Ans: (a)

Sol: 1. For temperature $T > T_C$ a superconductor transforms to normal conductor.

2. When $H > H_C$ a super conductor becomes a normal conductor.

3. High T_C super conductors have $T_C > 50°K$

35. Superconductivity is a material property associated with

(a) Changing shape by stretching (b) Stretching without breaking

(c) A loss of thermal resistance (d) A loss of electrical resistance

35. Ans: (d)

36. An atom in a crystal vibrates at a frequency, determined by

1. Crystal heat current
2. Crystal temperature
3. The stiffness of the bonds with neighbour atoms

Select the correct answer using the codes given below:

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

36. Ans: (d)

37. Consider the following statements:

1. Nano means 10^9 so that nano materials have an order of dimension higher than the size of atom and come in the form of rods, tubes spheres or even thin sheets/films
2. Nano materials have enhanced or changed structural property
3. Nano elements lend themselves to mechanical processing like rolling, twisting, positioning.
4. Nano elements show important electrical, magnetic and optical characteristics that are useful in electrical industry.

Which of the above statements are correct?

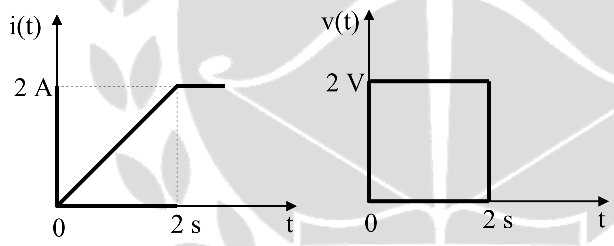
(a) 1, 2 and 3 only (b) 1,2,3 and 4 only

(c) 3 and 4 only (d) 1, 2 and 4 only

37. Ans: (b)

Sol: All the statements are true.

38. The voltage and current waveforms for an element are shown in the figure.



The circuit element and its value are

(a) Capacitor, 2 F (b) Inductor, 2 H

(c) Capacitor, 0.5 F (d) Inductor, 0.5 H

38. Ans: (b)

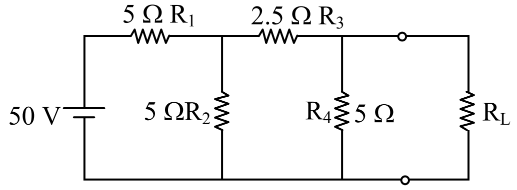
Sol: $V = L\frac{di}{dt} = L\left[\frac{i_2 - i_1}{t_2 - t_1}\right] = 2\left[\frac{2-0}{2-0}\right] \Rightarrow L = 2$

39. In a connected graph, the total number of branches is b and the total number of nodes is n. Then the number of links L of co-tree is

(a) b – n (b) b – n – 1 (c) b + n – 1 (d) b – n + 1

39. Ans: (d)

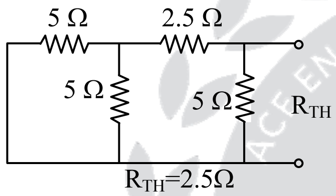
40. For the circuit shown, Thevenin's open circuit voltage V_{oc} and Thevenin's equivalent resistance R_{eq} at terminals A – B are, respectively,

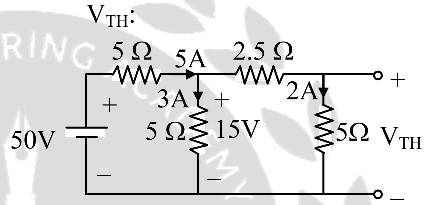


(a) 6.25 V and 2.5 Ω
(b) 12.5 V and 5 Ω
(c) 6.25 V and 5 Ω
(d) 12.5 V and 2.5 Ω

40. Ans: (d)

Sol:



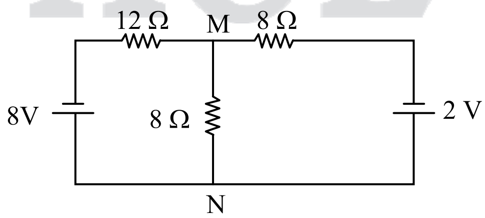


$40\text{ V} \rightarrow 2\text{ A}$

$$50\text{ V} \rightarrow \frac{100}{40} = \frac{10}{4}\text{A}$$

$$V_{TH} = \frac{10}{4} \times 5 = 12.5\text{V}$$

41. What is the current through the 8 Ω resistance connected across terminals, M and N in the circuit?



(a) 0.34 A from M to N
(b) 0.29 A from M to N
(c) 0.29 A from N to M
(d) 0.34 A from N to M

41. Ans: (d)

Sol: Nodal

$$\frac{(V+8)}{12}+\frac{V}{8}+\frac{(V+2)}{8}=0$$

$$\frac{(V+8)}{3}+\frac{V}{2}+\frac{(V+2)}{2}=0$$

$$\frac{2V+16+3V+3V+6}{6}=0$$

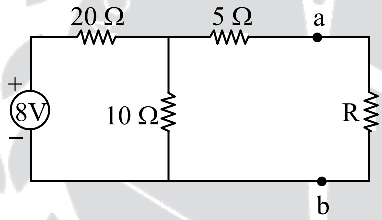
$8V = -22$

$$V=-\frac{22}{8}$$

So, $I=-\frac{22}{64}=-0.343$

So, 0.34 from N to M

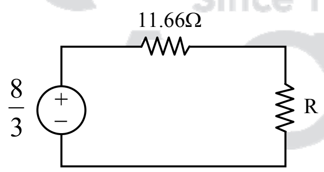
42. What is the value of resistance R which will allow maximum power dissipation in the circuit?



(a) 11.66 Ω (b) 10.33 Ω (c) 8.33 Ω (d) 7.66 Ω

42. Ans: (d)

Sol:



Now, for what valve of 'R' maximum power dissipation in circuit 'R' should be minimum
= 7.66Ω

43. Two resistors of 5 Ω and 10 Ω and an inductor L are connected in series across a 50 cos ωt voltage source. If the power consumed by the 5 Ω resistor is 10 W, the power factor of the circuit is

(a) 10 (b) 0.8 (c) 0.6 (d) 0.4

43. Ans: (c)

Sol: $P=|I|^2.R \Rightarrow 10=|I|^2.5$

$$I = \sqrt{2}$$

$$|I| = \frac{V}{Z} \Rightarrow Z = \frac{V}{I} = \frac{\frac{50}{\sqrt{2}}}{\sqrt{2}} = 25$$

$$\cos\phi = \frac{R}{Z} = \frac{15}{25} = \frac{3}{5} = 0.6(\text{lag})$$

44. A two-element series circuit is connected across an AC source given by e = $200\sqrt{2}\sin(314t + 20)$ V. The current is then found to be i = $10\sqrt{2}\cos(314t - 25)$ A. The parameters of the circuit are

(a) R = 20 Ω and C = 160 μF (b) R = 14.14 Ω and C = 225 μF

(c) L = 45 mH and C = 225 μF (d) L = 45 mH and C = 160 μF

44. Ans: (b)

Sol: $V = 200\angle 20°$

$I = 10\angle 65°$

$$Z = \frac{V}{i} = \frac{200\angle 20°}{10\angle 65°} = 20\angle -45° = 14.14 - j14.14$$

R = 14.14

$$X_C = \frac{1}{\omega C} = 14.14 \Rightarrow C = \frac{1}{\omega(14.14)} = \frac{1}{(314)(14.14)} = 225\ \mu F$$

45. How fast can the output of an OP Amp change by 10 V, if its slew rate is 1 μs?

(a) 5μs (b) 10 μs (c) 15 μs (d) 20 μs

45. Ans: (b)

Sol: Consider, slew rate = $\left[\frac{dV_0}{dt}\right]_{max}$ ……(1)

$$[dt]_{max} = \frac{[dV_0]}{\text{slew rate}} = \frac{10V}{1V/\mu sec} \text{ …..(2)}$$

∴ The time taken by op – amp to change its output by 10V = 10μ-sec

46. A threephase star-connected load is operating at a power factor angle ϕ, with ϕ being the angle between

(a) Line voltage and line current (b) Phase voltage and phase current

(c) Line voltage and phase current (d) Phase voltage and line current

46. Ans: (b)

47. For a two-port reciprocal network, the three transmission parameters are A = 4, B = 7 and C = 5. What is the value of D?

(a) 9.5 (b) 9.0 (c) 8.5 (d) 8.0

47. Ans: (b)

Sol: (AD–BC) = 1

4 (D) – 35 = 1

4D = 36 ⇒ D = 9

48. Consider the following as representations of reciprocity in terms of z-parameters:

1. $z_{11} = z_{12}$

2. $z_{12} = z_{22}$

3. $z_{12} = z_{21}$

Which of the above representations is/are correct?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

48. Ans: (c)

Sol: $Z_{12} = Z_{21}$

49. A parallel-plate capacitor is made of two circular plates separated by a dielectric constant f 2.2 between them. When the electric field in the dielectric is 3×10^4 V/m, the charge density of the positive plate will be nearly

(a) 58.5×10^4 C/m^2 (b) 29.5×10^4 C/m^2

(c) 29.5×10^{-4} C.m^2 (d) 58.5×10^{-4} C/m^2

49. Ans: (*)

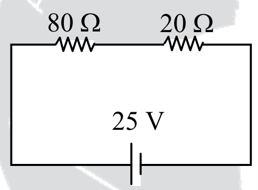
Sol: $\rho_S = \in E$

$\rho_S = 2.2 \times 8.854 \times 10^{-12} \times 3 \times 10^4$

$\rho_S = 58.5 \times 10^{-8}$ c/m^2

No option matching

50. What is the potential drop across the 80 Ω resistor in the figure?



(a) 20 V (b) 15 V (c) 10 V (d) 5 V

50. Ans: (a)

Sol: $V_{80\Omega} = 25\left[\frac{80}{100}\right] = 20V$

51. When 7/0.029 V.I.R cable is carrying 20 A, a drop of 1 V occurs every 12 m. The voltage drop in a 100 m run of this cable when it is carrying 10 A is nearly

(a) 4.2 V (b) 3.2 V (c) 1.2 V (d) 0.42 V

51. Ans: (a)

Sol: VIR cable has $I_{rating} = 20$ A

Voltage drop = 1V for 12 m

for 100 m length, v.drop = $\frac{100}{12} \times 1V = \frac{100}{12} V \rightarrow$ for 20A current

If cable carries 10 A current,

$$V.drop = \left(\frac{100}{12}\right)\times\frac{1}{2} = \frac{100}{24} = 4.2\ V$$

52. Consider the following statements:

If a high Q parallel resonant circuit is load… with a resistance

1. The circuit impedance reduces.
2. The resonant frequency remains the same
3. The bandwidth reduces.

Which of the above statements is are correct

(a) 3 only (b) 2 only (c) 1 only (d) 1, 2 and 3

52. Ans: (d)

Sol: 'f_0' is independent to 'R'

Adding extra parallel branch will reduce impedance

$$B.W = \frac{1}{RC} \text{ so, } R\uparrow \rightarrow BW\downarrow$$

53. A drawn wire of resistance 5 Ω is further drawn so that its diameter becomes one-fifth of the original. What is its resistance with volume remaining the same?

(a) 25 Ω (b) 125 Ω (c) 625 Ω (d) 3125 Ω

53. Ans: (d)

Sol: $V_1 = V_2$

$$\pi r_1^2 h_1 = \pi r_2^2 h_2$$

$$r_1^2 h_1 = \left(\frac{r_1}{5}\right)^2 h_2$$

$$h_1 = \frac{h_2}{25}$$

$h_2 = 25h_1$

$$R_2 = \frac{\rho_2 \ell_2}{a_2} = \frac{\rho_1(25\ell_1)}{\pi\left(\frac{r_1}{5}\right)^2} = 625[R_1]$$

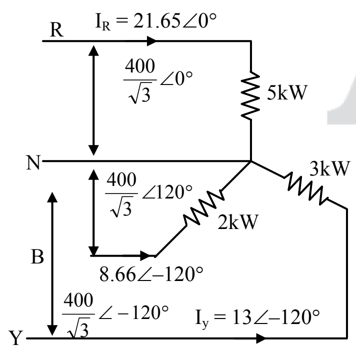
$R_2 = 625 \times 5 = 3125\Omega$

54. The three non-inductive loads of 5 kW, 3 kW and 2 kW are connected in a star network between R, Y and B phases and neutral. The line voltage is 400 V. The current in the neutral wire is nearly

(a) 11 A (b) 14 A (c) 17 A (d) 21 A

54. Ans: (a)

Sol:



$$I_N = \bar{I}_R + \bar{I}_Y + \bar{I}_B$$

$$I_N = [21.65\angle 0°] + [13\angle -120°] + 8.66\angle +120°$$

$$= 21.65j0 + [-6.5 - j11.25] + [-4.33 + j7.5] = 10.82 - j3.75 = 11.45\angle 19.11°$$

55. Kirchoff's current law is applicable to

1. Closed loops in a circuit
2. Junction in a circuit
3. Magnetic circuits

Which of the above is/are correct?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

55. Ans: (b)

56. Which of the following are satisfied in a non-linear network?

1. Associative
2. Superposition
3. Homogeneity
4. Bilarterality

Select the correct answer using the codes given below:

(a) 1 and 3 only (b) 1 and 4 only (c) 2 and 3 only (d) 2 and 4 only

56. Ans: (b)

57. $\nabla \times \bar{H} = \sigma E + \varepsilon\left(\frac{\partial E}{\partial t}\right)$ is

(a) Modified Faraday's law (b) Gauss's law

(c) Biot-Savart law (d) Modified Ampere's law

57. Ans: (d)

Sol: $\nabla \times H = J + \frac{\partial D}{\partial t}$

$\nabla \times H = \sigma E + \frac{\in \partial E}{\partial t}$

58. Consider the following statements:

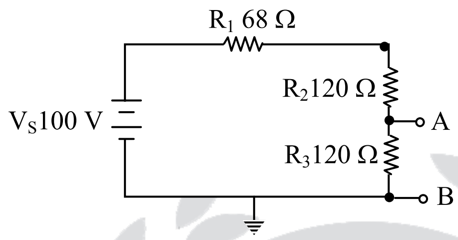
1. Network theorems are not derivable from Kirchoff's law.
2. To get the Norton current, one has to short the current source
3. Thevenin's theorem is suitable for a circuit involving voltage sources and series connections.

Which of the above statements is/are correct?

(a) 1, 2 and 3 (b) 1 only (c) 2 only (d) 3 only

58. Ans: (b)

59. What are the Thevenin's equivalent voltage V_{TH} and resistance R_{TH} between the terminals A and B of the circuit?



(a) 4.16 V and 120 Ω (b) 41.67 V and 120 Ω

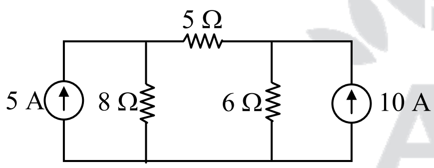
(c) 4.16 V and 70 Ω (d) 41.67 V and 70 Ω

59. Ans: (d)

Sol: $R_{TH} = 120//168 = 70\Omega$

$$V_{TH} = 100\left[\frac{120}{120+100+68}\right] = 41.67V$$

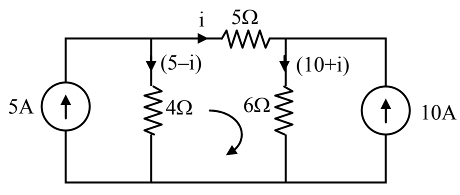
60. What is the current through the 5 Ω resistance in the circuit shown?



(a) 5.33 A (b) 4.66 A (c) 2.66 A (d) 1.33 A

60. Ans: (c)

Sol:



$-4[5 - i] + 5i + 6[10 + i] = 0$

$-20 + 4i + 5i + 60 + 6i = 0$

$15i = -40$

$i = -\frac{8}{3} = -2.66$

Magnitude = 2.66

61. Consider the following statements with regard to Lissajous pattern on a CRO:
    1. It is a stationary pattern on the CRO.
    2. It is used for precise measurement of frequency of a voltage signal.
    3. The ratio between frequencies of vertical and longitudinal voltage signals should be an integer to have a steady Lissajous pattern.

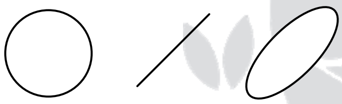
    Which of the above statements is/are correct?

    (a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

61. Ans: (d)

Sol: Lissajious pattern is a stationary pattern.

Example.

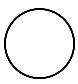


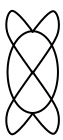
Lissajious pattern can be used for measurement of frequency of an unknown voltage signal.

$$f_y = \frac{n_x}{n_y} \times f_x$$

If the frequency ratio (f_y/f_x) is an integer, then only we get steady lissajious pattern.

Example.

1 : 1 ⇒  ⇒Steady Lissajious pattern

2 : 3 ⇒  ⇒not a Steady Lissajious pattern

∴ Statements 1, 2 and 3 are correct.

62. "Electric flux enclosed by a surface surrounding a charge is equal to the amount of charge enclosed". This is the statement of

(a) Faraday's law (b) Lenz's law

(c) Modified Ampere's law (d) Gauss's law

62. Ans: (d)

Sol: Gauss's Law:

The total electric flux leaving through any closed surface is equal to the total charge enclosed by that surface

$$\phi = \phi_{enc}$$

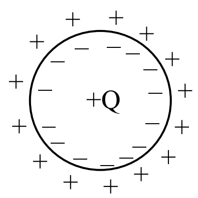
63. If a positively charged body is placed inside a spherical hollow conductor, what will be the polarity of charge inside and outside the hollow conductor?

(a) Inside positive, outside negative (b) Inside negative, outside positive

(c) Both negative (d) Both positive

63. Ans: (b)

Sol:



According to Gauss's Law

inside –ve charges and

Outside +ve charge will exist.

64. Consider the following statements regarding Peer-to-Peer computing environment:

1. In this system, clients and servers are not distinguished from one another.
2. All nodes distributed throughout the system (within) are considered Peers and each may act as either a client or a server.
3. Peer-to-Peer system assuredly offers certain advantages over the traditional client-server system.
4. Peer-to-Peer system is just a replica of the file-server system.

Which of the above statements are correct?

(a) 1, 2, 3 and 4 (b) 1, 2 and 3 only
(c) 1 and 4 only (d) 2, 3 and 4 only

64. Ans: (b)

65. What is the octal equivalent of $(5621.125)_{10}$?
(a) 11774.010 (b) 12765.100 (c) 16572.100 (d) 17652.010

65. Ans: (b)

Sol:

$$\begin{array}{r|l} 8 & 5621 \\ 8 & 702-5 \\ 8 & 87-6 \\ 8 & 10-7 \\ & 1-2 \end{array}$$

$0.125 \times 8 = 1.0 = 1$

$(12765 .100)_8$

66. What is the hexadecimal representation of $(657)_8$?
(a) 1 AF (b) D 78 (c) D 71 (d) 32 F

66. Ans: (a)

Sol: $(657)_8 = (000110101111)_2$

$= (1AF)_{16}$

67. In potential transformers, the secondary turns are increased slightly and the primary and secondary windings are wound as closely as possible to compensate for
(a) Phase angle and ratio error, respectively
(b) Ratio and phase angle error, respectively
(c) Any eddy current loss and hysteresis loss, respectively
(d) The hystersis loss and eddy current loss, respectively

67. Asn: (b)

Sol: in Potential transformer, $n = K_n$, $R > K_n$, so Ratio error (σ) is present due to $R > n$.

→ To reduce ratio error (σ) 'R' (actual ratio) is reduced. So, for reducing 'R', 'n' has to be reduced.

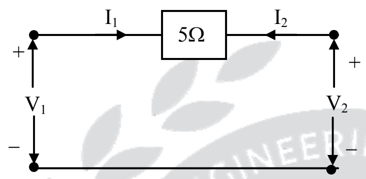
$\downarrow n = \dfrac{N_p}{N_s \uparrow}$, secondary winding turns are increased.

→ phase angle error (θ) depends on magnetising component of current (I_m)

i.e $\downarrow\theta \propto I_m\downarrow$

if primary and Secondary windings are very closer then leakage flux are reduced. Then 'I_m' becomes less, with this θ↓.

68. The y-parameters for the network shown in the figure can be represented by

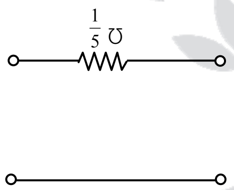


(a) $[y]=\begin{bmatrix} -\frac{1}{5} & \frac{1}{5} \\ \frac{1}{5} & -\frac{1}{5} \end{bmatrix}$ ℧ (b) $[y]=\begin{bmatrix} \frac{1}{5} & -\frac{1}{5} \\ -\frac{1}{5} & -\frac{1}{5} \end{bmatrix}$ ℧

(c) $[y]=\begin{bmatrix} -5 & 5 \\ 5 & -5 \end{bmatrix}$ ℧ (d) $[y]=\begin{bmatrix} 5 & -5 \\ -5 & -5 \end{bmatrix}$ ℧

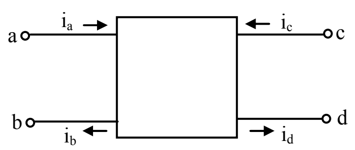
68. Ans: (b)

Sol:



$$Y = \begin{bmatrix} \frac{1}{5} & -\frac{1}{5} \\ -\frac{1}{5} & \frac{1}{5} \end{bmatrix}$$

69. In the two-part network shown, which of the following is correct?



(a) $i_b = i_c$ (b) $i_a = i_d$ (c) $i_c = i_d$ (d) $i_a = i_b$

69. Ans: (c)

Sol: Actually both

$i_c = i_d$ & $i_a = i_b$

70. A $4\frac{1}{2}$ digit volt meter is used for voltage measurement. How would 0.7525V be displayed in 1 V range?

(a) 0.7525 V (b) 0.752 V (c) 0.075 V (d) 0.0752 V

70. Ans: (a)

Sol: V_m=0.7525V by 4½ digit DVM in 1V range displayed as 0.7 5 2 5V

71. Which of the following equations represent Gauses's law adapted to a homogeneous isotropic medium?

1. $\oint_s \vec{D} \cdot d\vec{s} = \oint_v \rho\, dv$

2. $V \times \vec{H} = \vec{D}$

3. $\Delta.\vec{J} + \rho = 0$

4. $\Delta.\vec{E} = \frac{\rho}{\varepsilon}$

5. $\Delta^2\varphi=0$

Select the correct answer using the codes given below:

(a) 1 and 4 only (b) 2 and 3 only

(c) 3 and 5 only (d) 1,2,4 and 5 only

71. Ans: (*)

Sol: Gauss's Law:

$$\oint_s \overline{D}.ds = \int_v \rho_v\, dv$$

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

$\nabla.E = \frac{\rho_v}{\in}$ → Gauss's Law for homogeneous isotropic medium.

Note: $\oiint \overline{D}.ds = \iiint \rho\, dV$, as per the divergence theorem, the symbols which we have used are having their usual meaning, hence we have to follow strictly the integral symbols in the above equation. But in equation (1), the right hand side consists of closed symbol on the integral, which is not a valid notation as per the integral form of Gauss's law.

So, only 4th statement is correct.

72. Consider the following statements with regard to Moving Iron (MI) instruments :

1. These instruments posses high operating torque.
2. These instruments can be used in ac and dc circuits
3. Power consumption in these instruments is lower for low voltage range

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

72. Ans: (d)

Sol: → Iin M.I instrument $T_d \propto I^2$, so it has higher operating torque

→ As the range is extended with shunts or multipliers power consumption increases.

73. A current of (10+5 sin ωt +3 sin 2ωt) is measured using a moving iron instrument. The reading would be

(a) 08.82 A (b) 10.00 A (c) 10.82 A (d) 12.75 A

73. Ans: (c)

Sol: M.I meters indicate R.M.S value

$$I_{r.m.s} = \sqrt{10^2 + \left(\frac{5}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2} = 10.82\text{ A}$$

74. Which one of the following methods is used for the measurement of high resistances?

(a) Carey-Foster bridge method (b) Substitution method
(c) Loss of charge method (d) Potentiometer method

74. Ans: (c)

Sol: Loss of charge method used for high resistance measurement.

75. Consider the following statements with regard to induction type wattmeter:

1. Can be used on both ac and dc systems.
2. Power consumption is relatively low.
3. It is accurate only at stated frequency and temperature,

Which of the above statements is/are correct?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

75. Ans: (c)

Sol: Induction type wattmeter works only for AC,because induction is not possible for DC due to presence of more weight of moving system power consumption is relatively high and pressure coil is highly inductive, with shading bands meter is calibrated at supply frequency. So, if any other frequency used reading will changes.

Due to temperature, winding resistance increased, so eddy currents decreased then driving torque (T_d) is decreased but simultaneously breaking torque decreased ($T_B\downarrow$). So temperature effect is almost nullified.

76. A computer system has a cache with a cache access time T_C = 10 ns, a hit ratio of 80% and an average memory access time T_M = 20 ns.
What is the access time for physical memory T_P?

(a) 90 ns (b) 80 ns (c) 60 ns (d) 20 ns

76. Ans: (c)

Sol: $Tm = H_C*T_C + (1–H_C)* (T_M)$

20 ns = 0.8 * 10 ns + 0.2 *T_M

0.2 *T_M = 20 ns – 8 ns

T_M = 12/0.2 ns = 120/2 ns =60 ns

Tm = 60 ns

77. If n has the value 3, then the C language statement: a[+ + n] = n + +; assigns

(a) 3 to a [5] (b) 4 to a[5] (c) 4 to a [4] (d) 5 to a[5]

77. Ans: (c)

Sol: First array index value of n get incremented and in that index the incremented value of n will be stored and then again value of n get incremented.

78. The minimum number of arithmetic operations required to evaluate the polynomial $P(X) = X^5 + 8X^3 + X$ for a give value of X using only one temporary variable is

(a) 8 (b) 7 (c) 6 (d) 5

78. Ans: (d)

79. A freewheeling diode in phase-controlled rectifiers

(a) enables inverter operation

(b) is responsible for additional reactive power

(c) improves the line power factor

(d) is responsible for additional harmonics

79. Ans: (c)

Sol: Due to the free wheeling diode the negative portion in the output waveform will be removed so that net area under waveform will increases and hence average output voltage will increases so that input power factor i.e. line power factor improves.

80. Consider the following statements regarding electrical conductivity σ:

1. It increases with temperature in semiconductors.
2. Its increase with temperature is exponential.
3. It increases in metal and their alloys, linearly with temperature.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

80. Ans: (a)

Sol: 1. As temperature increases, covalent bonds are broken and so free electrons and holes increases. Thus the electrical conductivity(σ) increases in semiconductors.

2. $n_i = A \times T^{3/2} e^{-EG_0/KT}$

3. In metal, as the temperature increases, the electrical conductivity decreases.

81. What is the effect on the natural frequency (ω_n) and damping factor (δ) in the control systems when derivative compensation is used?

(a) ω_n increased and δ decreases (b) ω_n remains unchanged and δ increases

(c) ω_n remains unchanged and δ decreases (d) ω_n decreases and δ increases

81. Ans: (b)

Sol: Let G(s) = $\frac{\omega_n^2}{s(s+2\zeta\omega_n)}$ and H(s) = 1

For derivative controller

$G_1(s) = (1+T_D s)$

CE = $1 + G_1(s)G(s)H(s) = 0$

$$1 + \frac{\omega_n^2(1+T_D s)}{s(s+2\zeta\omega_n)} = 0$$

$$s^2 + 2\zeta\omega_n s + \omega_n^2 T_D s + \omega_n^2 = 0$$

$$s^2 + (2\zeta\omega_n + \omega_n^2 T_D)s + \omega_n^2 = 0$$

ω_n is unchanged

's' coefficient increases, ∴ ζ increases.

82. Consider the following components in a multi-stage R-C coupled amplifier:

1. Parasitic capacitance of transistor
2. Coupling capacitance

3. Stray capacitance

4. Wiring capacitance

Which of the above components effectively control high frequencies?

(a) 1, 2 and 3 (b) 1, 2 and 4 (c) 1, 3 and 4 (d) 2, 3 and 4

82. Ans: (c)

Sol: 1. In RC coupled amplifiers ,the performance (gain) is controlled by coupling capacitors at low frequencies.

2. The performance of amplifier may be controlled by, Parasitic capacitance of transistor , stray capacitance and wiring capacitances at higher frequencies.

83. A Wien Bridge Oscillator is suitable for

1. Audio frequency applications
2. Radio frequency applications
3. Very low frequency applications

Which of the above frequency applications is/are correct?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

83. Ans: (a)

Sol: 1. RC oscillators [RC phase shift and Wien Bridge oscillators] are suitable for Audio frequency (AF) applications.

2. LC oscillators [Hartley, Colpit's & Crystal oscillators] are suitable for Radio frequency (RF) applications.

84. In an R-C phase shift oscillator using FET and 3-section R-C phase shift network, the condition for sustained oscillation is

(a) $\beta > 6\,n$ (b) $\beta > 29$ (c) $\beta > 4n + 23 + \frac{29}{n}$ (d) $\beta > 23 + \frac{29}{n}$

Where, $n = \frac{R_d}{R}$

84. Ans: (c)

Sol: In a RC- phase shift oscillator using FET, the condition for sustained oscillations.

$A_V > -[29+23n+4n^2]$…..(1)

Where $n = \frac{R_L}{R_i} = \frac{R_D}{R}$ ….(2)

But $A_V = \frac{-\beta R_L}{R_i}$

$\Rightarrow \frac{\beta R_L}{R_i} > 29 + 23n + 4n^2$ …….(3)

$\beta n > 29+23n+4n^2$…..(4)

$\therefore \beta > \frac{29}{n} + 23 + 4n$ …….(5)

85. A tuned-collector oscillator has a fixed inductance of 100 μH and has to be tunable over the frequency band of 500 kHz to 1500 kHz. What is the range of variable capacitor to be used?

(a) 115 – 1021 pF (b) 113 – 1015 pF (c) 93 – 1015 μF (d) 110 – 1021 μF

85. Ans: (b)

Sol: Given L = 100μH, f =500kHz to 1500kHz

Consider, $f = \frac{1}{2\pi\sqrt{LC}} \Rightarrow C = \frac{1}{(4\pi^2 f^2)L}$ ...(1)

Case i: If f = 500kHz

$C = \frac{1}{4\times\pi^2\times(500\times10^3 Hz)^2\times100\times10^{-6} H}$ = 112.6933pF…(2)

Case (ii):If f = 1500kHz

$C = \frac{1}{4\times\pi^2\times(1500\times10^3 Hz)^2\times100\times10^{-6} H}$

= 1014.2399PF…..(3)

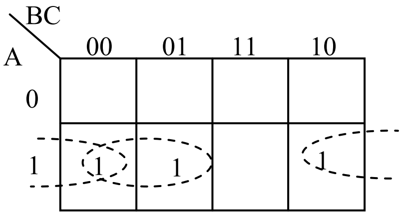
∴ The range of capacitor to be used to get oscillations in the range of 500kHz to 1500kHz frequency = 112.6933pF to 1014.2399pF

86. The logical expression, $AB\overline{C} + A\overline{B}C + A\overline{B}\,\overline{C}$ is equivalent to

(a) $\overline{A}(B+C)$ (b) $\overline{A}+\overline{B}+\overline{C}$ (c) $\overline{A}\,\overline{B}\,\overline{C}$ (d) $A(\overline{C}+\overline{B})$

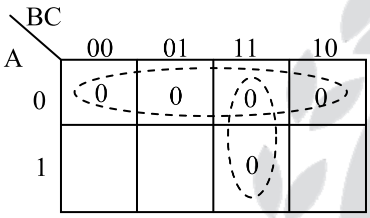
86. Ans: (d)

Sol: $AB\overline{C} + A\overline{B}C + A\overline{B}\,\overline{C}$



$A\overline{B} + A\overline{C} = A\left(\overline{B} + \overline{C}\right)$

OR



$A\left(\overline{B} + \overline{C}\right)$

87. What is the analog output for a 4-bit R 2R ladder DAC when input is $(1000)_2$, for $V_{ref} = 5V$?
    (a) 2.3333 V (b) 2.4444 V (c) 2.5556 V (d) 2.6667 V

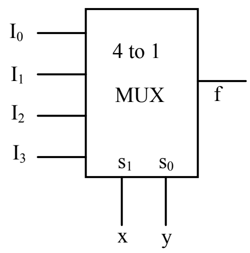
87. Ans: (*)

Sol: DAC Resolution = $\dfrac{V_R}{2^n} = \dfrac{5}{2^4} = \dfrac{5}{16}$

Given digital input = $(1000)_2 = (8)_{10}$

Thus DAC output = $8 \times \dfrac{5}{16} = 2.5$ V

88. Which logic inputs should be given in the input lines I_0, I_1, I_2 and I_3, if the MUX is to behave as two input XNOR gate?



(a) 0110 (b) 1001 (c) 1010 (d) 1111

88. Ans: (b)

Sol: For X NOR gate output f = $\overline{X}\overline{Y} + XY$

$\therefore$ $I_0 = 1, I_1 = 0, I_2 = 0, I_3$ 1

89. Fourier series of any periodic signal x(t) can be obtained if

1. $\int_0^T |x(t)|\,dt < \infty$

2. Finite number of discontinuities within finite time interval t

3. Infinite number of discontinuities

Select the correct answer using the codes given below:

(a) 1, 2 and 3 (b) 1 and 3 only

(c) 1 and 2 only (d) 2 and 3 only

89. Ans: (c)

Sol: The dirichlet condition for existence of Fourier series

(a) function must be single valued

(b) function must have finite number of discontinuities over interval T

(c) function must have finite number of maximum and minimum over period T

(d) $\int_{-\frac{T}{2}}^{T/2} 1 = |x(t)|\,dt < \infty$

$\int_0^T |x(t)|\,dt < \infty$

90. Which one of the following statements correct?

(a) If and only if its impulse response non-zero for negative values of n.

(b) If and only if its impulse response non-zero for positive values of n.

(c) If its impulse response is zero negative values of n.

(d) If its impulse response is zero positive values of n.

90. Ans: (c)

Sol: For a causal LTI system

$h(n) = 0 \quad n< 0$

91. Consider the following statements with respect to Discrete Fourier Transform (DFT):

1. It is obtained by performing a sampling operation in the time domain.
2. It transforms a finite duration sequence into a discrete frequency spectrum.
3. It is obtained by performing a sampling operation in both time and frequency domains.

Which of the above statements is/are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 only
(d) 3 only

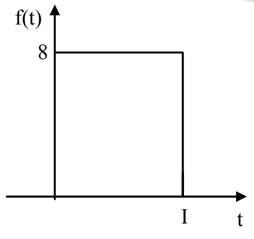
91. Ans: (b)

Sol: DFT of sequence is given by $X(k) = \sum_{n=0}^{N-1} x(n)\, e^{\frac{-j2\pi kn}{N}}$ hence signal x(n) is having length N or finite also spectrum X(k) is is finite having length N

$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} x(k)\, e^{\frac{j2\pi kn}{N}}$$

DFT is sample of DTFT over period

92. The Laplace transform of the below function is



(a) $F(s) = 8s\,(1 - e^{-s})$
(b) $F(s) = \frac{8}{s}(1 + es)$
(c) $F(s) = 8s(1 + e^{-s})$
(d) $F(s) = \frac{8}{s}(1 - e^{-s})$

92. Ans: (d)

Sol: From the given diagram, the function f(t) is

$$f(t) = \begin{cases} 8 & 0 \le t \le 1 \\ 0 & \text{otherwise} \end{cases}$$

$$L\{f(t)\} = \int_0^1 e^{-st}\ 8\,dt = 8\left(\frac{e^{-st}}{-s}\right)_0^1$$

$$L\{f(t)\} = \frac{8}{s}\left[e^0 - e^{-s}\right]$$

$$\therefore L\{f(t)\} = \frac{8}{s}[1 - e^{-s}]$$

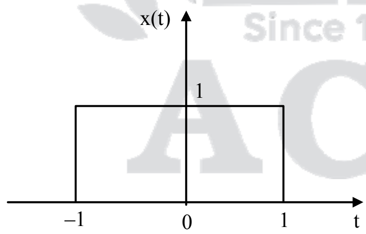
93. The number of complex additions and multiplications in direct DFT are, respectively

(a) $N(N-1)$ and N^2
(b) $N(N+1)$ and N^2
(c) $N(N+1)^2$ and N
(d) N and N^2

93. Ans: (a)

Sol: The number of complex addition in N-point DFT is N(N–1). The number of complex multiplication in a point DFT is N^2

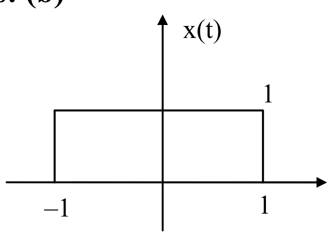
94. The Fourier transform of a unit rectangular pulse shown in the figure is



(a) $\omega \sin \omega$
(b) $\frac{2\sin\omega}{\omega}$
(c) $\frac{\omega}{\sin\omega}$
(d) $\frac{\cos\omega}{2\omega}$

94. Ans: (b)

Sol:



Fourier Transform of signal is given by

$$x(j\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt$$

$$= \int_{-1}^{1} 1\ e^{j\omega t}\ dt$$

$$= -\frac{1}{j\omega}[e^{-j\omega} - e^{j\omega}]$$

$$= \frac{1}{\omega}\left[\frac{e^{j\omega} - e^{-j\omega}}{j}\right]$$

$$= 2\frac{\sin\omega}{\omega}$$

95. The number of complex additions and multiplications in FFT are, respectively,

(a) $\frac{N}{2}\log_2 N$ and $N\log_2 N$ (b) $N\log_2 N$ and $\frac{N}{2}\log_2 N$

(c) $\frac{N}{2}\log_2 N$ and $\log_2 N$ (d) $\log_2 N$ and $\frac{N}{2}\log_2 N$

95. Ans: (b)

Sol: For N point FFT

number of complex multiplication

$$= \frac{N}{2}\log_2 N$$

Number of complex addition= $N\log_2 N$

96. Consider the following driving point impedance functions:

$$Z_1(s) = \frac{(s+2)}{(s^2+3s+5)}$$

$$Z_2(s) = \frac{(s+2)}{(s^2+5)}$$

$$Z_3(s) = \frac{(s+2)}{(s^2+2s+1)}$$

$$Z_4(s) = \frac{(s+2)(s+4)}{(s+1)(s+3)}$$

Which one of the above is positive real?

(a) Z_1 (b) Z_2 (c) Z_3 (d) Z_4

96. Ans: (d)

97. The closed-loop transfer function of a system is $\frac{C(s)}{R(s)} = \frac{s-2}{s^3+8s^2+19s+12}$. The system is

(a) Stable (b) Unstable

(c) Conditionally stable (d) Critically stable

97. Ans: (a)

Sol:

$+s^3$	1	19
$+s^2$	8	12
$+s^1$	$\frac{(19)(8)-12}{8}$	
$+s^0$	12	

Number of sign changes in the first column is zero. Hence,

Number of R.H.S poles=0

Number of poles on jω axis = 0

Number of L.H.S poles =3

∴ System is stable

98. A system has 14 poles and 2 zeros in its open-loop transfer function. The slope of its highest frequency asymptote in its magnitude plot is

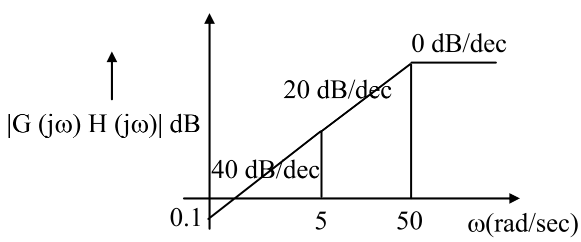
(a) –40 dB/dec (b) –240 dB/dec (c) +40 dB/dec (d) +240 dB/dec

98. Ans: (b)

Sol: $\underset{\omega\to\infty}{\text{slope}} = (14-2)(-20\text{dB/dec})$

$= -240$ dB/dec

99. The open-loop transfer function for the Bode' magnitude plot is



(a) $G(s)\,H(s) = \dfrac{K}{s^2(1+0.2s)(1+0.02s)}$

(b) $G(s)\,H(s) = \dfrac{K\,s}{(1+0.2s)(1+0.02s)}$

(c) $G(s)\,H(s) = \dfrac{K\,s^2}{(s+5)(s+50)}$

(d) $G(s)\,H(s) = \dfrac{K}{s^2(s+5)(s+50)}$

99. Ans: (c)

Sol: Initial slope = 40 dB/dec $\Rightarrow ks^2$

$$\therefore\ G(s)H(s) = \frac{ks^2}{(s+5)(s+50)}$$

100. While forming a Routh array, the situation of a row of zeros indicates that the system

(a) has symmetrically located roots

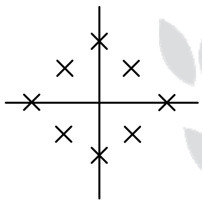
(b) is stable

(c) is insensitive to variations in gain

(d) has asymmetrically located roots

100. Ans: (a)

Sol: Symmetrical located roots with respect to origin



101. A linear time-invariant control system with unsatisfactory steady state error is to be compensated. Which is/are correct type of cascade compensation to be provided?

1. Lead
2. Lag
3. Lag-lead

Select the correct answer using the codes given below:

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

101. Ans: (b)

Sol: Lag compensator improves steady state performance

$\therefore$ Error reduced

102. A phase-lead network has its transfer function $G_C(s) = \frac{(1+0.04s)}{(1+0.01s)}$. What is the frequency at which the maximum phase-lead occurs?

(a) 25 rad/sec (b) 50 rad/sec (c) 75 rad/sec (d) 100 rad/sec

102. Ans: (b)

Sol: $\omega_m = \sqrt{\frac{1}{0.04} \times \frac{1}{0.01}} = \sqrt{\frac{(100)(100)}{4}}$ = 50 rad/sec

103. What is the open-loop transfer function for the system, whose characteristic equation is $F(s) = s^3 + 3s^2 + (K+2)s + 5K = 0$?

(a) $G(s)\,H(s) = \frac{5K}{s(s+1)(s+3)}$ (b) $G(s)\,H(s) = \frac{Ks}{s(s+1)(s+2)}$

(c) $G(s)\,H(s) = \frac{K(s+5)}{s(s+1)(s+2)}$ (d) $G(s)\,H(s) = \frac{5K}{s(s+1)(s+2)}$

103. Ans: (c)

Sol: Characteristic Equation

$1 + G(s)H(s) = s^3 + 3s^2 + (k+2)s + 5k = 0$

$= s^3 + 3s^2 + 2s + 5k + ks = 0$

$= s^3 + 3s^2 + 2s + k(s+5) = 0$

Divide above equation by $s^3 + 3s^2 + 2s$

$$= \frac{s^3 + 3s^2 + 2s + k(s+5)}{s^3 + 3s^2 + 2s} = 0$$

$$= 1 + \frac{k(s+5)}{s^3 + 3s^2 + 2s}$$

$$1 + G(s)H(s) = 1 + \frac{k(s+5)}{s(s+1)(s+2)} = 0$$

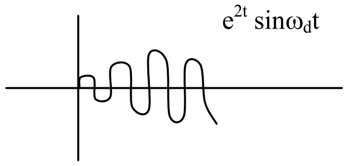
$$G(s)H(s) = \frac{k(s+5)}{s(s+1)(s+2)}$$

104. In a system, the damping coefficient is –2. The system response will be

(a) Undamped
(b) Oscillations with decreasing magnitude
(c) Oscillations with increasing magnitude
(d) Critically damped

104. Ans: (c)

Sol: Roots = $-\alpha \pm j\omega_d$



Damping coefficient $\alpha = -2$

Roots = $2 \pm j\omega_d$

$\therefore$ System has oscillations with increasing magnitude.

105. A dynamic system is described by the following equations:

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \text{ and}$$

Y = [10   0] u

Then the transfer function relating Y and u is given by

(a) $\frac{Y(s)}{u(s)} = \frac{10s}{s^2+4s+3}$
(b) $\frac{Y(s)}{u(s)} = \frac{10}{s^2+4s+3}$
(c) $\frac{Y(s)}{u(s)} = \frac{s}{s^2+2s+1}$
(d) $\frac{Y(s)}{u(s)} = \frac{s}{s^2+3s+1}$

105. Ans: (b)

Sol: TF = $C[sI - A]^{-1} B = \frac{10}{s^2+4s+3}$

106. The characteristics of a mode of controller are summarized:

1. If error is zero, the output from the controller is zero.
2. If error is constant in time, the output from the controller is zero.
3. For changing error in time, the output from the controller is |K|% for every 1% sec^{-1} rate of change of error.
4. For positive rate of change of error, the output is also positive.

The mode of controller is

(a) Integral controller
(b) Derivative controller
(c) Proportional derivative
(d) Proportional integral

106. Ans: (b)

Sol: If the error is constant, output of the derivative control is zero.

i.e. $\frac{d}{dt}(\text{constant } error) = 0$

107. A 1000 V/400 V power transformer has a nominal short-circuit voltage V_{SC} = 40%. Which one of the following statements is correct?

(a) A voltage of 400 V appears across the short-circuited secondary terminals

(b) A voltage of 16V appears across the short-circuited, secondary terminals

(c) When the secondary terminals are short-circuited, the rated current flows at the primary side at a primary voltage of 400 V.

(d) The primary voltage drops to 400 V, when the secondary terminals are short-circuited.

107. Ans: (c)

Sol: At primary side $V_{SC} = \frac{40}{100} \times 1000 = 400\,V$

$\therefore V_{SC}$ is 40 percent means 400 V is required on primary side with secondary short circuited, so that rated short circuited current flows in the secondary winding.

108. Consider the following statements regarding three-phase transformers in Open-Delta (V-V) connections:

1. Being a temporary remedy when one transformer forms of Delta-Delta system is damaged, and removed from service.
2. The Volt Ampere (VA) supplied by each transformer is half of the total VA, and the system is not overloaded
3. An important precaution is that load shall be reduced by $\sqrt{3}$ times in this case.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

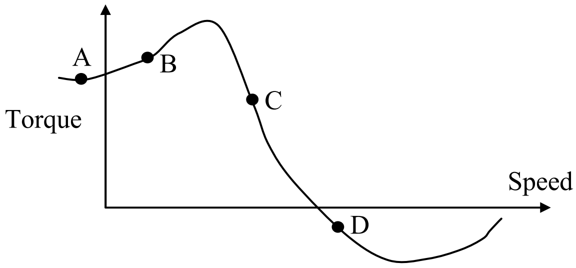
(c) 2 and 3 only (d) 1, 2 and 3

108. Ans: (b)

Sol: Capacity of v v bank is 57.7 percentage of total load.

If 100% load is maintained on open delta bank, then the line current is $\sqrt{3}\,I_1$ and each single transformer overloaded by 73%.

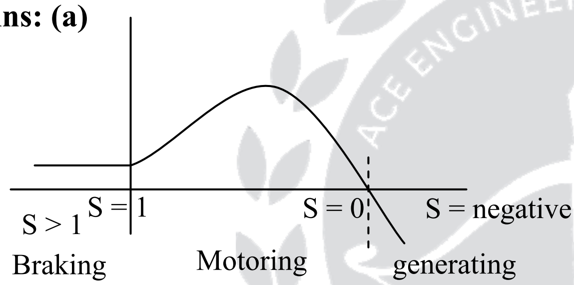
109. On the Torque/Speed curve of an induction motor shown in the figure, four point of operation are marked as A, B, C and D.



Which one of them represents the operation at a slip greater than 1?

(a) A (b) B (c) C (d) D

109. Ans: (a)



110. A 3-phase, 460 V, 6-pole, 60 Hz cylindrical rotor synchronous motor has a synchronous reactance of 2.5 Ω and negligible armature resistance. The load torque, proportional to the square of the speed, is 398 N.m at 1200 rpm. Unity power factor is maintained by excitation control. Keeping the v/f constant, the frequency is reduced to 36 Hz. The torque angle δ is

(a) 9.5° (b) 12.5° (c) 25.5° (d) 30°

110. Ans: (b)

Sol: A 3-ϕ, 460V, P = 6, f = 60 Hz , cylindrical rotor synchronous motor, $X_s = 2.5\Omega$, $R_a = 0$.

$T \alpha N^2$; Torque at 1200 rpm, $T_1 = 398$N-m, UPF, $\frac{V}{f} = \text{constant}$

If f = 36Hz ; $\delta = ?$

$V_L = 460V \Rightarrow Vph = \frac{460}{\sqrt{3}} = 245.58V$; $N_{s_1} = \frac{120 \times 60}{6} = 1200 rpm$

$$\mathbf{N_s} = \frac{120 \times 60}{6} = 1200\,\mathbf{rpm}$$

At f = 36Hz, $V_L = 460 \times \frac{36}{60} = 276V$;

$$N_{s_2} = \frac{120 \times 36}{6} = 720\text{rpm}$$

$$\frac{T_2}{T_1} = \frac{N_{s_2}^{\ 2}}{N_{s_1}^{\ 2}} = \frac{T_2}{398} = \frac{720^2}{1200^2}$$

T_2 = 143.28N-m

$$P = \frac{2\pi NT}{60} = \frac{2\pi \times 720 \times 143.28}{60} = 10.8\text{kW}$$

$$P = \sqrt{3} V_L I_L \cos\phi$$

$$10.8 \times 10^3 = \sqrt{3} \times 276 \times I_L \times 1$$

I_L = 22.59A

$E = V\angle 0 - I_a\angle \pm\phi\ Z_s\angle\theta$

$$\left[\because X_{s_2} = X_{s_1} \times \frac{36}{60} = 2.5 \times \frac{36}{60} = 1.5\Omega\right]$$

$$= \frac{276}{\sqrt{3}}\angle - 22.59\angle 0 \times 1.5\angle 90^\circ = 162.9\angle 12.1^\circ$$

$$\therefore \delta \approx 12.5^\circ$$

111. Consider the following statements regarding capability curves of a synchronous generator:

1. The MVA loading should not exceed the generator rating.
2. The field current should not be allowed to exceed a specified value determined by field heating.
3. The MW loading should not exceed the rating of the prime mover.
4. The load angle must be more than 90°.

Which of the above statements are correct?

(a) 1, 2, 3 and 4
(b) 1 and 4 only
(c) 1, 2 and 3 only
(d) 2, 3 and 4 only

111. Ans: (c)

Sol: 1. The machines are designed to operate with in certain specified limits. The operating limits are active power dependent upon the prime mover output.

2. The MVA loading should not exceed the generator set because the rotor heating limit depends on field current and armature heating is depends on armature current.

3. The stability limit i.e $\delta<90^{o}$

$\therefore$ statement 1,2&3 are correct.

112. A 12-pole, 440 V, 50 Hz, 3-phase synchronous motor takes a line current of 100 A at 0.8 pf leading. Neglecting losses, the torque developed will be

(a) 705 Nm (b) 1165 Nm

(c) 1058 Nm (d) 525 Nm

112. Ans: (b)

Sol: A 12-pole, 440V, 50Hz,

3-Phase synchronous motor

I_L = 100A at 0.8PF leading

T = ?

$$\mathbf{P} = \sqrt{3}\mathbf{V_L I_L \cos\phi} = \sqrt{3}\times 440\times 100\times 0.8 = 60.968\text{kW}$$

$$N_s = \frac{120f}{P} = \frac{120\times 50}{12} = 500\text{rpm}$$

$$T = \frac{p}{\omega} = \frac{p}{2\pi\frac{N}{60}} = \frac{60.968\times 10^3}{2\pi\times\frac{500}{60}} = 1164.4\text{N}-\text{m} \approx 1165\text{N-m}$$

113. Consider the following statements:

1. Salient pole alternators have small diameters and large axial lengths.
2. Cylindrical rotor alternators have a distributed winding.
3. Cylindrical rotor alternators are wound for large number of poles.
4. Salient pole alternators run at speeds slower than cylindrical rotor machines.

Which of the above statements re correct?

(a) 1 and 3 only (b) 2 and 4 only (c) 1 and 4 only (d) 2 and 3 only

113. Ans: (b)

Sol: 1. Salient pole alternator will have larger diameter, smaller axial length.

$\therefore$ statement given is wrong

2. The field winding of the cylindrical motor is distributed around $\frac{2}{3}$rd of rotor periphery.

$\therefore$ correct statement.

3. Cylindrical motor alternator will have smaller number of poles generally 2 or 4.

$\therefore$ wrong statement.

4. salient pole alternator rotate at low speed and cylindrical rotor alternator rotate at high speed.

$\therefore$ correct statement

114. A permanent magnet stepper motor with 8 poles in stator and 6 poles in rotor will have a step angle of

(a) 7.5° (b) 15° (c) 30° (d) 60°

114. Ans: (b)

Sol: Permanent magnet stepper motor with stator poles, $P_s = 8$

rotor poles, $P_r = 6$

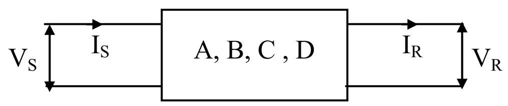
$$\text{Then step angle}, \beta = \frac{P_s - P_r}{P_s \times P_r} \times 360 = \frac{8-6}{8 \times 6} \times 360 = 15^{\circ}$$

115. The transmission line is represented as a two-port network as shown in the figure. The sending end voltage and current are expressed in terms of receiving end voltage and current for the network as

$V_S = AV_R + BI_R$

$I_S = CV_R + DI_R$

Where A, B, C and D are generalized circuit constants.



The condition for symmetry for the network is

(a) A = C (b) A = D (c) B = C (d) B = D

115. Ans: (b)

Sol: Symmetrical network A = D

116. A power system has two synchronous generators having governor turbine characteristics as

$P_1 = 50\ (50 - f)$

$P_2 = 100\ (51 - f)$

Where f represents the system frequency. Assuming a lossless operation of the complete power system, what is the system frequency for a total load of 800 MW?

(a) 55.33 Hz (b) 50 Hz (c) 45.33 Hz (d) 40 Hz

116. Ans: (c)

Sol: For the given two generators system

$P_1 = 50\ (50 - f)$

$P_2 = 100(51 - f)$

Total load, $P_{load} = 800$ MW

So, $P_1 + P_2 = 800$

$50(50 - f) + 100(51 - f) = 800$

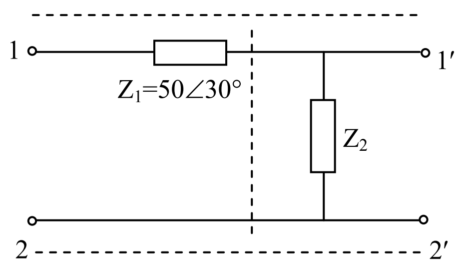
$50 - f + 2\ (51 - f) = 16$

$50 + 102 - 3f = 16$

$3f = 152 - 16$

$f = 45.33$ Hz

117. Two networks are connected in cascade in the figure. The equivalent ABCD constants are obtained for the combined network having $C = 0.1\angle 90°$.



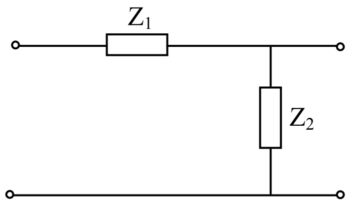
What is the value of Z_2?

(a) $500\angle -60°$ (b) 0.10j (c) –10j (d) $50\angle -60°$

117. Ans: (c)

Sol: ABCD of the cascaded network

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & Z_1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 1/Z_2 & 1 \end{bmatrix}$$



from this multiplication,

$C = \frac{1}{Z_2}$, $Z_2 = \frac{1}{C}$

as it is given $C = 0.1\angle 90°$

now, $Z_2 = \frac{1}{0.1\angle 90°} = 10\angle -90° = -j10\ \Omega$

118. Which of the following does not have an effect on corona?

(a) Spacing between conductors
(b) Conductor size
(c) Line voltage
(d) Length of conductor

118. Ans: (d)

Sol: Corona independent on length of transmission line.

119. Consider the following statements regarding corona:

1. It caused radio interference.
2. It attenuates lightning surges.
3. It causes power loss.
4. It is more prevalent in the middle conductor of a transmission line employing flat conductor configuration.

Which of the above statements are correct?

(a) 1, 2 and 3 only
(b) 1, 2 and 4 only
(c) 1, 2, 3 and 4
(d) 3 and 4 only

119. Ans: (c)

120. The loss formula coefficient matrix for a two-plant system is given by

$$B = \begin{bmatrix} 0.001 & -0.0001 \\ -0.0001 & 0.0013 \end{bmatrix} M\omega^{-1}$$

The economic schedule for a certain load is given as

$P_1 = 150$ MW and $P_2 = 275$ MW.

What is the penalty factor for plant 1 for this condition?

(a) 1.324 (b) 1.515 (c) 1.575 (d) 1.721

120. Ans: (a)

Sol: Penalty factor for plant -1 is,

$$L_1 = \frac{1}{1-\frac{\partial P_{loss}}{\partial P_{G1}}}$$

$$P_{loss} = B_{11}\ P_{G1}^2 + B_{22}P_{G2}^2 + 2P_{G1}P_{G2}B_{12}$$

$$\frac{\partial P_{loss}}{\partial P_{G1}} = 2B_{11}P_{G1} + 2P_{G2}\ B_{12}\ = (2\times0.001\times150)+(2\times275\times-0.0001) = 0.245$$

$$L_1 = \frac{1}{1-0.245} = 1.3245$$

121. A lossless power system has two generators G_1 and G_2; and total load to be served is 200 MW. The respective cost curve C_1 and C_2 are defined as

$$C_1 = P_{G1} + 0.01\ P_{G1}^2$$

$$C_2 = 5P_{G2} + 0.02\,P_{G2}^2$$

Assume the minimum loading on any generator to be 30 MW, the most economical loads P_{G1} and P_{G2} for the two generators are, respectively

(a) 170 MW and 100 MW (b) 200 MW and 100 MW

(c) 170 MW and 30 MW (d) 200 MW and 30 MW

121. Ans: (c)

Sol: Total load, $P_{load} = 200$ MW

$$P_{G1} + P_{G2} = 200 \text{ MW } \ldots..(1)$$

Cost curves $C_1 = P_{G1} + 0.01\ P_{G1}^2$

$$C_2 = 5P_{G2} + 0.02\,P_{G2}^2$$

Most economical load scheduling, $\frac{dC_1}{dP_{G1}} = \frac{dC_2}{dP_{G2}}$

$1+0.02\ P_{G1} = 5 + 0.04\ P_{G2}$

$0.02\ P_{G1} - 0.04\ P_{G2} = 4$

$2\ P_{G1} - 4P_{G2} = 400$

$P_{G1} - 2P_{G2} = 200$ …….(2)

Equation (1) – equation (2) give $3P_{G2} = 0$

$P_{G2} = 0$

But minimum loading on each generator given as 30 MW

So, P_{G2} must be set to 30 MW

$P_{G2} = 30$ MW

Then $P_{G1} = 200 - P_{G2}$

$\therefore P_{G1} = 170$ MW

122. In a 3-phase ac power transmission system using synchronous generation

(a) The steady state power limits of both round rotor and salient pole machines are reached at $\theta = \frac{\pi}{2}$ of their respective power angle characteristics.

(b) The steady state power limit of round rotor machines occurs at a much smaller angle θ as compared to that of salient pole machine power angle characteristic.

(c) The steady state power limit of salient pole machines occurs at smaller angle θ as compared to that of round rotor machine power angle characteristic.

(d) The transient state power limits of synchronous generators do not depend on initial load just before the large change in load or on 3-phase fault.

122. Ans: (c)

Sol: Steady state power limit occurs generally, for cylindrical rotor machine at θ = 90° for salient pole machine at θ < 90°. (where 'θ' is the power angle)

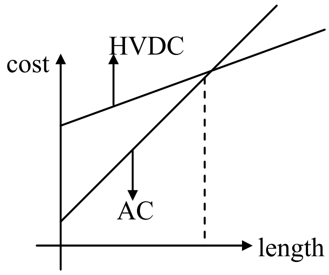
123. Bulk power transmission over long HVDC lines is preferred because of

(a) Low cost of HVDC terminal (b) No harmonic losses

(c) Minimum line power losses (d) Simple protection

123. Ans: (a)

Sol:



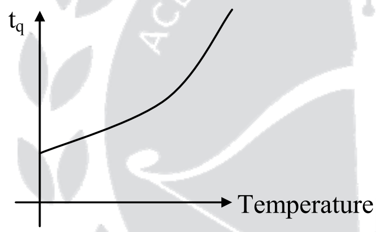
For long transmission of bulk power cost of HVDC system is less compared to AC system.

124. The turn-off time of a thyristor is 30 μs at 50°C. What is its turn-off time at 100°C ?

(a) 15 μs (b) 30 μs (c) 60 μs (d) 120 μs

124. Ans: (c)

Sol:



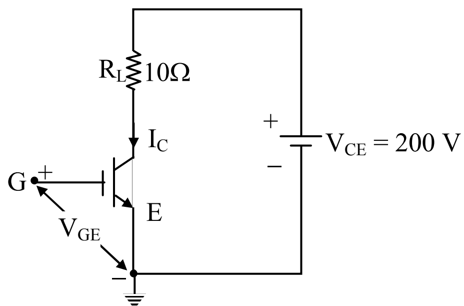
As temperature increases turn off time of thyristor increases but not linearly.

So turn off time of thyristor is more than 30 μs, but it is not 4 times at 100 °C

So 60 μs is more suitable turn off time at 100 °C.

125. The IGBT (Insulated Gate Bipolar Transistor) used in the circuit has the following data: t_{ON} = 3μs, t_{OFF} = 1.2 μs, Duty cycle (D) = 0.7, $V_{CE(sat)}$ = 2V and f_s =1 kHz.

What are the switching power losses during turn-on and turn-off, respectively?



(a) 1.98 W and 1.7 W (b) 2.2 W and 1.7 W

(c) 1.98 W and 0.792 W (d) 2.2 W and 0.792 W

125. Ans: (c)

Sol: $I_C = \dfrac{V_{CC} - V_{CE(sat)}}{R_L} = \dfrac{200-2}{10} = 19.8\text{ A}$

$$P_{on} = \frac{V_{CC} \times I_C}{6} \times t_{on} \times f_s$$

$$= \frac{200 \times 19.3}{6} \times 3\mu \times 1k = 1.98\text{ W}$$

$$P_{off} = \frac{V_{CC} \times I_C}{6} \times t_{off} \times f_s = 0.792\text{ W}$$

126. Consider the following statements with regard to a GTO:

1. The turn-off gain of the GTO is large.
2. Large negative gate current pulses are required to turn off the GTO.
3. GTO has large reverse blocking capability.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

126. Ans: (b)

Sol: GTO has poor turn off gain and large negative gate current pulses are required to turn off the GTO.

127. Consider the following statements with regard to power diodes:

1. The breakdown voltage is directly proportional to the doping density of the drift region.
2. Losses in the diode are less due to conductivity modulation of the drift region in the on-state.
3. The vertically oriented structure supports large blocking voltages.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

127. Ans: (b)

Sol: Power diodes and SCRs comes under minority carrier devices. In minority carrier devices a process called conductivity modulation phenomenon exist. Due to this process when the device enter into conduction state the ON state losses will be less.

128. A three-phase fully-controlled bridge converter is connected to a 415 V supply, having a source resistance of 0.3 Ω and inductance of 1.2 mH per phase. The converter is working in the inversion mode at a firing advance angel of 30°. What is the average generator voltage for the conditions: dc current I_d = 60 A, thyristor drop = 1.5 V and f = 50 Hz?

(a) 180 V (b) 210 V (c) 230 V (d) 240 V

128. Ans: *

Sol: $$\frac{3V_{ml}}{\pi}\cos(180° - \alpha) = -E + 2I_0r_s + 2 \times V_t + \frac{3\omega L_s}{\pi} I_0$$

$$\frac{3\times 415\sqrt{2}}{\pi}\cos 150° = -E + (2\times 60 \times 0.3) + (2 \times 1.5) + \frac{3\times 100\pi\times 1.2\times 10^{3}}{\pi} \times 60$$

E = 545.96 V

129. A large dc motor is required to control the speed of the blower from a 3-phae ac source. The suitable ac to dc converter is, 3-phase

(a) Fully controlled bridge converter

(b) Fully controlled bridge converter with freewheeling diode

(c) Half controlled bridge converter

(d) Converter pair in sequence control

129. Ans: (c)

Sol: For motoring operation half controlled bridge is suitable.

130. Consider the following statements:

1. The voltage developed across the OFF switches of the half bridge converter is the maximum dc link voltage.
2. In the full bridge converter, the voltage across the primary of the transformer is the dc link voltage.
3. The voltage developed across the OFF switches of the full bridge converter is half the maximum dc link voltage.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1 and 3 only

(c) 1 and 2 only (d) 2 and 3 only

130. Ans: (c)

Directions: Each of the next twenty (20) items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)

(c) Statement (I) is true but Statement (II) is false

(d) Statement (I) is false but Statement (II) is true

131. **Statement (I):** A superconductor is perfect diamagnetic material.

Statement (II): A superconductor is a perfect conductor.

131. Ans: (c)

132. **Statement (I):** Limiting factor of DC transmission is the high cost of conversion equipment.

Statement (II): Generation of harmonics is used for reactive power transfer only which has the ability to alter voltage levels.

132. Ans: (c)

133. **Statement (I):** A lattice defect gets created whenever the periodicity or order of the crystal lattice gets disturbed.

Statement (II): Point defect, line defect, surface defect and volume defect create defect in lattice.

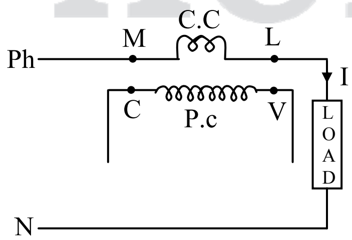
133. Ans: (a)

134. **Statement (I):** To measure power consumed by the load, it is necessary to interchange the pressure coil terminals when the pointer of a wattmeter kicks back.

Statement (II): The pressure coil terminals are interchanged to get upscale reading in a wattmeter without affecting the continuity of power to the load.

134. Ans: (a)

Sol: If load p.f < 0.5 lag, wattmeter pointer comes below zero reading but no readings below zero. So, to obtain either current coil (C.C) or pressure coil (P.C) terminals are reversed. But P.C terminals are preferred without affecting continuity of load.



135. **Statement (I):** An instrument manufactured as an ammeter should not be used as a voltmeter.

Statement (II): The high resistance winding of an ammeter will suffer serious damage if connected across a high voltage source.

135. Ans: (c)

Sol: When instrument manufactured as ammeter we can't use as voltmeter due to low resistance of ammeter, when connected in parallel draw high current & damages so, statement 'I' is correct.

Statement 'II' is wrong, because ammeter has low resistance.

136. **Statement (I):** Moving iron instruments are used in ac circuits only.

Statement (II): The deflecting torque in moving iron instruments depends on the square of the current.

136. Ans: (d)

Sol: → M.I can be used for both A.C & D.C, so statement 'I' is wrong.

→ in M.I, $T_d = \frac{1}{2} I^2 \frac{dL}{d\theta}$

$T_d \propto I^2$.

So, statement 'II' is correct.

137. **Statement (I):** PMMC instruments are suitable in aircraft and air space applications.

Statement (II): PMMC instruments use a core magnet which possesses self-shielding property.

137. Ans: (a)

138. **Statement (I):** A ballistic galvanometer is preferred as a detector in an AC bridge to measure inductance supplied by a source at power frequency.

Statement (II): An Ac bridge to measure inductance is balanced at the fundamental component.

138. Ans: (d)

Sol: Vibration galvanometers are used as a detector in an AC bridge for power and low audio frequency ranges.

The effective inductance and resistance vary with frequency so that a bridge balanced at fundamental frequency is never truly balanced for harmomics.

139. **Statement (I):** Phase lag network is used to increase stability as well as bandwidth of the system.

Statement (II): Phase lead network increases bandwidth of the system.

139. Ans: (d)

Sol: Phase lag network decrease the bandwidth.

Phase lead network increases the bandwidth.

140. **Statement (I):** The inductor is not used to fabricate a lag network as it produces time delay and hysteresis loss.

Statement (II): A capacitor cannot be used to fabricate a lag network.

140. Ans: (c)

Sol: Due to hysteresis loss, inductor cannot be used as a lag network. Capacitor network is used as a lag network.

141. **Statement (I):** Roots of closed-loop control systems can be obtained from the Bode plot.

Statement (II): Nyquist criterion does not give direct value of corner frequencies.

141. Ans: (d)

Sol: From the Bode plot, corner frequencies of the open loop transfer function can be obtained, but not the closed loop poles. Nyquist plot gives magnitude and phase of the open loop transfer function but not the corner frequency.

142. **Statement (I):** The IGBT makes use of the advantages of both powers MOSFET and BJT.

Statement (II): The IGBT has MOS input characteristic and bipolar output characteristic.

142. Ans: (a)

Sol: Advantage of MOSFET is less switching time and advantage of BJT is conduction loss is less.

In IGBT both switching time is less and conduction loss is less.

143. **Statement (I):** The power distribution system are 3-phase 4-wire circuits.

Statement (II): A neutral wire is necessary to supply single-phase loads of domestic and marginal commercial consumers.

143. Ans: (a)

144. **Statement (I):** The maximum torque of an introduction motor is independent of rotor resistance.

Statement (II): The slip at which the maximum torque occurs is directly proportional to rotor resistance.

144. Ans: (b)

Sol: $T_{max} = \frac{180}{2\pi N_s}\frac{E_{20}^2}{2x_{20}}$

$S_{Tmax} = \frac{R_2}{X_{20}}$;

$N_{Tmax} = N_s(1-\frac{R_2}{X_{20}})$

By adding additional resistance in the rotor circuit R_2/S_{Tmax} remains constant, hence rotor current and rotor input power at maximum torque conditions. Therefore maximum torque remains constant. But slip and speed at which maximum torque occurs depends on rotor resistance and they change.

145. **Statement (I):** A 3-phase induction motor is a self-starting machine.

Statement (II): A star-delta starter is used to produce starting torque for the induction motor.

145. Ans: (c)

Sol: A 3-phase induction motor is basically a self starting motor. But the purpose of starters for 3-ϕ IM is not for starting torque, but starters are required to limit high starting currents.

One of the starter is star-delta starters, which reduces the starting current drawn from the supply to 1/3 value compared to delta.

146. **Statement (I):** Leakage reactance of the lower cage in a double-squirrel-cage motor is considerably higher than that of the upper cage.

Statement (II): The lower cage has high permeance for leakage flux.

146. Ans: (a)

Sol: For rotor using squirrel cage bars, the change in resistance from a high value at starting to a low value at full load is accomplished by using

(a) Deep Bars

(b) Double cage

In each design the undergoing principle is to achieve a high rotor resistance at starting and a low rotor resistance at the rated speed. At starting the frequency of the rotor is the same as the frequency of the applied source. At full load, the rotor frequency is very low. Thus skin effect is more pronounced at starting than at full load.

The current induced in the rotor bar they produce a secondary magnetic field. Part of the secondary magnetic field links only rotor conductors and manifests itself as leakage flux and then increases as we move radially away from the air-gap towards shaft.

Owing to the high leakage reactance of the inner cage, the rotor current tend to flow in the outer cage at starting. Hence high starting torque.

147. **Statement (I):** Superconducting compounds and alloys must have components which are themselves superconducting.

Statement (II): Metals and compounds which are superconducting are rather bad conductors at ordinary temperatures.

147. Ans: (d)

Sol: When alloying a non-superconductor metal with a super conducting one, T_C may be increased. These findings established that super conductivity is a property of the solid and nor of the elements forming the solid.

The metals which are very good conductors at room temperature (eg) Cu, Ag and Au do not exhibit superconducting property, whereas metals and compounds such as oxides which are bad conductors exhibit super conductivity relatively higher temperature than normal conductors.

148. **Statement (I):** The relative dielectric constant of an insulator decreases with increase in the frequency of the applied alternating field.

Statement (II): With increase in frequency of the applied field, polarization process increases.

148. Ans: (c)

149. **Statement (I):** One series RC circuit and the other series RL circuit are connected in parallel across an ac supply. The circuit exhibits two resonances when L is variable.

Statement (II): The circuit has two values of L for which the imaginary part of the input admittance of the circuit is zero.

149. Ans: (a)

150. **Statement (I):** The power available from wind is directly proportional to V^3, where V is the velocity.

Statement (II): Drag type wind turbines have lower speeds and high torque capabilities.

150. Ans: (b)

Sol: Power available from wind turbine $\propto V^3$

This will be derived from basics of mechanics it self. This may be true for all types of turbines.

Drag type turbine: Its an example for this type of turbine is savonius turbine.

It is a vertical axis type wind turbine.

It will be used for lower wind speeds with high torque capabilities. This turbine (VAWT) will have low efficiency than HAWT.