# IES MASTER

Institute for Engineers (IES/GATE/PSUs)

# ESE 2017

## Prelims Exam Detailed Solution

ELECTRICAL ENGINEERING (SET–B)

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# Explanation of Electrical Engg. Prelims Paper (ESE - 2017)

## SET - B

**1.** 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

**Sol. (c)**

- In the Lissajous pattern on the CRO, if the ratio of the two frequencies is an integer, then the pattern will be stationary. If the ratio of frequencies is not an integer, then it does not give stationary pattern.
- The ratio of the two frequencies should not be such as to make the pattern too complicated, otherwise determination of frequency would become difficult.

**2.** "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

**Sol. (d)**

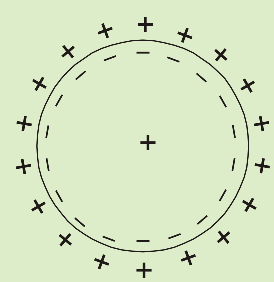
Gauss law states that "The net electric flux through any closed surface is equal to the net charge within that closed surface."

Electric flux $= \phi_E = \oint \vec{D}.\vec{ds} = Q_{enclosed}$

**3.** 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

**Sol. (b)**



The positively charged body will induce negative charge on the inner surface of the hollow sphere. As the sphere is neutral, equal amount of positive charge will appear on the outer surface so that net charge on the sphere is zero.

**4.** 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.

Which of the above statements are correct?

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

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

**Sol.** **(c)**

**5.** What is the octal equivalent of $(5621.125)_{10}$?

(a) 11774.010 (b) 12765.100

(c) 16572.100 (d) 17652.010

**Sol.** **(b)**

Octal equivalent of $(5621.125)_{10}$

For integer part

| | | |
|---|---|---|
| 8 | 5621 | |
| 8 | 702 | 5 |
| 8 | 87 | 6 |
| 8 | 10 | 7 |
| | 1 | 2 |

= 12765

For decimal part 0.125 × 8 = 1

Hence, $(5621.125)_{10} = (12765.100)_8$

**6.** What is the hexadecimal representation of $(657)_8$?

(a) 1 AF (b) D 78

(c) D 71 (d) 32 F

**Sol.** **(a)**

Given $(657)_8 = (1\underbrace{1010}\underbrace{1111})_2$

$= (1AF)_{16}$

**7.** 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

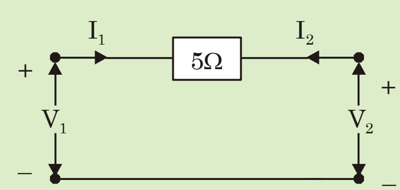
(c) Any eddy current loss and hysteresis loss, respectively

(d) The hysteresis loss and eddy current loss, respectively

**Sol.** **(b)**

- In potential transformer, the ratio error can be reduced by turn compensation. ie. by making the secondary turns increased slightly that required with rated ratio at one particular value and type of burden.
- Primary and secondary windings in potential transformer are wound as closely as possible to compensate for phase angle error.

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




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

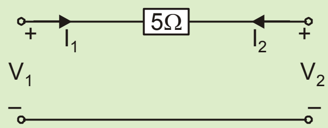
(b) $[y] = \begin{bmatrix} \frac{1}{5} & -\frac{1}{5} \\ -\frac{1}{5} & \frac{1}{5} \end{bmatrix} \mho$

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

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

**Sol. (b)**

Given two-part network is




The currents $I_1$ and $I_2$ can be expressed in terms of $V_1$ and $V_2$ as

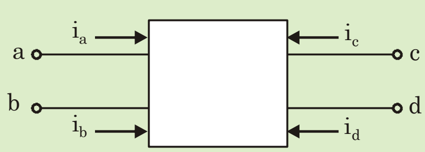
$$I_1 = \frac{V_1 - V_2}{5} = \frac{1}{5}V_1 - \frac{1}{5}V_2 \quad ..(i)$$

$$\text{and } I_2 = \frac{V_2 - V_1}{5} = -\frac{1}{5}V_1 + \frac{1}{5}V_2 \quad ...(ii)$$

Thus, admittance matrix of the given two - port

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

**9.** In the two-port network shown, which of the following is correct?

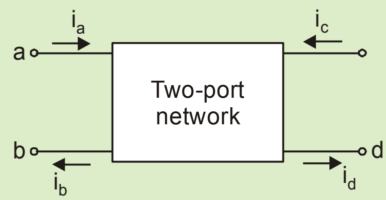



(a) $i_b = i_b$ (b) $i_1 = i_d$

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

**Sol. (c&d)**

Given, two-port network is




For a two-port network, the current entering to terminal 'a' of port 1 is same as the the current coming from terminal 'b' of port 1.

Similarly at port 2.

Thus,

$i_a = i_b$ and $i_c = i_d$

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

(a) 0.725 V (b) 0.752 V

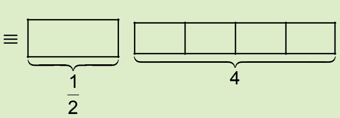
(c) 0.075 V (d) 0.0752 V

**Sol. (a)**

Number of full digit on a $4\frac{1}{2}$ digits display = 4

$\therefore$ Resolution $= \frac{1}{10^4} = 0.0001$

The resolution on 1V range = 1×0.0001 = 0.0001V

$4\frac{1}{2}$DVM ≡ 


$\because$ Range is 1V

$\therefore$ Decimal position in density will be

| 0 | | .7 | 5 | 2 | 5 |
|---|---|---|---|---|---|

Therefore on 1V range, any reading can be displayed to 4th decimal place.

Hence, on 1V range display will be 0.7525 V

**11.** Which of the following equations represent Gausss law adapted to a homogeneous isotropic medium?

1. $\oint_s \vec{D}.\vec{ds} = \oint_v \rho dv$
2. $\nabla \times \vec{H} = \vec{D}$
3. $\nabla.\vec{J} + \rho = 0$
4. $\nabla.\vec{E} = \frac{\rho}{\varepsilon}$
5. $\nabla^2.\varphi = 0$

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

**Sol. (a)**

Gauss law is given by :

$$\phi_E = \oint_S \vec{D}.\vec{ds} = Q_{enclosed}$$

If $\rho_v$ is charge per unit volume. Then, $Q_{enclosed}$

$$= \oint_v \rho_v dv$$

$$\therefore \oint \vec{D}.\vec{ds} = \oint \rho_v dv$$

Also, by divergence theorem, Gauss law for homegeneous isotropic medium can be written in differential form as :

$$\nabla.\vec{E} = \frac{\rho}{\epsilon_0}$$

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

1. These instruments possess 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

**Sol. (a)**

- MI type instruments possess high operating torque and can withstand overloads momentarily.
- It can be used for the measurement of AC and DC both quantities.
- For low voltage range measurement, the power consumption is higher.

**13.** A current of (10 + 5 sin $\omega$t + 3 sin 2$\omega$t) 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

**Sol. (c)**

Moving iron instrument indicates rms value.

Given, i(t) = $10 + 5\sin\omega t + 3\sin 2\omega t$

So, $I_{rms} = \sqrt{(10)^2 + \left(\frac{5}{\sqrt{2}}\right)^2 + \left(\frac{3}{\sqrt{2}}\right)^2}$

$$= \sqrt{100 + \frac{25}{2} + \frac{9}{2}}$$

$$= \sqrt{\frac{234}{2}} = \sqrt{117} = 10.81A$$

**14.** 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

**Sol. (c)**

Methods used for measurement of high resistances:

1. Direct deflection method
2. Loss of charge method
3. Megohm bridge method
4. Meggar

**15.** 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

**Sol. (c)**

- Induction type wattmeter can be used only in ac system.
- In induction type wattmeter, power consumption is relatively higher than electro-dynamo type wattmeter.
- It is accurate only at given frequency and temperature.

**16.** 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

**Sol. (c)**

Cache access time ($T_c$) = 10 nsec.
hit ratio = 80%
Average memory access time ($T_m$) = 20nsec.
Access time for physical memory $T_P = T + T_c$
$T_c \times$hit ratio + miss ratio × $(T_c+T)$ = 20
$10 \times 0.8 + (1-0.8) \times (10+T) = 20$
$8+2+0.2T = 20$
$0.2T = 10$

$$T = \frac{10}{2} \times 10 = 50$$

$T_p = 50 + T_c = 60$ nsec.

**17.** 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]

**Sol. (a)**

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

(a) 8 (b) 7

(c) 6 (d) 5

**Sol. (d)**

**19.** 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

**Sol. (c)**

A freewheeling diode does not allow reverse power flow from load to source and all the power is consumed in the load and hence it improves the line power factor.

**20.** Consider the following statements regarding electrical conductivity $\sigma$:

1. It increases with temperature in semiconductors.
2. Its increase with temperature is exponential.
3. It increases in metals 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

**Sol. (a)**

As temperature increases in semiconductor, the conductivity starts to increase and this increase in conductivity is exponential. But for metals and its alloys, as temperature increases its resistivity starts to increase hence we say conductivity decreases.

**21.** What is the effect on the natural frequency ($\omega_n$) and damping factor ($\delta$) in the control systems when derivative compensation is used?

(a) $\omega_n$ increases and $\delta$ decreases
(b) $\omega_n$ remains unchanged and $\delta$ increases
(c) $\omega_n$ remains unchanged and $\delta$ decreases
(d) $\omega_n$ decreases and $\delta$ increases

**Sol. (b)**

Derivative compensation is phase lead compensation so damping factor ($\delta$) increases $\omega_n$ (natural frequency) remains unchanged.

**22.** Consider the following components in a multi-state 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 freqencies?

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

**Sol. (c)**

In multi-stage R-C coupled amplifier, parasitic capacitance of transistor, wiring capacitance and stray capacitance effectively control the high frequencies.

**23.** 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

**Sol. (a)**

Wien bridge oscillator is suitable for audio frequency applications.

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

(a) $\beta > 6n$

(b) $\beta > 29$

(c) $\beta > 4n + 23 + \frac{29}{n}$

(d) $\beta > 23 + \frac{29}{n}$

where, $n = \frac{R_d}{n}$.

**Sol. (c)**

The condition for sustained oscillation is

$$\beta > 4n + 23 + \frac{29}{n}$$

**25.** A tuned-collector oscillator has a fixed inductance of 100 $\mu$H 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 $\mu$F (d) 119 – 1021 $\mu$F

**Sol. (b)**

$$f = \frac{1}{2\pi\sqrt{LC}}$$

or $$C = \frac{1}{4\pi^2 L f^2}$$

at 1500 KHz,

$$C_1 = \frac{1}{4\times 100\times 10^{-6}\times (15\times 10^5)^2\times \pi^2}$$

$$= \frac{10^6}{900\pi^2}$$

$$= 112.58\times 10^{-12}\text{ F}$$

at 500 KHz,

$$C_2 = \frac{1}{4\pi^2\times 100\times 10^{-6}\times (5\times 10^5)^2}$$

$$= \frac{10^{-6}}{100\pi^2}$$

$$= 1013.21\times 10^{-12}\text{ F}$$

**26.** The logical expression, $AB\bar{C} + A\bar{B}C + A\bar{B}\bar{C}$

(a) $\bar{A}(B+C)$ (b) $\bar{A}+\bar{B}+\bar{C}$

(c) $\bar{A}\bar{B}\bar{C}$ (d) $A(\bar{C}+\bar{B})$

**Sol. (d)**

$y = AB\bar{C} + A\bar{B}C + A\bar{B}\bar{C}$

Using k-map,

| A \ BC | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | | | | |
| 1 | 1 | 1 | | 1 |

$y = A\bar{B} + A\bar{C}$

$= A(\bar{B}+\bar{C})$

**27.** 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

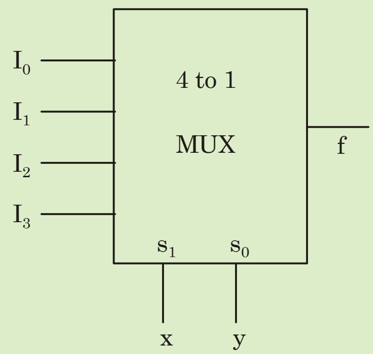
**Sol. (d)**

For R – 2R ladder DAC, analog output

$V_0 = \frac{V_{ref}}{2^n - 1}$ × (Decimal equivalent of input degital signal)

$$= \frac{5}{2^4-1}\times 8 = \frac{5}{15}\times 8 = 2.667\text{V}$$

**28.** Which logic inputs should be given to 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

**Sol. (b)**

Output of given MUX

$$f = I_0\bar{S}_1\bar{S}_0 + I_1\bar{S}_1S_0 + I_2S_1\bar{S}_0 + I_3S_1S_0$$

$$= I_0\bar{x}\,\bar{y} + I_1\bar{x}y + I_2x\bar{y} + I_3xy \quad \text{...(i)}$$

To behave as XNOR gate f = $xy + \bar{x}\,\bar{y}$ ...(ii)

Equating (i) & (ii) $I_0$ = 1, $I_1$ = 0, $I_2$ = 0, $I_3$ = 1

**29.** 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

**Sol. (c)**

Condition for Existence of Fourier series

**Condition (1).** x(t) must be absolutely integrable over one time period.

$$\int_T |x(t)| dt < \infty$$

**Condition (2).** x(t) has finite number of maxima and minima over one time period.

**Condition (3).** x(t) has finite number of discontinuity over one time period.

**30.** Which one of the following statements is correct?

LTI system is causal

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

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

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

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

**Sol. (c)**

A LTI system is causal iff

h(t) = 0 $t < 0 \rightarrow$ for continuous time

h(n) = 0 n < 0 $\rightarrow$ for discrete time

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

1. If 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 operration in both time and frequency domains.

Which of the above statements is/are correct?

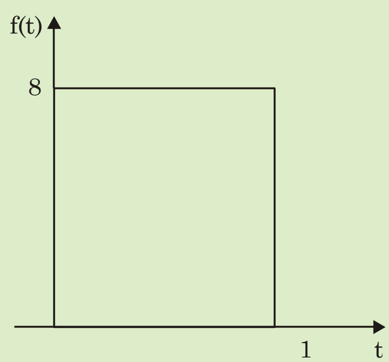
(a) 1 and 2 only (b) 2 and 3 only

(c) 1 only (d) 3 only

**Sol. (b)**

Discrete Fourier Transform (DFT) is obtained by performing sampling operation in both time and frequency domain and in DTFT, sampling is performed only in time domain. In DFT there is discrete frequency spectrum (discrete function of $\omega$) and in DTFT, there is a continuous frequency spectrum (condition function of $\omega$)

**32.** The laplace transform of the below function is




(a) $F(s) = 8s\,(1 - e^{-s})$

(b) $F(s) = \dfrac{8}{s}\left(1+e^{-s}\right)$

(c) $F(s) = 8s\,(1 + e^{-s})$

(d) $F(s) = \dfrac{8}{s}\left(1-e^{-s}\right)$

**Sol. (d)**

Given function can be written as

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

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

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

(a) $N(N-1)$ and $N^2$

(b) $N(N+1)$ and $N^2$

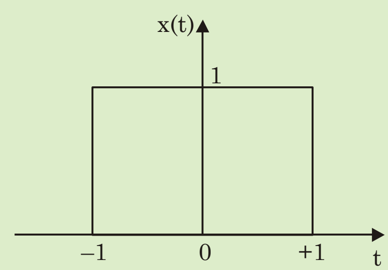
(c) $N(N+1)^2$ and N

(d) N and $N^2$

**Sol. (a)**

In DFT $N(N-1)$ complex addition and $N^2$ complex multiplication.

**34.** The laplace transform of the below function is




(a) $\omega \sin \omega$ (b) $\dfrac{2\sin\omega}{\omega}$

(c) $\dfrac{\omega}{\sin\omega}$ (d) $\dfrac{\cos\omega}{2\omega}$

**Sol. (b)**

Given function is $f(t) = \begin{cases} 1, & -1 \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$

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

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

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

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

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

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

**35.** The number of complex additions and multiplications in GFT 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 $\frac{N}{2}\log_2 N$

**Sol.** **(b)**

The number of complex addition is N $\log_2$N and number of complex multiplication is N/2 $\log_2$N.

**36.** 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 of the above is positive real?

(a) $Z_1$ (b) $Z_2$

(c) $Z_3$ (d) $Z_4$

**Sol.** **(a, c & d)**

To check f(s) is positive Real function (PRF)

$$F(s) = \frac{P(s)}{Q(s)} = \frac{\text{Numnator Polynomial}}{\text{Denominator Polynomial}}$$

(i) P(s) must be Hurnitz

(ii) Q(s) must be Hurnitz

(iii) Re[F(s)] $\geq 0$ for Re[s] $\geq 0$

$$F(s) = \frac{P(s)}{Q(s)} = \frac{M_1(s)+N_1(s)}{M_2(s)+N_2(s)} = \frac{M_1+N_1}{M_2+N_2}$$

$M_1 \rightarrow$ even part of numerator polynomial

$M_2 \rightarrow$ even part of denominator polynomial

$N_1 \rightarrow$ odd part of numerator polynomial

$N_2 \rightarrow$ odd part of denominator polynomial

Re [s] $\geq 0$ for s = $j\omega$

$$\frac{M_1M_2 - N_1N_2}{M_2^2 - N_2^2} \geq 0$$

$$M_1\ M_2 - N_1\ N_2 \geq 0$$

**Ex.** $$F(s) = \frac{s+a}{s^2+bs+c} = \frac{P(s)}{Q(s)}$$

P(s) = s+a $\boxed{a \geq 0}$ for P(s) to be Hurwitz

Q(s) = $s^2$+bs+c $\boxed{b, c \geq 0}$ for Q(s) to be Hurwitz

$M_1\ M_2 - N_1N_2 \geq 0$ for s = $j\omega$

$M_1 = a \quad N_1 = s$

$M_2 = s^2 + c \quad N_2 = bs$

$M_1 M_2 - N_1 N_2 \geq 0$

$a(s^2 + c) - bs^2 \geq 0$

$a\left(j^2\omega^2 + c\right) - bj^2\omega^2 \geq 0$

$\omega^2 \underbrace{(b-a)}_{\geq 0} + \underbrace{ac}_{\geq 0} \geq 0$

$b - a \geq 0$

$b \geq a$

$\boxed{\begin{matrix} a, b, c \geq 0 \\ b \geq a \end{matrix}} \Rightarrow$ Condition for F(s) to be P.R.F

(i) $Z_1(s) = \dfrac{s+2}{s^2+3s+5} = \dfrac{s+a}{s^2+bs+c}$

$a = 2, \; b = 3, \; c = 5$

$\boxed{\begin{matrix} a, b, c > 0 \\ b > a \end{matrix}} \Rightarrow Z_1(s)$ is P.R.F.

(ii) $Z_2(s) = \dfrac{s+2}{s^2+5} = \dfrac{s+a}{s^2+bs+c}$

$a = 2, \; b = 0, \; c = 5$

$a, b, c \geq 0$

$b < a$

Therefore $Z_2(s)$ is not P.R.F.

(iii) $Z_3(s) = \dfrac{s+2}{s^2+2s+1} = \dfrac{s+a}{s^2+bs+c}$

$a = 2, \; b = 2, \; c = 1$

$a, b, c \geq 0$

$b = a$

$Z_3(s)$ is P.R.F.

(iv) $Z_4(s) = \dfrac{(s+2)(s+4)}{(s+1)(s+3)} = \dfrac{s^2+6s+8}{s^2+4s+3}$

$M_1 = s^2 + 8, \quad N_1 = 6s$

$M_2 = s^2 + 3, \quad N_2 = 4s$

$M_1M_2 - N_1 N_2 \geq 0$

$(s^2 + 8)(s^2 + 3) - 6s \, 4s \geq 0$

$(s^4 + 11s^2 + 24) - 24 s^2 \geq 0$

$s^4 - 13s^2 + 24 \geq 0$

$\omega^4 + 13\omega^2 + 24 \geq 0$

$Z_4(s)$ is P.R.F.

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

The system is

(a) Stable

(b) Unstable

(c) Conditionally stable

(d) Critically stable

**Sol. (a)**

The characteristic equation of given system is

$s^3 + 8s^2 + 19s + 12 = 0$

Routh table is

| | | |
|---|---|---|
| $s^3$ | 1 | 19 |
| $s^2$ | 8 | 12 |
| $s^1$ | 17.5 | 0 |
| $s^0$ | 12 | |

No sign change in the first column. Hence, system is stable.

**38.** 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

**Sol. (b)**

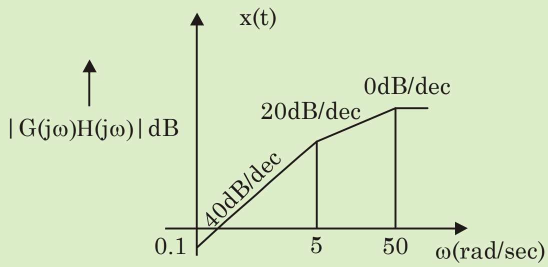
The slope of highest frequency asymptote

= (Z – P) × 20 dB/dec

= (2 – 14) × 20

= –240 dB/dec

**39.** The open-loop transfer function for the Bode's magnitude plot is




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

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

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

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

**Sol. (c)**

The initial slope of the plot is 40 dB/dec. Hence it has two zeroes at origin

at ω = 5 rad/sec, slope of the plot changes by –20 db/dec, hence the corresponding term of the transfer function is

$$\frac{1}{\left(\frac{s}{5}+1\right)} \quad \text{or} \quad \frac{1}{(0.2s+1)}$$

At ω = 50 rad/sec, slope of the plot again changes by –20 dB/dec., Hence the corresponding terms of the transfer function is $\dfrac{1}{\left(\frac{s}{5}+1\right)}$ or $\dfrac{1}{(0.02s+1)}$

Hence, the open-loop transfer function of the given system is

$$G(s)H(s) = \frac{Ks^2}{\left(\frac{s}{5}+1\right)\left(\frac{s}{50}+1\right)}$$

$$= \frac{K's^2}{(s+5)(s+50)}$$

**40.** 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

**Sol. (a)**

All the elements of a row in Routh's tabulation being zero indicate a pair of conjugate root on imaginary axis. i.e. system has symmetrically located roots.

**41.** A linear time-invariant control system with unsatisfactory steady stae error is to be compensated. Which is/are the 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 only

**Sol.** **(b)**

The steady state error can be reduced by lag compensator.

**42.** 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

**Sol.** **(b)**

The two corner frequencies of lead network are

$$\omega_1 = \frac{1}{0.04} \text{ and } \omega_2 = \frac{1}{0.01}$$

or, $\omega_1 = 25$ and $\omega_2 = 100$

The maximum phase-lead occurs at mid-frequency

$$\omega_m = \sqrt{\omega_1\omega_2} = \sqrt{25\times100} = \sqrt{2500} = 50\text{rad/sec.}$$

**43.** 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) $G(s)H(s) = \frac{5K}{s(s+1)(s+2)}$

**Sol.** **(c)**

The given characteristic equation is

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

or $$s^3+3s^2+2s+K(s+5) = 0$$

or $$1+\frac{K(s+5)}{s^3+3s^2+2s} = 0$$

or $$1+\frac{K(s+5)}{s(s+1)(s+2)} = 0$$

$$\therefore \quad G(s)H(s) = \frac{K(s+5)}{s(s+1)(s+2)}$$

**44.** 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

**Sol.** **(c)**

A system with negative damping coefficient is dynamically unstable. So, the system response will be oscillations with increasing magnitude.

**45.** A dynamic system is described by the following equations: $X = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$ 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) $\frac{Y(s)}{u(s)} = \frac{s}{s^2+3s+1}$

**Sol. (b)**

Given

$$[A]=\begin{bmatrix}0 & 1\\ -3 & -4\end{bmatrix},\ [B]=\begin{bmatrix}0\\1\end{bmatrix} \text{ and } [C]=[10\quad 0]$$

$$[sI-A] = \begin{bmatrix}s & -1\\ 3 & s+4\end{bmatrix}$$

$$[sI-A]^{-1} = \frac{1}{s(s+4)+3}\begin{bmatrix}s+4 & 1\\ -3 & s\end{bmatrix}$$

$$[C][sI-A]^{-1} = \frac{1}{s^2+4s+3}[10\quad 0]\begin{bmatrix}s+4 & 1\\ -3 & s\end{bmatrix}$$

$$= \frac{1}{s^2+4s+3}[10(s+4)\quad 10]$$

$$[C][sI-A]^{-1}[B] = \frac{1}{s^2+4s+3}[10(s+4)\quad 10]\begin{bmatrix}0\\1\end{bmatrix}$$

$$= \frac{10}{s^2+4s+3}$$

**46.** 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

**Sol. (b)**

From statement 2.

Output of controller = $\dfrac{Kde(t)}{dt}$

From statement 4, K is positive.

From statement 3, if $\dfrac{de(t)}{dt} = 1\%$ then

Change in output of controller is $|K|\%$.

Hence the mode of controller is derivative controller.

**47.** A 1000V/400vV 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 16 V 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.

**Sol. (c)**

Given transformer voltage ratio = 1000/400

and short circuit voltage (Nominal) = 40%

i.e., the primary terminal voltage

= 0.4 × 100 = 400 V.

the secondary terminal voltage

= 0.4 × 400 = 160 V.

Short circuit voltage is the amount of voltage required to be applied to the transformer in order to allow the rated transformer current to flow through the transformer hence answer is option (c).

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

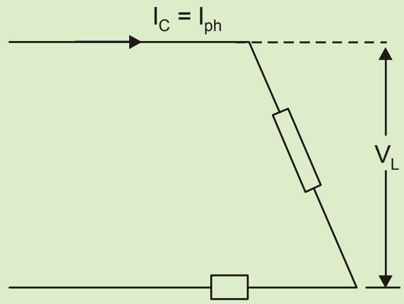
1. Being a temporary remedy when one transformer forms of Delta-Delta system is damaged, and removed from service.
2. The Volt Ampere (VA) suplied by each transformer is half of the total VA, and the system is not overloaded.
3. An important precaution is that load shall be reduced by $\sqrt{3}$ times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

**Sol. (d)**

In open delta connection of transformer




Total power supplied by two phases =

$\sqrt{3}\,V\,I_{ph} = \sqrt{3}\,V_{ph}\,I_{ph}$

Total power supplied in $\Delta-\Delta$ connection =

$\sqrt{3}\,V_L I_L = 3\,V_{ph} I_{ph}$

$$\therefore \quad \frac{\text{Power}\,(V-V)}{\text{power}\,(\Delta-\Delta)} = \frac{\sqrt{3}\,V_{ph} I_{ph}}{3\,V_{ph} I_{ph}} = \frac{1}{3}$$

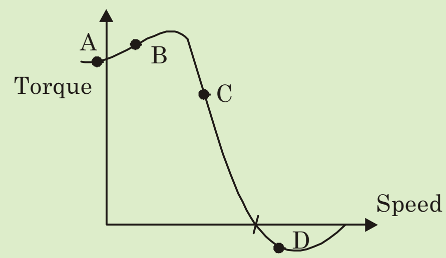
Power (V – V) = 57.7% (Power $\Delta$-$\Delta$)

Hence statement – 3 is true

- It is temporary remedy when one transformer forms of Delta-Delta system is damaged, removed from service hence statement -I is true.

- VA supplied by each transformer is $\frac{\sqrt{3}\,V_{ph} I_{ph}}{2} = 86.6\%$ i.e. half of 1.73 (Power of $\Delta$-$\Delta$) hence statement – 2

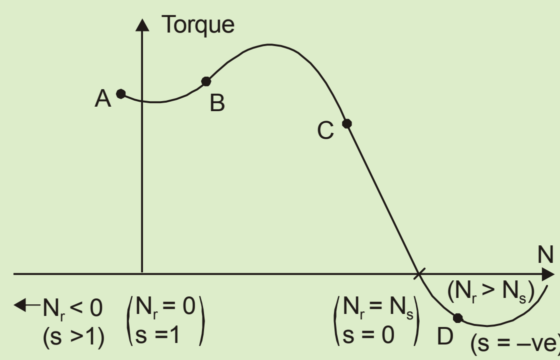
**49.** On the Torque/Speed curve of an induction motor shown in the figure, four points of operation are marked as A, B, C and D.




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

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

**Sol. (a)**




**50.** 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 $\delta$ is

(a) 9.5°  (b) 12.5°
(c) 25.5°  (d) 30°

**Sol. (b)**

Given that

$N_1$ = 1200 Rpm, $f_1$ = 60 Hz, $T_1$ = 398N-m

$N_2$ = ?, $f_2$ = 36 Hz

$$N_2 = \frac{120\times36}{6} = 720 \text{ rpm}$$

$$T \propto N^2, \quad T \propto \sin\delta$$

$$\frac{T_1}{T_2} = \frac{N_1^2}{N_2^2}$$

$$\frac{T_1}{T_2} = \left(\frac{1200}{720}\right)^2$$

$$T_2 = \left(\frac{720}{1200}\right)^2 \times 398$$

$T_2$ = 143.28 N-m

$$\text{We know, } T_1 = \frac{P_1\times60}{2\pi N_1}$$

$$P_1 = \frac{2\pi N_1}{60}\times T_1 = 50.014 \text{ kW}$$

$$\text{We know, } P_1 = \frac{V_sV_R}{x}\sin\delta_1 \quad (\because V_s = V_R)$$

$$= \frac{V^2}{X}\sin\delta_1$$

$$50.014\times10^3 = \frac{(460)^2}{2.5}\sin\delta_1$$

$$\sin\delta_1 = \frac{2.5\times50.014\times10^3}{(460)^2}$$

$$\sin\delta_1 = 0.590$$

$$\therefore \frac{T_1}{T_2} = \frac{\sin\delta_1}{\sin\delta_2}$$

$$\frac{398}{143.28} = \frac{0.590}{\sin\delta_2}$$

$$\sin\delta_2 = 0.590\times\frac{143.28}{398}$$

$$\sin\delta_2 = 0.2127$$

$$\delta_2 = \sin^{-1}(0.2127)$$

$$= 12.28°$$

$$\delta \approx 12.5°$$

**51.** 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

**Sol. (c)**

Capability curve: of a synchronous generator defines a boundary with in which the machine can operate safely. It is also known as operating charts (or) capability charts.

1. The MVA loading should not exceed the generator rating hence statement-1 is true

2. The field current should not be allowed to exceed a specified value determined by the heating of the field hence statement-2 is true

3. The MW loading should not exceed the rating of the prime mover hence statement-3 is true

4. For steady state (or) stable operation the load angle $\delta < 90°$ hence statement-4 is false

**52.** 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

**Sol. (b)**

Given data of synchronous motor

$$P = 12 \text{ Pole}$$

$$V_L = 440 \text{ V}$$

$$f = 50 \text{ Hz}$$

$$I_L = 100 \text{ A}$$

$\text{Cos}\,\phi = 0.8$ p.f. leading

$$P = \sqrt{3}\, V_L I_L \cos\phi \quad (3\text{-}\phi \text{ power})$$

$$= \sqrt{3} \times 440 \times 100 \times 0.8$$

$$= 60.968 \text{ kW}$$

As $$P = \frac{2\pi NT}{60} \text{ (neglecting losses)}$$

$\because$ $$N = \frac{120f}{P}$$

$$= 500 \text{ rpm}$$

$$T = \frac{P \times 60}{2\pi N}$$

$$= \frac{60.968 \times 10^3 \times 60}{2\pi \times 500}$$

$$= 1164.40 \text{ Nm}$$

$\approx$ 1165 Nm (rounding off to nearest decimal)

**53.** 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. Salinet pole alternators run at speeds slower than cylindrical rotor machines.

Which of the above statements rotor machines.

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

**Sol. (b)**

1. Salient pole alternators have large diameter and small axdial length hence **statement 1 is false.**
2. Cylindrical rotor alternators have distributed winding **statement 2 is true.**
3. Cylindrical rotor alternators are wound for less no of poloes as they run at higher speeds.

$\left(\uparrow N \propto \frac{1}{P\downarrow}\right)$. Hence **Statement 3 is false.**

4. Salient pole alternators runs at speed lower than cylindrical rotor machines because of **large diameter and large no of poles**

$\left(\downarrow N \propto \frac{1}{P\uparrow}\right)$ hence **statement 4 is true.**

**54.** 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°

**Sol. (b)**

Given

$$N_s = 8, \quad N_r = 6$$

Then step angle $(\beta) = \dfrac{(N_s - N_r)}{N_s \cdot N_r} \times 360°$

$$= \frac{(8-6)}{8 \times 6} \times 360$$

$$= \frac{2}{48} \times 360° = \frac{1}{24} \times 360$$

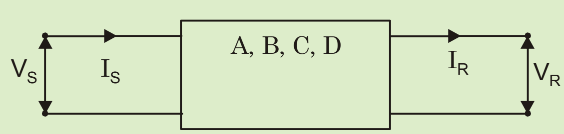
$$\beta = 15°$$

**55.** 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

$$V_S = AV_R + B\,I_R$$

$$I_S = CV_R + D\,I_R$$

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

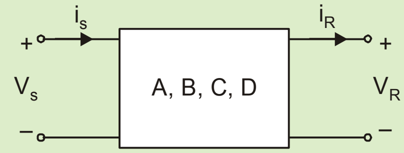



The condition for symmetry for the network is

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

**Sol. (b)**

Transmission line is represented as a two-port netwrok, is shown below:




Symmetry condition for a two-port network in terms of transmission parameters is given as

$$A = D$$

**56.** 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

**Sol. (c)**

A power system has two generators having powers $P_1$ and $P_2$

Given $P_1 = 50\,(50\text{-}f)$

$P_2 = 100\,(51\text{-}f)$

Total power P = 800 MW

i.e., $P_1 + P_2 = P$

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

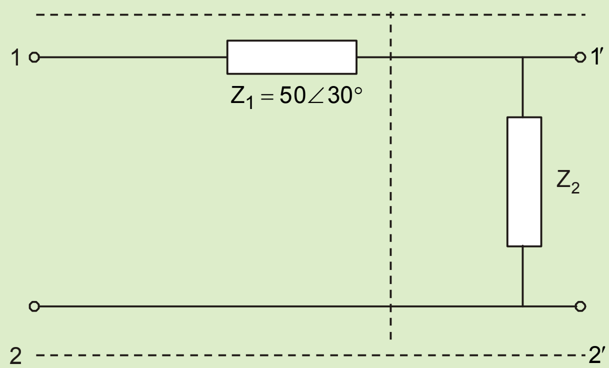
$2500 - 50f + 5100 - 100f = 800$

$7600 - 800 = 150f$

$6800 = 150f$

$f = \dfrac{6800}{150} = 45.33$ Hz

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

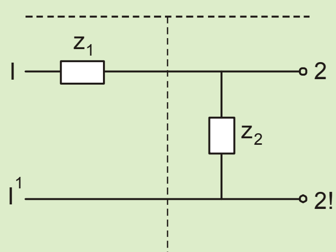



What is the value of $Z_2$?

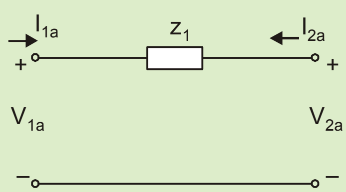
(a) $500\angle -60°$ (b) 0.10 j

(c) – 10 j (d) $50\angle -60°$

**Sol.** **(c)**




$N_a$




$V_{1a} = A_aV_{2a} - B_aI_{2a}$

$I_{1a} = C_aV_{2a} - D_aI_{2a}$

$A_a = \left.\dfrac{V_{1a}}{V_{2a}}\right|_{I_{2a}=0}, B_a = \left.\dfrac{V_{1a}}{-I_{2a}}\right|_{V_{2a}=0}$

$C_a = \left.\dfrac{I_{1a}}{V_{2a}}\right|_{I_{2a}=0},$

$D_a = \left.\dfrac{I_{1a}}{-I_{2a}}\right|_{V_{2a}=0}$

From network k $N_a$.

$V_{2a} - V_{1a} = I_{2a} Z_1$

$V_{1a} = V_{2a} - Z_1I_{2a}$ ...(i)

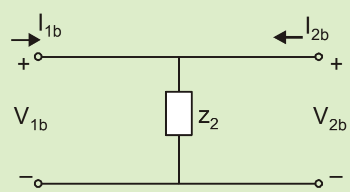
$I_{1a} = -I_{2a}$ ...(ii)

$A_a = 1, \quad B_a = Z_1$

$C_a = 0, \quad D_a = 1$

$$\begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} = \begin{bmatrix} 1 & Z_1 \\ 0 & 1 \end{bmatrix}$$

$N_b$




$V_{1b} = V_{2b}$ ...(i)

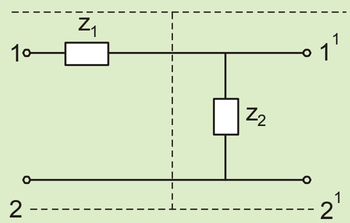
$I_{1b} + I_{2b} = \dfrac{V_{2b}}{Z_2}$

$I_{1b} = \dfrac{V_{2b}}{Z_2} - I_{2b}$ ...(ii)

$A_b = 1, B_b = 0, C_b = \dfrac{1}{Z_2}, D_b = 1$

$$\begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \frac{1}{Z_2} & 1 \end{bmatrix}$$

When Network $N_a$ & $N_b$ are cascaded




ABCD parameters of the equivalent network

$$\begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix}\begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

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

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

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

$$0.1\underline{|90^\circ} = \frac{1}{Z_2}$$

$$Z_2 = \frac{1}{0.1\underline{|90^\circ}}$$

$$Z_2 = 10\underline{|-90^\circ} = 10\left[\cos(-90^\circ)+j\sin(-50^\circ)\right]$$

$$Z_2 = -10\,j$$

**58.** Which one of the following does not have an effect on corona?

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

**Sol. (d)**

We know corona loss

$$P = 241\times10^{-5}\frac{(f+25)}{\delta}\sqrt{\frac{r}{d}}\left(V_P-V_d\right)^2 \text{ kw/km/phase.}$$

It depends on
(a) radius of conductor (r)
(b) line voltage (v)
(c) spacing between the conductors (d)

**59.** Consider the following statements regarding corona:

1. It causes radio interference
2. It attenuatres 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

**Sol. (c)**

Corona causes :
(i) radio interference
(ii) power loss
(iii) It reduces the magnitude of lightning (&) switching
(iv) It is also more prevalent in the middle conductor in a flat conductor configuration.

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

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

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

**Sol.** **(a)**

$P_L = B_{11} P_1^2 + 2B_{12} P_1 P_2 + B_{22} P_2^2$ (loss equation)

Given $B_{12} = B_{21} = -0.0001\ MW^{-1}$

$B_{11} = 0.0010\ MW^{-1}$

$B_{11} = 0.0010\ MW^{-1}$

$P_1 = 150MW$ $P_2 = 275\ MW$

$P_L = (0.001)\ P_1^2 + 2\,(-0.0001)\ P_1P_2 + (0.0013)P_2^2$

$\frac{\partial P_L}{\partial P_1} = 2\ (0.001)P_1 + 2\ (-0.0001)\ P_2$

= 2 (0.001) (150) + 2 (– 0.0001) (275)

= 0.245

Penality factor = $\frac{1}{\left(1-\frac{\partial P_L}{\partial P_1}\right)}$

$= \frac{1}{(1-0.245)}$

$= \frac{1}{0.755}$

= 1.3245 = 1.324

**61.** If a square matrix of order 100 has exactly 15 distinct eigenvalues, then the degree of the minimum polynomial is

(a) At least 15 (b) At most 15

(c) Always 15 (d) Exactly 100

**Sol.** **(a)**

By property of "minimal property". If matrix has 15 distinct Eigen values, then its minimal polynomial must be of at least 15 degree.

**62.** 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) $\sqrt{1+x^2} + \sqrt{1+y^2} = c$

**Ans.** **(c)**

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

Using variable separable,

$$\frac{y.dy}{\sqrt{1-y^2}} = -\frac{xdx}{\sqrt{1-x^2}}$$

On integrating, $\int \frac{ydy}{\sqrt{1-y^2}} = -\int \frac{xdx}{\sqrt{1-x^2}}$

Put $1 - y^2 = u^2$ and $1 - x^2 = v^2$

i.e., ydy = –udy and xdx = –vdv

so, $\int -\frac{udu}{u} = -\int -\frac{vdv}{v}$

$\Rightarrow \quad u = v + c$

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

or $\quad \sqrt{1-x^2} + \sqrt{1-y^2} = c$

**63.** The general solution of the differential equation

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

(a) $y = (c_1 - c_2 x) e^x + c_3 \cos x + c_4 \sin x$

(b) $y = (c_1 + c_2 x) e^x - c_3 \cos x + c_4 \sin x$

(c) $y = (c_1 + c_2 x) e^x + c_3 \cos x + c_4 \sin x$

(d) $y = (c_1 + c_2 x) e^x + c_3 \cos x - c_4 \sin x$

**Sol. (c)**

Given DE is $y^{iv}(x) - 2y^{iii}(x) + 2y^{ii}(x) - 2y^{i}(x) + y = 0$

or $\quad [D^4 - 2D^3 + 2D^2 - 2D + 1]y = 0 \quad \ldots$(i)

A.E. is $\quad m^4 - 2m^3 + 2m^2 - 2m + 1 = 0$

$(m - 1)^2 (m^2 + 1) = 0$

$m = 1, 1, \pm i$

so, $\quad CF = (C_1 + C_2x)e^x + C_3\cos x + C_4\sin x$

$PI = 0$

Hence solutions is $y = CF + PI = (C_1 + C_2x)e^x + C_3\cos x + C_4\sin x$

**64.** 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) $\frac{(-1)^2 2n}{n^2 - 1}$

**Sol. (b)**

$f(x) = x\cos x$ in $(-\pi, \pi)$

$\because \quad f(-x) = (-x)\cos(-x) = -x\cos x = -f(x)$

so $f(x)$ is an odd function

Now using Fourier series.

$$a_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx = 0 \quad (\because f(x) \text{ is an odd})$$

**65.** The Fourier series expansion of the saw-toothed waveform

$f(x) = x$ in $(-\pi, \pi)$ of period $2\pi$ gives the series,

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{4} + \ldots$$

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

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

**Sol. (d)**

$f(x) = x$, $(-\pi, \pi)$ it is again an odd function.

$$a_0 = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)dx = 0, \quad a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx dx = 0$$

$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin nx dx = \frac{1}{\pi}\int_{-\pi}^{\pi} x\sin nx dx = \frac{2(-1)^{n+1}}{n}$$

Hence Fourier series is, $f(x) =$

$$\frac{a_0}{2} + \Sigma a_n \cos nx + \Sigma b_n \sin nx$$

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

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

Put $x = \frac{\pi}{2}$, $\frac{\pi}{2} = 2\left[1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + .....\right]$

So, $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + ..... = \frac{\pi}{4}$

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

(a) 1 (b) –1
(c) 2 (d) **–2**

**Sol. (a)**

Let $\phi = 2x - x^2 + my^2$

Any function is HARMONIC if it satisfies Laplace equation.

i.e., $\phi_{xx} + \phi_{yy} = 0$

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$$

$$\frac{\partial}{\partial x}(2 - 2x) + \frac{\partial}{\partial y}(2my) = 0$$

$-2 + 2m = 0 \Rightarrow m = 1$

**67.** Evlauate

$\int \frac{dz}{z\sin z}$, where c is $x^2 + y^2 = 1$

(a) 1 (b) 2
(c) 0 (d) –1

**Sol. (c)**

$f(z) = \frac{1}{z\sin z} \Rightarrow$, c : |z| = 1

Poles of f(z) are zsinz = 0

z = 0 and sinz = 0

z = 0 and z = $n\pi$, $n \in I$

z = 0 and z = ..... $-2\pi, -\pi, 0, \pi, 2\pi$,.....

so z = 0 (double pole) lies inside c.

$$R = \underset{(z=0)}{\operatorname{Res}} f(z) = \frac{1}{(2-1!)}\left[\frac{d}{dz}(z-0)^2 f(z)\right]_{z=0}$$

$$= \left[\frac{d}{dz}\left(\frac{z}{\sin z}\right)\right]_{z=0}$$

= 0

so by Cauchy residue theorem,

$$\int_c f(z)dz$$

= $2\pi i$ [sum of residue inside c]

= $2\pi i[0]$

= 0

**68.** 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

**Sol. (c)**

$f(z) = \frac{2z}{(z-1)^2(z-2)}$,

poles are z = 2 (simple pole) and z = 1 (double pole)

$$R_1 = \underset{(z=2)}{\operatorname{Res}} f(z) = \lim_{z\to 2}(z-2)f(z) = \lim_{z\to 2}\left[\frac{2z}{(z-1)^2}\right] = 4$$

$$R_2 = \underset{(z=1)}{\operatorname{Res}} f(z) = \frac{1}{(2-1!)}\left[\frac{d}{dz}(z-1)^2 f(z)\right]_{z=1}$$

$$= \left[\frac{d}{dz}\left(\frac{2z}{z-2}\right)\right]_{z=1} = -4$$

Hence required sum = $R_1 + R_2 = 0$

**69.** 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) $\frac{4}{55}$

**Sol. (b)**

P(both red balls) = $\frac{^7C_2}{^{11}C_2} = \frac{7\times 6}{11\times 10} = \frac{21}{55}$

**70.** 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) $\pi$ (b) $\frac{1}{\pi}$

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

**Sol. (b)**

$\because$ $f(x) = \frac{K}{1+x^2}$ is p.d.f.

so we have, $\int_{-\infty}^{\infty} f(x)dx = 1$

$$\Rightarrow \int_{-\infty}^{\infty} \frac{K}{1+x^2}dx = 1$$

$$\Rightarrow 2K[\tan^{-1}x]_0^{\infty} = 1$$

$$\Rightarrow 2K\left(\frac{\pi}{2} - 0\right) = 1$$

$$\Rightarrow K = \frac{1}{\pi}$$

**71.** A random variable X has a probability density function

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

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}

**Sol. (c)** We know that

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

Let n is 2 then

$$\int_0^{\infty} kx^2 e^{-x}\,dx = 1$$

or $x^2(-e^{-x})]_0^{\infty} - \int_0^{\infty} 2x\cdot(-e^{-x})dx = \frac{1}{k}$

or $0 + 2\int_0^{\infty} xe^{-x}dx = \frac{1}{k}$

or $\left.-e^{-x}\right]_0^{\infty} = \frac{1}{2k}$

or $0 + \int_0^{\infty} e^{-x}dx = \frac{1}{2k}$

or $\left.-e^{-x}\right]_0^{\infty} = \frac{1}{2k}$

or $-[0-1] = \frac{1}{2k}$

or $k = \frac{1}{2}$

Hence, option (c) is correct

**72.** 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) 0·82

**Sol. (b)**

The probability of finding defective fuses, p = $2/100$. Therefore average number of defective fusel in a box of 200 fuses = np = $200 \times \frac{2}{100} = 4$.

Therefore the mean of the Poisson distribution is given by m = n = 4

Required probability, $P(r \le 5) = \sum_{r=0}^{5} \frac{4^r e^{-4}}{r!}$

$= e^{-4}\left(1+4+\frac{4^2}{2!}+\frac{4^3}{3!}+\frac{4^4}{4!}+\frac{4^5}{5!}\right)$

= 0.7845

**73.** If X is a normal variate with mean 30 and standard deviatio 4, what is Probability $(26 \le X \le 34)$, given A (z = 0·8) = 0·2881?

(a) 0.2881 (b) 0.5762

(c) 0.8181 (d) 0.1616

**Sol. (b)**

We know that, $Z = \frac{X-\mu}{\sigma}$

$\therefore \quad Z_1 = \frac{26-30}{5} = -0.8$

and $\quad Z_2 = \frac{34-30}{5} = 0.8$

$\therefore \; P(26 \le X \le 34) = P(-0.8 \le Z \le 0.8)$

$= 2P(0 \le Z \le 0.8)$

$= 2 \times 0.2881$

$= 0.5762$

**74.** 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

**Sol. (a)**

Ferrites are employed for the construction of core for high speed reading and storing of data (or) information in a computer.

**75.** 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

**Sol. (a)**

A soft magnetic materials should

(i) Easily magnetized and demagnetized

(ii) have high saturation magnetization

(iii) have low coercivity

(iv) have high permeability

**76.** Gauss's theorem states that total electric flux $\Phi$ 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

**Sol. (b)**

Gauss theorem states that the total electric flux through any closed surface is equal to the net charge within that closed surface.

$$\oint_s \vec{D}.\vec{ds} = Q_{enclosed}$$

**77.** 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

**Sol. (b)**

The orbital and spin magnetic dipole moments of electrons are of the order of $1\mu_B$.

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

(a) Diamagnetic material

(b) Ferrimagnetic material

(c) Paramagnetic material

(d) Antiferromagnetic material

**Sol. (c)**

Above curie temperature, ferromagnetic material behaves as paramagnetic material.

**79.** 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

**Sol. (a)**

The photoconductivity device is based on the decrease in the resistance of certain semiconductor materials when they are exposed to both infrared and visible radiation. The photo conductivity is the result of carrier excitation due to light absorption and the figure of merit depends on the light absorption efficiency. The increase in conductivity is due to an increase in the number of mobile charge carriers in the material.

**80.** The resistivity of intrinsic germanium at 30°C is 0.46 $\Omega$-m. What is the intrinsic carrier density $n_i$ at 30°C, taking the electron mobility $\mu_n$ as 0.38 $m^2$/V-s and hole mobility $\mu_p$ as 0.18 $m^2$/V-s?

(a) $2.4 \times 10^{19}/m^3$ (b) $4.2 \times 10^{19}/m^3$

(c) $2.4 \times 10^{10}/m^3$ (d) $4.2 \times 10^{10}/m^3$

**Sol. (a)**

As we know that

$$\sigma = \eta_i q\left[\mu_n + \mu_p\right]$$

$$\Rightarrow \frac{1}{\rho} = \eta_i q\left[\mu_n + \mu_p\right]$$

$$\Rightarrow \eta_i = \frac{1}{q\rho\left[\mu_n + \mu_p\right]}$$

$$\Rightarrow \eta_i = \frac{1}{1.6 \times 10^{-19} \times 0.46(0.38 + 0.18)}$$

$$\Rightarrow \quad \eta_i = \frac{10^{19}}{0.412} = 2.42 \times 10^{19} \ /m^3$$

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

(a) $7.0 \times 10^{12} m^{-3}$ (b) $0.7 \times 10^{12} m^{-3}$

(c) $7.0 \times 10^{-12} m^{-3}$ (d) $0.7 \times 10^{-12} m^{-3}$

**Sol. (a)**

The intrinsic carrier concentration at room temperature is given by

$$\eta_i = \frac{\sigma}{q\left[\mu_n + \mu_p\right]}$$

$$\Rightarrow \quad \eta_i = \frac{10^{-6}}{1.6 \times (0.89 + 0.04) \times 10^{-19}}$$

$$= \frac{10^{13}}{1.488}$$

$$= 6.72 \times 10^{12} \ /m^3$$

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

(a) 54% (b) 68%

(c) 94% (d) 98%

**Sol. (c)**

As we know,

$$R_T = R_0 \left[1 + \alpha \Delta T\right]$$

$$\Rightarrow \quad \frac{1}{\sigma_T} = \frac{1}{\sigma_0}\left[1 + \alpha \Delta T\right]$$

$$\Rightarrow \quad \sigma_T = \left(\frac{1}{1 + \alpha \Delta T}\right)\sigma_0$$

$$\Rightarrow \quad = \frac{1}{(1 + 0.00428 \times 16)}\sigma_0$$

$$\Rightarrow \quad = 0.9359 \ \sigma_0$$

i.e. 93.59% of $\sigma_0$

So, $\sigma_T$ (to nearest unit value) is 94% of $\sigma_0$.

**83.** 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

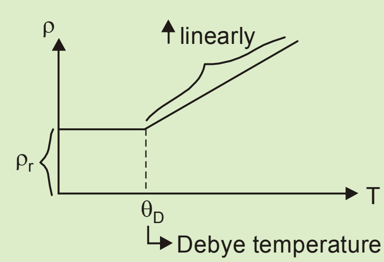
(a) Bernoulli Temperature

(b) Curie Temperature

(c) DebyeTemperature

(d) Neel Temperature

**Sol. (c)**




Above debye temperature, the resistivity increases linearly as shown in the figure.

**84.** Consider the following statements:

1. The critical magnetic field of a 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 at its critical temperature.
4. Superconductors show very high conductivity below the critical temperature.

Which of the above statements are correct ?

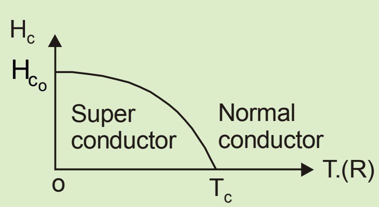
(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 2, 3 and 4 only (d) 1, 3 and 4 only

**Sol. (d)**

The critical magnetic field of a super conductor is given by

$$H_c = H_{c_0}\left[1-\left(\frac{T}{T_c}\right)^2\right]$$

Graphically,




From the graph, we may conclude that

(i) at absolute zero, Hc = maximum = $H_{c_0}$

(ii) at $T = T_c$, $H_c = 0$

(iii) at $T < T_c$, superconductivity is exhibited.

Hence, statements 1, 3, 4 are correct

**85.** What is the correct sequence of the following mateials in ascending order of their resistivity?

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

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

**Sol. (a)**

Resistivity Table: [Increasing order]

| | |
|---|---|
| (1) | Silver |
| (2) | Copper |
| (3) | Aluminium |
| (4) | Tungsten |
| (5) | Iron |
| (6) | Platinum |
| (7) | Manganin |
| (8) | Lead |
| (9) | Mercury |
| (10) | Nichrome |
| (11) | Constantan |
| (12) | Graphite |
| (13) | Mica |

Resistivity increases
= conductivity decreases

Hence, from the table:

Silver < Aluminium < Iron < Constantan < Mica
(2) (5) (1) (3) (4)

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

(a) Series capacitor (b) Series inductor

(c) Shunt capacitor (d) Shunt inductor

**Sol. (b)**

$$Z(s) = \frac{a_n s^n + a_{n-2} s^{n-2} + ...}{b_m s^m + b_{m-2} s^{m-2} + ...}$$

n > m, a pole is at $\omega = \infty$ and it is possible to represent Z(s) in the continued function form by dividing the numerator by denominator, inventing and dividing until the expansion terminates. In this case C.F.E will give a series inductor as first element.

**87.** 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) Both 1 and 2 (d) Neither 1 nor 2

**Sol. (b)**

The total magnetic moment depends on the number of magnetic dipoles per unit volume, the instant electric current and the area of the current loop.

**88.** 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 or 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

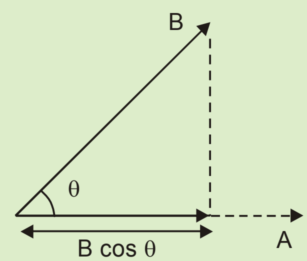
**Sol. (b)**

Dot product is given by

$$\vec{A} \cdot \vec{B} = |A||B|\cos\theta$$

where $\theta$ is angle between the vector A & B.

Also




So dot product is product of one vector and the projection of the other vector on the first vector.

**89.** 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

**Sol. (c)**

Susceptibility of a diamagnetic material is:

(i) Negative

(ii) Independent of temperature

For other magnetic material susceptibility is a function of temperature.

**90.** Consider the following statements:

1. The susceptibility $\chi$ 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

**Sol. (a)**

(1) The magnetic susceptibility $\chi$ of diamagnetic materials are small and negative.

(2) The magnetic susceptibility of para and anti ferro-magnetic materials is small but positive.

(3) The magnetic susceptibility of free space or air is zero.

$$\chi_m = \mu_r - 1$$

$$\Rightarrow \quad \chi_m = 1 - 1 \qquad [\because \text{ for air } \mu_r = 1]$$

$$\Rightarrow \quad \chi_m = 0$$

Hence (a) is correct.

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

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

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

Assume the minimum loading on any generator ot 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

**Sol. (d)**

Given

$$P_1 + P_2 = 200\text{MW} \qquad \text{...(i)}$$

$$P_{min} = 30 \text{ MW}$$

$$C_1 = P_1 + 0.01P_1^2$$

$$C_2 = 5P_2 + 0.02P_2^2$$

$$\frac{\partial C_1}{\partial P_1} = 1 + 2\,(0.01)\,P_1 = \lambda_1$$

$$\frac{\partial C_2}{\partial P_2} = 5 + 2\,(0.02)\,P_2 = \lambda_2$$

incremental fuel cost $\lambda_1 = \lambda_2 = \lambda$

$$\therefore \quad 1 + 2\,(0.01)\,P_1 = 5 + 2\,(0.02)\,P_2$$

$$0.02\,P_1 - 0.04\,P_2 = 4$$

$$P_1 - 2P_2 = \frac{4}{0.02}$$

$$P_1 - 2P_2 = \frac{400}{2}$$

$$P_1 - 2P_2 = 200 \qquad \text{...(ii)}$$

Solving equations (i) and (ii)

$P_1 = 200$ and $P_2 = 0$

But given minimum loading should be 30 MW

**92.** 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 $\theta = \frac{\pi}{2}$ of their respective power angle characteristics.

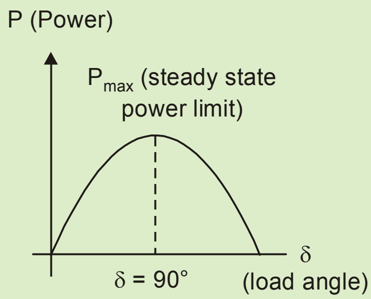
(b) the steady state power limit of round rotor motor machiens occurs at a much smaller angle $\theta$ as compared to that of salient pole machine power angle characteristics.

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

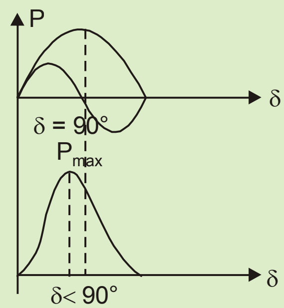
(d) The transient state power limits of synchronous gemnerators do not depend on initial load just before the large change in load or on 3-phase fault.

**Sol.** **(c)**

**Round rotor machine**




**Salient Pole machine**




From the characteristics the steady state power limit for salient pole machine occurs at smaller load angle hence. Option (c)

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

(a) Low cost of HVDC terminal

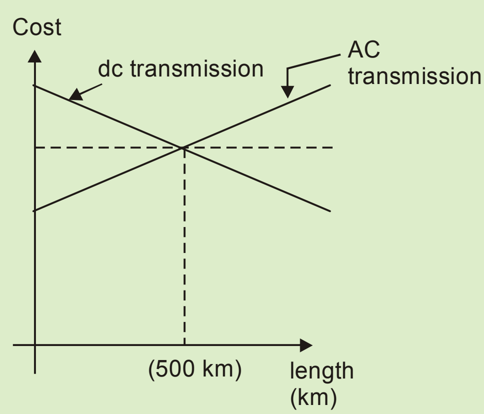
(b) No harmonic losses

(c) Minimum line power losses

(d) Simple protection

**Sol.** **(c)**

- We can observe from the graph when the length of the line is less than 500 kms HVDC is costlier because of high cost of HVDC terminal.



- Beyond 500km range HVDC becomes cheaper because of less transmission losses and No stability problems where as AC transmission liner are having higher cost because of 3 lines, it also losses and stability problem.

**94.** 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

**Sol. (c)**

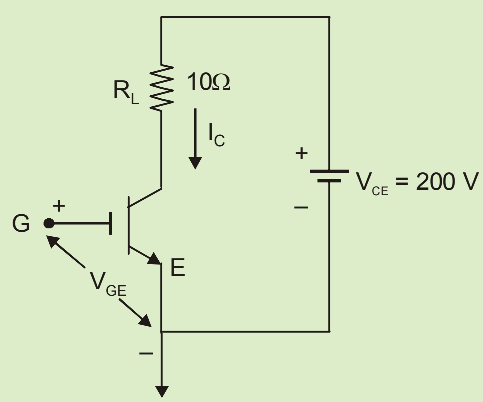
The turn-off time is temperature dependent and doubles between 25°C to 125°C hence

turn off time = $2 \times 30\mu s$

= $60\mu s$

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

**Sol. (c)**

From the given circuit

$$I_{C(max)} = \frac{V_{CE} - V_{CE(sat)}}{R_L} = \frac{200-2}{10}$$

$$= 19.8A$$

Therefore, switching power loss during turn on

$$= W_{on} \times f_s = \frac{V_{CE(max)}.I_{C(max)}.t_{on}}{6} \times f_s$$

$$= \frac{200 \times 19.8 \times 3 \times 10^{-6}}{6} \times 1 \times 10^3$$

= 1.98 W

and during turnoff, the switching power loss

$$= W_{off}.f_s = \frac{V_{CE(max)}\,I_{CE(max)}.t_{off}}{6} \times f_s$$

$$= \frac{200 \times 19.8 \times 1.2 \times 10^{-6}}{6} \times 1 \times 10^3$$

= 0.792 W

**96.** 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 statemetns is/are correct?

(a) 1 only (b) 2 only

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

**Sol. (b)**

1. The turn-off gain of the GTO is small hence statement 1 is false
2. A large negative gate current with short duration is required to turn off the GTO hence statement 2 is true
3. GTO has less reverse blocking hence statement 3 is false

**97.** 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

**Sol. (c)**

1. The break down voltage is inversely proportional to the doping denstiy of the drift region hence statement 1 is false.
2. Losses in the diode are more due to addition of significant ohmic resistance to the diode when it is conducting a forward current. This leads to large power dissipation of diode. Hence statement 2 is false
3. Power diodes are constructed with a vertically oriented structure that includes a drift region to support large blocking voltages. Hence statement 3 is true.

**98.** 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 woking in the inversion mode at a firing advance angle of 30°. What is the average generator voltage for the condition: dc current $I_d$ = 60A, thyristor drop = 1.5 V and f = 50 Hz?

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

**Sol. (*)**

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

(a) Fully controlled bridge converter
(b) Fully controlled bridge converter with free wheeling diode
(c) Half controlled bridge converter
(d) Converter pair in sequence control

**Sol. (c)**

The power rating of the blower is high as the dc motor rating is large and hence inertia is more. Therefore speed can be controlled by just 3-phase half controlled bridge converter.

**100.** 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 in half the maximum dc link votage.

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

**Sol.** **(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 Statements (II) are individually true and Statements (II) is the correct explanation of Statement (I)

(b) Both Statment (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

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

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

**Sol.** **(c)**

**Statement I:** A superconductor satisfies following criteria

(i) Perfect diamagnnetism

(ii) $H < H_c$

(iii) $T < T_c$

So statement (I) is correct

**Statement II:** A superconductor is not perfect conductor because a perfect conductor may or may not exhibit diamagnetism.

So statement (II) is wrong.

**102.** 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.

**Sol.** **(b)**

**Statement 1:** HVDC terminals are of high cost hence statement 1 is true.

**Statement 2:** Generation of harmonic is used for reactive power transfer only hence statement 2 is also true.

$\therefore$ Statement 1 and 2 are individually true but statement 2 is not correct explanation of 1.

**103.** 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.

**Sol.** **(b)**

**Statement I:** whenever there is irregularity in the periodicity of atoms in a crystal lattice voids or sites may get created which is called as lattice defects. so, statement I is true.

**Statement II:** Point, line, surface and volume defects are basically 0-dimensional, 1-dimensional, 2-dimensional and 3-dimensional defects respectively which occurs in a lattice at different condition. so statement II is true.

But statement II does not follow statement I because statement II depends on various other factors other than periodic arrangement of atoms.

**104.** 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.

**Sol. (a)**

When pointer of a wattmeter kicks back, it means power is negative. So, we must either reverse the current coil or the pressure coil connections. Hence statement I is correct.

The statement II is the correct explanation of statement I.

**105.** Statement (I) : An instrument manufacture 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.

**Sol. (c)**

An instrument manufactured as an ammeter should not be used as a voltmeter, as the low resistance winding of an ammeter will suffer serious damage if connected across a high voltage source statement (II) is false.

But a voltmeter can be used as an ammeter as no damage will be done by connecting a voltmeter as an ammeter as long as the voltage of the system is not above the range of voltmeter.

**106.** 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.

**Sol. (d)**

- Moving iron insturments are used in both ac and dc circuits.
- The deflecting torque in MI instruements depends on the square of the current.

$$T_d \propto \frac{1}{2} I^2 \left(\frac{dL}{d\theta}\right)$$

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

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

**Sol. (a)**

PMMC instruments use a core magent which posses self-shielding property because of high magnetic field produced by permanent magnet. Hence, this type of instruments find application in aircraft and air space application.

**108.** 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.

**Sol. (d)**

For AC bridge, used for measurement of inductance, the circuit balance equations are independent of frequency. An AC bridge to measure inductance is balanced at the fundamental component.

**109.** 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.

**Sol. (d)**

The phase lag network reduces the bandwidth. Hence statement– I is wrong.

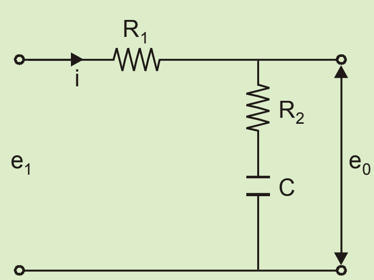
**110.** Statement (I) : The inductor is not used to fabricate a lag network as it produces time delay and hysteresis loss.

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

**Sol. (c)**

Inductance is not used in lag network beacause of time delay and hysteresis losses. So statement 1 is correct.

Phase lag compensating network is given as:




Hence statement (II) is wrong.

**111.** 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.

**Sol. (d)**

From bode plot we can determine the open loop transfer function but to determine the roots of closed-loop control system we have to know G(s) or H(s) seperately. So, statement-I is wrong.

**112.** 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.

**Sol. (a)**

**Statement I:** IGBT makes use of advantages of both power MOSFET and BJT hence statement-I is true.

**Statement II:** IGBT has high impedance gate like MOSFET at input. Like BJT IGBT has small on-state voltage.

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

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

**Sol. (a)**

**Statement I:** The distribution systems are 3-phase 4-wire circuits hence Statement-I is true.

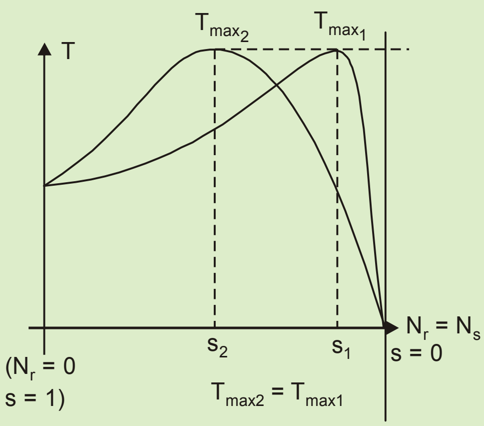
**Statement I:** A neutral wire is necessary to supply single-phase loads of domestic and marginal commercial consumers hence statement-II is true

Both statements are true and statement-II is correct explanation of statement-I

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

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

**Sol.** **(b)**




We know condition for maximum torque is

$$\frac{R}{s} = X$$

i.e. $s = \frac{R}{X}$ (Max) $(s \propto R)$

where s = slip at which maximum torque

Statement-I is as the rotor resistance changes the slip at which maximum torque occurs changes but maximum torque remains same.

The slip at which maximum torque occurs directly proportional to resistance of rotor (R) hence Statement-II is true.

Both statements I and II are true but II is not correct explanation of A hence answer is option (b).

**115.** 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.

**Sol.** **(c)**

**Statement-I:** A 3-phase induction motor is self starting machine hence statement-I is true

**Statement-II:** A star-delta starter is used to reduce the starting current of the induction motor hence statement-II is false.

**116.** 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.

**Sol.** **(a)**

The lower cage has high permeance for leakage flux due to which in a double squirrel cage motor leakage reactance of the lower cage is higher than that of upper cage.

**117.** 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.

**Sol.** **(d)**

A large number of metals become superconducting below a temperature which is characteristic of the particular metal. Superconducting compounds and alloys do not necessarily have compounds which are themselves superconducting. Note that metals which are very good conductors at room temperature eg. Cu, Ag, Au do not exhibit superconducting properties, whereas metals and compounds which is superconducting are rather bad conductors at ordinary temperature. Further-more, monovalent metal and ferromagnetic and anti-ferro-magnetic materials are not superconducting.

**118.** Statement (I) : The relative dielectric consstant 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.

**Sol.** **(c)**

Mathematically

$$\tan \delta = \frac{\in''_r}{\in'_r} = \frac{\sigma}{\omega \in}$$

as $f\uparrow \Rightarrow \omega\uparrow \Rightarrow \tan\delta \downarrow \Rightarrow \in''_r$

Hence as f↑, relative dielectric constant decreases.

So statement I is correct.

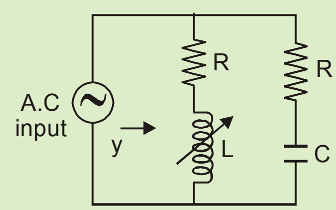
Polarisation means orientation and depends on the applied E and H field. With change in frequency its orientation can not be changed. It can be changed only when either or both E and H fields changes.

**119.** Statement (I) : One series RC circuit and the other series RL circuit are connected in parallel across at ac supply. The circuit exhibits two reasonance 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.

**Sol.** **(a)**

For the circuit given below,




$$\text{Admittance } y(j\omega) = \frac{1}{R + j\omega L} + \frac{1}{R - \frac{j}{\omega C}}$$

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

For resonance, $I_m\left[y(j\omega)\right] = 0$

$$\Rightarrow \frac{1/\omega C}{R^2 + \left(\frac{1}{\omega C}\right)^2} - \frac{\omega L}{R^2 + (\omega L)^2} = 0$$

$$\therefore \frac{1}{\omega C} \cdot \left\{R^2 + (\omega L)^2\right\} = \omega L \cdot \left\{R^2 + \left(\frac{1}{\omega C}\right)^2\right\}$$

Above equation is a quadratic equation in ‘L’, which gives two values of ‘L’ for which Imaginary part of admittance is zero.

$$y(j\omega) = \frac{R}{R^2 + (\omega L)^2} + \frac{R}{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

(At resonance)

For two values of 'L', given circuit exhibits two resonance.

**120.** 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 speed and high torque capabilites.

**Sol. (b)**

Power of wind turbine

(P) = 0.5 × swept area × Air density × $(\text{Velocity})^3$

hence **statement-I is true** $(P \propto V^3)$

Drag type wind turbines have lower speed and high torque capabilities hence **statement-II is also true.**

But statement-II is not correct explanation of statement-I hence.

**121.** 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 he codes given below:

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

**Sol. (a)**

Eddy current losses in a transformer can be reduced by:

(1) Solid cores (statement 1 is false)

(2) Laminated cores (statement 2 is true)

(3) Ferrites (statement 3 is true)

hence statement 2 and 3 are true

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

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

**Sol. (b)**

Magnetostriction is characterised by change in the physical dimension of the magnetic material when magnetic field is applied to it:

**123.** What type of defect causes F-centers 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

**Sol. (b)**

In metal excess defect due to anionic vacancies causes F-centers in a crystal. This type of defect is observed in those crystals which are likely to form schottky defects. Alkali metal halides like NaCl and KCl show this type of defect.

**124.** Consider the following statements:

1. Superconductors exhibit normal conductivity behaviour above a transition temperature $T_c$
2. Superconductors lose their superconducting nature in an external magnetic field, provided the external magnetic field is above a 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

**Sol. (a)**

(1) at $T > T_c$, superconductivity is lost and hence behaves as normal conductor.

(2) at $H > H_c$, superconductivity is lost.

**125.** 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

**Sol. (d)**

A superconductor exhibits zero electrical resistance below transition temperature.

**126.** 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

**Sol. (c)**

An atom in a crystal vibrates at a frequency, determined by the stiffness of the bonds with neighbor atoms.

**127.** Consider the following statmenets:

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 enchanced of 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 inductry

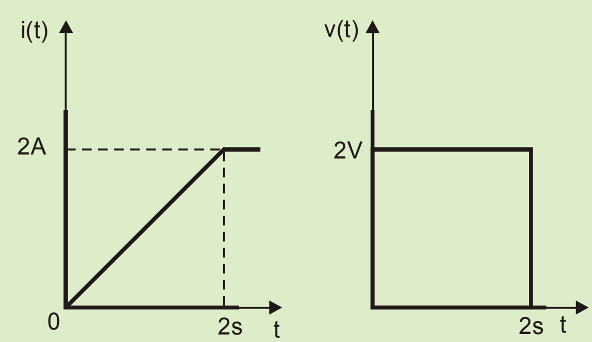
Which of the above statements are correct?

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

**Sol. (b)**

The atomic radius is of the order of $10^{-10}$ to $10^{-14}$ m whereas Nano means $10^{-9}$m whose order of dimension is higher and nano materials do exist in the ferm of rods, tabes, spheres etc. Nano elements under goes nano technology in which manipulation of materials are done and processed at the nanoscale level. Such as carbon nanotabe etc. Moreover, Nano elements exhibit prominent electrical, magnetic, optical characteristics and these materials can be processed through rolling etc.

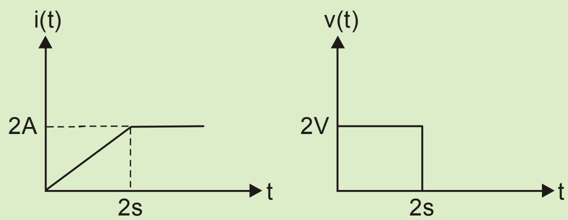
**128.** The voltage and current waveforms for an element are shown in the figure



The circuit element and its value are

(a) Capacitor, 2F (b) Inductor, 2H
(c) Capacitor, 0.5F (d) Inductor, 0.5H

**Sol. (b)**




Here, voltage across the unknown element

$= K\frac{d}{dt}$ {current flowing through the element}

i.e. $$V = K\cdot\frac{di}{dt}$$

Thus, the circuit element is an inductor.

Also, $$2 = L\frac{di}{dt}$$

$$\Rightarrow \quad L\cdot\frac{2}{2} = 2$$

$$\therefore \quad L = 2 \text{ Henry}$$

**129.** 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 a co-tree is

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

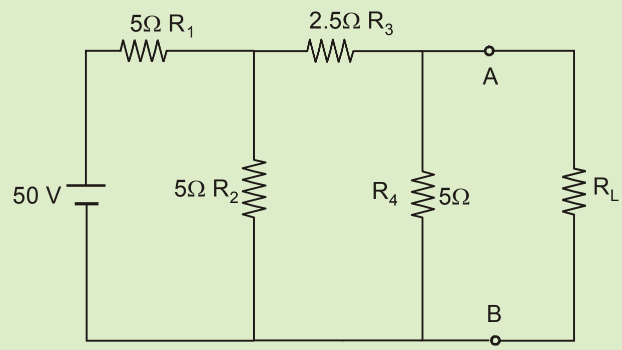
**Sol. (d)**

Number of links (L) of a co-tree = (No. of branches) – {(No. of nodes) – 1}

$$= b - (n - 1)$$
$$= b - n + 1$$

Also, No. of links = No. of mesh equations = No. of tie sets

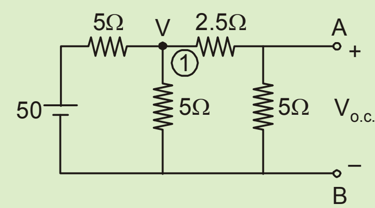
**130.** For the circuit shown, Thevenin's open circuit voltage $V_{oc}$ and Thevenin's equivalent resistnace $R_{eq}$ at terminals A – B are, respectively,




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

**Sol. (d)**

To find Thevenin's voltage ($V_{Th} = V_{OC}$ i.e. open circuit voltage across load)




Apply KCL at node '1', we get

$$\frac{V-50}{5}+\frac{V}{5}+\frac{V}{7.5} = 0$$

$$\Rightarrow \quad \frac{2V-50}{5}+\frac{V}{7.5} = 0$$

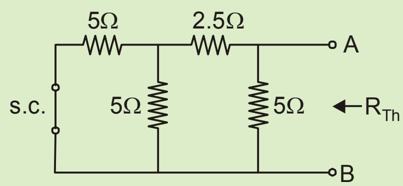
$$\therefore \quad V = \frac{75}{4}V$$

$$\therefore \quad V_{OC} = \frac{V-0}{7.5}\times 5$$

$$= \frac{75}{4} \times \frac{1}{7.5} \times 5$$

$$= 12.5 \text{ V}$$

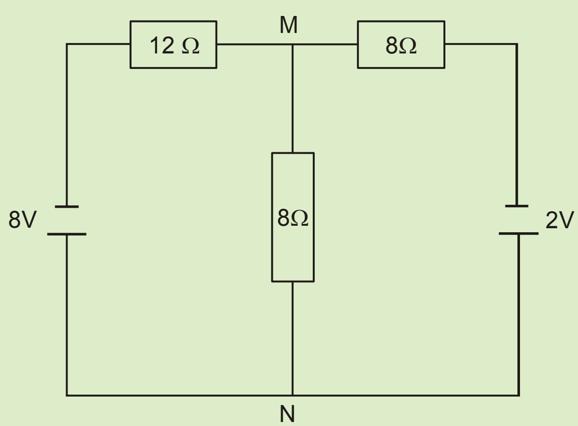
To find Thevenin's resistance ($R_{Th}$): Short circuit the voltage source.




$\therefore$ $R_{Th}$ = {(5||5) + 2.5}||5 = {2.5 + 2.5}||5

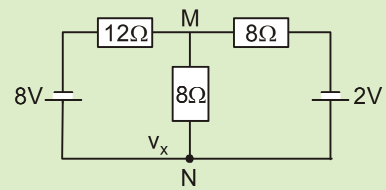
= (5||5) Ω = 2.5Ω

**131.** What is the current through the 8Ω resistance connected acorss 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

**Sol. (d)**




Let us assume that 'M' is the referenced ground/datum node.

Applying KCL at node 'N', we get

$$\frac{V_x - 8}{12} + \frac{V_x}{8} + \frac{V_x - 2}{8} = 0$$

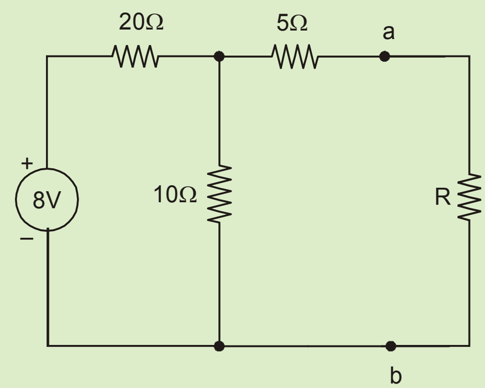
$$\Rightarrow \frac{V_x - 8}{12} + \frac{2V_x - 2}{8} = 0$$

$$\therefore \quad V_x = \frac{11}{4} \text{V}$$

$\therefore$ Current flowing in branch NM = $\dfrac{V_x}{8} = \dfrac{11}{4 \times 8}$ A

= 0.34 A [From N to M]

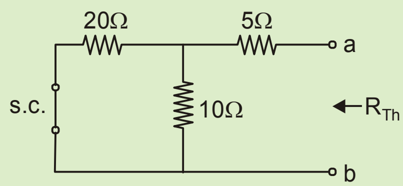
**132.** What is the value of resistance R which will allow maximum power dissipation in the circuit?




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

**Sol. (a)**

To find Thevenin resistance ($R_{Th}$) : Deactivate the voltage source




$$\therefore \quad R_{Th} = \{(20||10) + 5\}$$
$$= 11.67\ \Omega$$

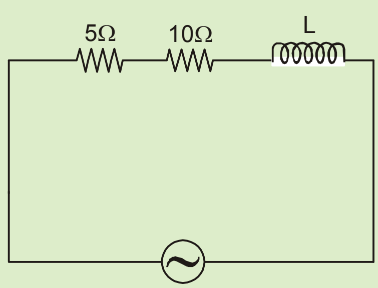
For maximum power transfer to the load resistance (R),

$$R = R_{Th}$$
$$= 11.67\ \Omega$$

**133.** Two resistors of $5\Omega$ and $10\Omega$ and an inductor L are connected in series across a $50\cos\omega t$ voltage source. If the power consumed by the $5\Omega$ resistor is 10 W, the power factor of the circuit is

(a) 1.0 (b) 0.8
(c) 0.6 (d) 0.4

**Sol. (c)**




50 cosωt

$$Z = 15 + jX_L$$
$$|Z| = \sqrt{225 + X_L^2}$$

$$P_{5\Omega} = 10\ \text{W}$$
$$I_{rms}^2 5 = 10$$
$$I_{rms} = \sqrt{2}$$
$$\frac{I_m}{\sqrt{2}} = \sqrt{2}$$
$$\Rightarrow \quad I_m = 2A$$
$$V = I\,|Z|$$
$$50 = 2\sqrt{225 + X_L^2}$$
$$25 = \sqrt{225 + X_L^2}$$
$$X_L = 20$$

$$\text{Power factor} = \cos\phi = \frac{R}{Z} = \frac{15}{25} = \frac{3}{5} = 0.6$$

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

(a) R = $20\Omega$ and C = $160\mu F$

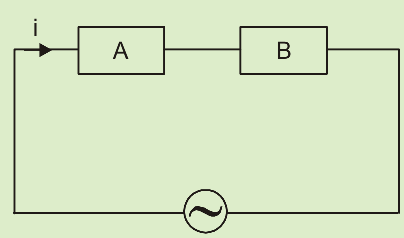
(b) R = $14.14\Omega$ and C = $225\mu F$

(c) L = 45 mH and C = $225\mu F$

(d) L = 45 mH and C = $160\mu F$

**Sol. (b)**

$$i = 10\sqrt{2}\cos(314t - 25)$$




$e = 200\sqrt{2}\sin(314t + 20)$

$$e = 200\sqrt{2}\sin(314t+20)$$

$$i = 10\sqrt{2}\cos(314t-25)$$

$$i = 10\sqrt{2}\sin(314t+65°)$$

i lead by v by 45°. Therefore elements are R & C.

$$|Z| = \frac{e_m}{i_m} = \frac{200\sqrt{2}}{10\sqrt{2}} = 20$$

$$Z = R - \frac{j}{\omega C}$$

$$Z = \sqrt{R^2 + \frac{1}{\omega^2 C^2}} \angle -\tan^{-1}\left(\frac{1}{\omega RC}\right)$$

$$|Z| = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}$$

$$20 = \sqrt{R^2 + \left(\frac{1}{314C}\right)^2} \quad \ldots\text{(i)}$$

$$\tan^{-1}\left(\frac{1}{\omega RC}\right) = 45°$$

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

$$RC = \frac{1}{\omega} = \frac{1}{314} \quad \ldots\text{(ii)}$$

Solving equation (i) and (ii) we get

$R = 14.14\,\Omega$ and $C = 225$ μF

**135.** How fast can be output of an OP Amp change by 10 V, if its slew rate is 1 $V/\mu s$?

(a) 5μs (b) 10μs

(c) 15μs (d) 20μs

**Sol. (b)**

Slew rate of an op-Amp is defined as the maximum rate of change of output voltage with time. It is given by

$$\text{Slew rate (SR)} = \left.\frac{dV_0}{dt}\right|_{maximum}$$

The output voltage of the Op-amp changes by 10 V in time (t, say). Then

$$SR = 1V/\mu s = \frac{10}{t}$$

$$\therefore \quad t = \frac{10V}{1\,V/\mu s}$$

$$= 10\mu s$$

**136.** A three-phase star-connected load is operating at a power factor angle $\phi$ with $\phi$ 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

**Sol. (b, d)**

A 3-phase star connected load is operating at a power factor angle $\phi$, with $\phi$ being the angle between phase voltage and line current (or) phase voltage and phase current as in

Y-connected load $I_L = I_P$ and $V_{ph} = \frac{V_L}{\sqrt{3}}$

We know is any power system

$V_L = V_{ph(load)} + (Z_{phase})\, I_{ph}$

sending end angle is more than receiving end angle

$(\phi_s > \phi_r)$

**137.** For a two-part reciprocal network, the three thransmission 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

**Sol. (b)**

Network to be reciprocal if

AD – BC = 1

4D – 7 × 5 = 1

4D = 36

$\boxed{D = 9}$

**138.** Consider the following as representations of reciprocity in terms of z-paramters:

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

**Sol. (c)**

Condition for reciprocity in Z parameter

$$\boxed{Z_{12} = Z_{21}}$$

Condition for symmetricity in Z parameter

$$\boxed{Z_{11} = Z_{22}}$$

**139.** A parallel-phate capacitor is made of two circular plates separated by a distance of 5 mm and with a dielectric with dielectric constant of 2.2 between them. When the electric field in the diectric is 3 × $10^4$ V/m, the charnge 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$^2$

**Sol. (None)**

Let the charge on the plates be Q. Then

Q = CV

$$= \frac{\varepsilon A}{d} \times \frac{E}{d} \qquad \left(\because C = \frac{\varepsilon A}{d} \text{ and voltage, } V = \frac{\text{Electric field}}{\text{distance}} = \frac{E}{d}\right)$$

$$\Rightarrow \quad \frac{Q}{A} = \frac{\varepsilon E}{d^2} = \frac{\varepsilon_0 \varepsilon_r E}{d^2}$$

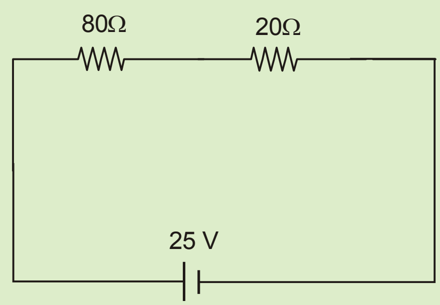
$$= \frac{8.854 \times 10^{-12} \times 2.2 \times 3 \times 10^4}{\left(5 \times 10^{-3}\right)^2}$$

$$= \frac{8.854 \times 2.2 \times 3 \times 10^{-12} \times 10^4}{25 \times 10^{-6}}$$

= 2.33 × $10^{-2}$ c/m$^2$

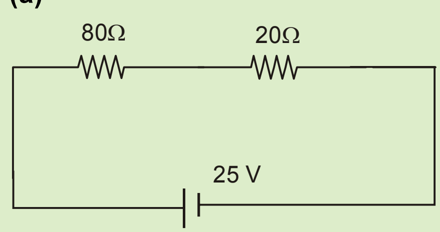
= 23.3 × $10^{-3}$ c/m$^2$

**140.** What is the potential drop across the $80\Omega$ resitor in the figure?




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

**Sol. (a)**



$$V_{80\Omega} = \frac{80}{80+20}\times 25$$

$$= \frac{80}{100}\times 25 = 20\text{ V}$$

$$\boxed{V_{80\Omega} = 20V}$$

**141.** 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 V is nearly

(a) 4.2 V (b) 3.2 V

(c) 1.2 V (d) 0.42 V

**Sol.** **(a)**

**142.** Consider the following statements:

If a high Q parallel resonant circuit is loaded with a resistance

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

Which of the above statments is/are correct?

(a) 3 only (b) 2 only

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

**Sol.** **(d)**

For parallel resonant circuit

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

and $Q = \omega_0 RC$

so as R increases Q increases but $\omega_0$ remains same.

Impedance of parallel resonant circuit will reduce on increasing resistance.

**143.** A drawn wire of resistnace $5\Omega$ is further drawn so that its diameter becomes one-fifth of the orginal. What is its resitance with volume remaining the same?

(a) $25\Omega$ (b) $125\Omega$

(c) $625\Omega$ (d) $3125\Omega$

**Sol.** **(d)**

Since, volume of the wire remain same

So, $\frac{4}{3}\pi r_1^2\ell_1 = \frac{4}{3}\pi r_2^2\ell_2$

$$\Rightarrow \quad r_1^2\ell_1 = r_2^2\ell_2$$

$$\Rightarrow \quad \left(\frac{d_1}{2}\right)^2\ell_1 = \left(\frac{d_2}{2}\right)^2\ell_2$$

$$\Rightarrow \quad d_1^2\ell_1 = d_2^2\ell_2$$

$$\Rightarrow \quad d_1^2\ell_1 = \left(\frac{d_1}{5}\right)^2\times\ell_2$$

$$\Rightarrow \quad \boxed{\ell_2 = 25\,\ell_1}$$

i.e. length becomes 25 times that of original one

Now, resistance $R = \rho\cdot\frac{\ell}{A} = \rho\cdot\frac{\ell.\ell}{(A.\ell)}$

$$= \rho\cdot\frac{\ell^2}{V}$$

i.e. $\boxed{R\,\alpha\,\ell^2}$

$$\frac{R_1}{R_2} = \left(\frac{\ell_1}{\ell_2}\right)^2$$

$$\Rightarrow \quad \frac{5}{R_2} = \left(\frac{\ell_1}{25\,\ell_1}\right)^2$$

$$\Rightarrow \quad R_2 = (25)^2 \times 5$$

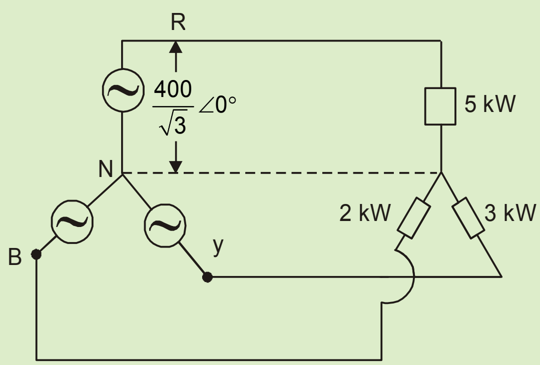
$$= 625 \times 5$$

$$= 3125\ \Omega$$

**144.** The three non-indcutive loads of 5 kW, 3 kW and 2 kW are connected in a star network bewteen 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

**Sol. (a)**




Given line voltage $V_L$ = 400V

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}}$$

$$P_R = V_{ph_R} I_{ph_R} \cos\phi_R = 5\text{kW}$$

$$P_Y = V_{ph_Y} I_{ph_Y} \cos\phi_Y = 3\text{kW}$$

$$P_B = V_{ph_B} I_{ph_B} \cos\phi_B = 2\text{kW}$$

For non inductive loads $\phi = 0 \quad \cos\phi = 1$

$$I_R = \frac{5\times10^3}{V_{ph}\underline{|0^\circ}} = \frac{5\times 10^3}{\frac{400}{\sqrt{3}}\underline{|0^\circ}} = 21.65\underline{|0^\circ}$$

$$I_Y = \frac{3\times10^3}{V_{ph}\underline{|-120^\circ}}$$

$$= 12.99\underline{|+120^\circ}$$

$$I_B = \frac{2\times10^3}{\frac{400}{\sqrt{3}}\underline{|-240}} = 8.66\ \underline{|240^\circ}$$

$$I_N = I_R + I_Y + I_B$$

$$= 21.65\underline{|0^\circ} + 12.99\underline{|120^\circ} + 8.66\ \underline{|240^\circ}$$

$$= 11.45\underline{|19.10^\circ} \simeq 11\text{ A}$$

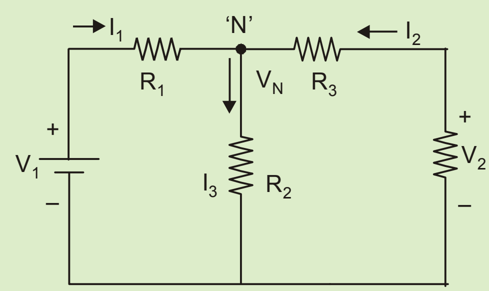
**145.** Kirchhoff's current law is applicable to

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

**Sol. (b)**




Applying KCL at mode 'N'

$I_1 + I_2 = I_3$

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AIR 11 CE PRAKHAR TRIPATHI
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AIR 14 CE MITARPAL TANWAR
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AIR 3 ME CHIRAG SRIVASTAV
AIR 5 ME DEEPAK VIJAY
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AIR 224 CE ANKIT KR. SHUKLA
Received so far..... [ If found any discrepancy please bring it to our notice. ]

$$\frac{V_1 - V_N}{R_1} + \frac{V_2 - V_N}{R_3} = \frac{V_N}{R_2}$$

KCL is applicable to junction in the circuit.

**146.** Which of the following are satisfied in a non-linar network?

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

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

**Sol. (b)**

For Linear Network there are two rules to be followed by network

(i) Superposition

$$x_1(t) \longrightarrow y_1(t)$$

$$x_2(t) \longrightarrow y_2(t)$$

$$x_1(t) + x_2(t) \longrightarrow y_1(t) + y_2(t)$$

(ii) Homogeneity

$$x(t) \longrightarrow y(t)$$

$$ax(t) \longrightarrow ay(t)$$

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

(a) Modified Faraday's law
(b) Gauss's law
(c) Biot-Savart law
(d) Modified Ampere's law

**Sol. (d)**

Amperis circuital law with maxwell addition states that the magnetic field induced around a closed loop is proportional to electric current plus displacement current (rate of change of electric field) it encloses.

$$\Delta \times H = \sigma E + \in \left(\frac{\partial E}{\partial t}\right)$$

**148.** Consider the following statements:

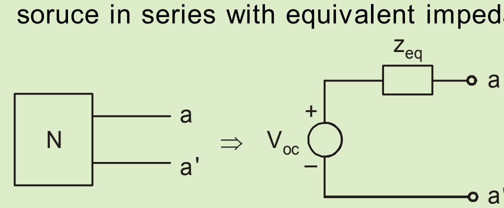
1. Network theorems are not derivable from Kirchoff's law
2. To get the Norton current, one has to short the current source
3. Thevenin's theorem is suitable for a circuit involving voltage sources and series connections

Which of the above statements is/are correct?

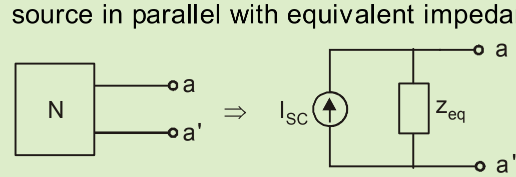
(a) 1, 2 and 3 (b) 1 only
(c) 2 only (d) 3 only

**Sol. (d)**

**Thevenin Theorem:** A linear active RLC network which contains one or more independent or dependent voltage or current source can be replaced by a single voltage soruce in series with equivalent impedance.



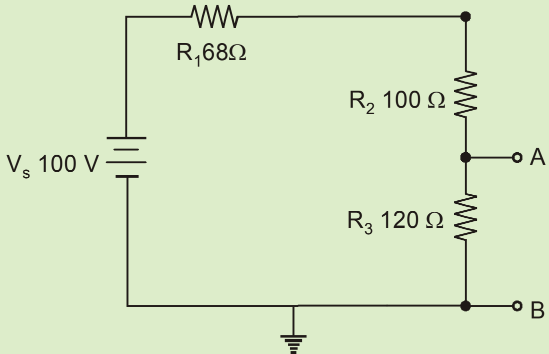

**Norton's Theorem:** A linear active RLC network which contains one or more independent or dependent voltage or current source can be replace by a single current source in parallel with equivalent impedance.




$$\boxed{Z_{eq} = \frac{V_{OC}}{I_{SC}}}$$

$I_{sc} \Rightarrow$ short circuit current between a & a′.

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



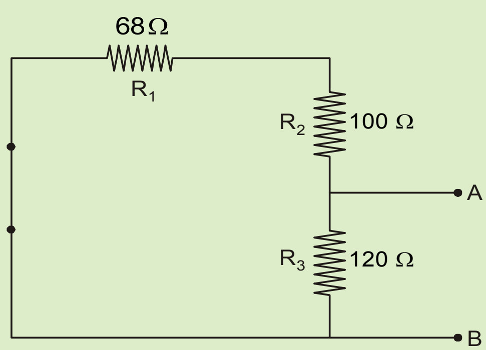

(a) 4.16 V and $120\Omega$ (b) 41.67 V and $120\Omega$

(c) 4.16 V and $70\Omega$ (d) 41.67 V and $70\Omega$

**Sol.** **(d)**

Thevenin's resistance is obtained by replacing the voltage source by its internal resistance. Here, voltage source is ideal one, so it has no internal resistance

$R_{Th}$:




So, $R_{Th}$ = (168) || (120)

$$= \frac{168 \times 120}{168 + 120} = 70\Omega$$

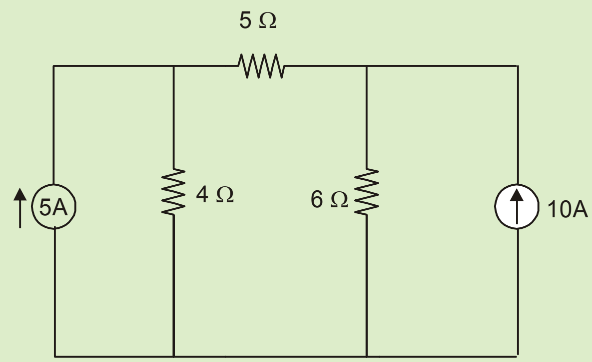
Now, Thevenin's voltage is the voltage across the terminal A-B.

So, $V_{Th} = V_{AB} = \dfrac{120}{120+168} \times 100$

$$= \frac{120}{288} \times 100$$

= 41.67 V

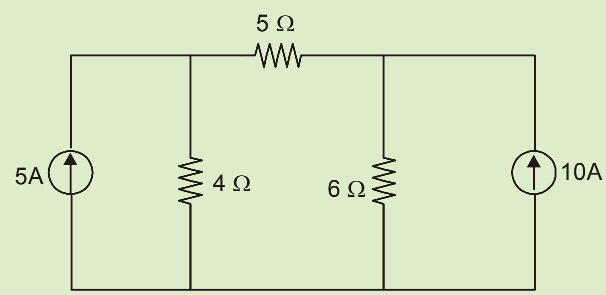
**150.** What is the current through the $5\Omega$ resistance in the circuit shown?



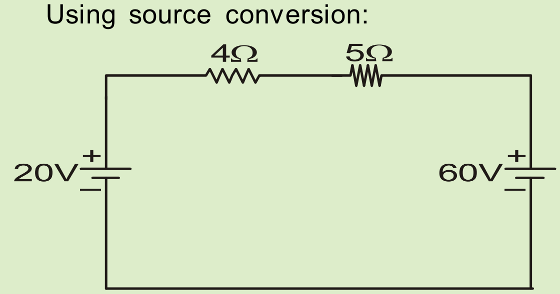

(a) 5.33 A (b) 4.66 A

(c) 2.66 A (d) 1.33 A

**Sol.** **(c)**




Using source conversion:




$$I = \frac{60-20}{4+5+6}$$

$\boxed{I = 2.66A}$