Youth Competition Times

RRB JE

2nd Stage (CBT-II)

CAPSULE

ELECTRICAL & ALLIED ENGINEERING

Theory + MCQ's

Study Material and Question Bank

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Syllabus for Electrical & Allied Engineering Exam Group–JE

- **Basic concepts:**
  Concepts of resistance, inductance, capacitance, and various factors affecting them. Concepts of current, voltage, power, energy and their units.
- **Circuit law:**
  Kirchhoff's law, Simple Circuit solution using network theorems.
- **Magnetic Circuit:**
  Concepts of flux, mmf, reluctance, Different kinds of magnetic materials, Magnetic calculations for conductors of different configuration e.g. straight, circular, solenoidal, etc. Electromagnetic induction, self and mutual induction.
- **AC Fundamentals:**
  Instantaneous, peak, R.M.S. and average values of alternating waves, Representation of sinusoidal wave form, simple series and parallel AC Circuits consisting of R.L. and C, Resonance, Tank Circuit. Poly Phase system – star and delta connection, 3 phase power, DC and sinusoidal response of R-Land R-C circuit.
- **Measurement and measuring instruments:**
  Measurement of power (1 phase and 3 phase, both active and reactive) and energy, 2 wattmeter method of 3 phase power measurement. Measurement of frequency and phase angle. Ammeter and voltmeter (both moving oil and moving iron type), extension of range wattmeter, Multimeters, Megger, Energy meter AC Bridges. Use of CRO, Signal Generator, CT, PT and their uses. Earth Fault detection.
- **Electrical Machines:**
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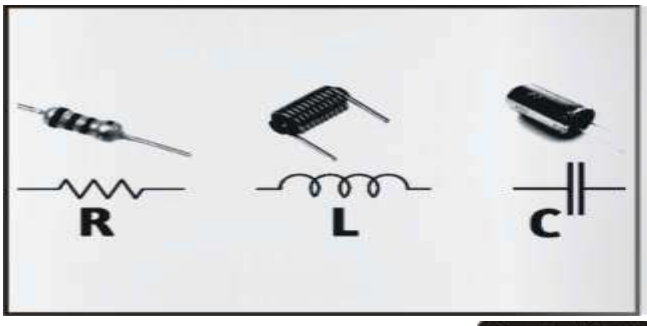
  (b) 1 phase and 3 phase transformers – Construction, Principles of operation, equivalent circuit, voltage regulation, O.C. and S.C. Tests, Losses and efficiency. Effect of voltage, frequency and wave form on losses. Parallel operation of 1 phase/3 phase transformers. Auto transformers. (c) 3 phase induction motors, rotating magnetic field, principle of operation, equivalent circuit, torque-speed characteristics, starting and speed control of 3 phase induction motors. Methods of braking, effect of voltage and frequency variation on torque speed characteristics, Fractional Kilowatt Motors and Single Phase Induction Motors: Characteristics and applications.
- **Synchronous Machines:**
  Generation of 3-phase e.m.f. armature reaction, voltage regulation, parallel operation of two alternators, synchronizing, control of active and reactive power. Starting and applications of synchronous motors.
- **Generation, Transmission and Distribution:**
  Different types of power stations, Load factor, diversity factor, demand factor, cost of generation, inter-connection of power stations. Power factor improvement, various types of tariffs, types of faults, short circuit current for symmetrical faults. Switchgears and Protection: Rating of circuit breakers, Principles of arc extinction by oil and air, H.R.C. Fuses, Protection against earth leakage / over current, etc. Buchholz relay, Merz-Price system of protection of generators & transformers, protection of feeders and bus bars. Lightning arresters, various transmission and distribution system, comparison of conductor materials, efficiency of different system. Cable – Different type of cables, cable rating and derating factor.
- **Estimation and costing:**
  Estimation of lighting scheme, electric installation of machines and relevant IE rules. Earthing practices and IE Rules.
- **Utilization of Electrical Energy:**
  Illumination, Electric heating, Electric welding, Electroplating, Electric drives and motors.
- **Basic Electronics:**
  Working of various electronic devices e.g. P N Junction diodes, Transistors (NPN and PNP type), BJT and JFET. Simple circuits using these devices.



1

Basic Concepts

Content Detailed

■ Concepts of Resistance ■ Inductance ■ Capacitance, and various factors affecting them ■ Concepts of Current ■ Voltage ■ Power ■ Energy and their units.

Units and Dimensions

Quantities	Unit	Dimension
Resistance	Ohm	$[ML^2T^{-3}A^{-2}]$
Resistivity	Ohm-meter	$[ML^3T^{-3}A^{-2}]$
Conductivity	Mho/m or Siemens/m	$[M^{-1}L^{-3}T^3A^2]$
Voltage	Volt	$[ML^2T^{-3}A^{-1}]$
Current	Ampere	[A]
Electric Power	Watt	$[ML^2T^{-3}]$
Electric Energy	kWh	$[ML^2T^{-2}]$
Permittivity	Farad/meter	$[M^{-1}L^{-3}T^4A^2]$
Electric field intensity	V/m or N/C	$[MLT^{-3}A^{-1}]$
Capacitance	Farad	$[M^{-1}L^{-2}T^4A^2]$
Inductance	Henry	$[ML^2T^{-2}A^{-2}]$
Permeability	Henry/meter	$[MLT^{-2}A^{-2}]$
Magnetic field Density	Wb/m^2	$[MT^{-2}A^{-1}]$
mmf	AT or Gilbert	[A]
Reluctance	AT/Wb or per Henry	$[M^{-1}L^{-2}T^2A^2]$
Permeance	Wb/AT or Henry	$[ML^2T^{-2}A^{-2}]$
Luminous flux	Lumen	$[ML^2T^{-3}]$
Illumination	Lux or Lumen/ m^2	$[MT^{-3}]$

❒ Resistance

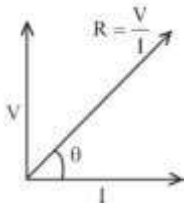
It may be defined as the property of a substance due to which it opposes the flow of electricity through it. It is represented by R.

■ Ohm's Law-

Ohm's law states that current through a conductor between two points is directly proportional to the potential difference across its ends, provided all physical conditions and temperature, remain constant.

$I \propto V$

$$\boxed{I = \frac{V}{R}}$$



Slop = resistance

❒ Vector form of Ohm's law-

$$\boxed{\vec{j} = \sigma\vec{E}},$$

where, j = current density

E = electric field

σ = Conductivity

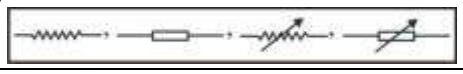
❒ Limitations

- It is not applicable to unilateral electrical components like diode and transistor etc.
- It is not applicable to non-linear, non-metallic, vacuum tubes, electrolytes, semi-conductor etc.

☛ Applicable

- It is applicable to both AC and DC circuit and bilateral elements.
- It is also applicable to metallic conductor and linear elements such as resistor.

■ Symbol of resistance:



- ➲ Low value (up to 1Ω) → Conductor
- ➲ Medium value (1Ω to 0.1MΩ) → Resistor
- ➲ High value (0.1MΩ above)→Insulator

■ The unit of Resistance

- The practical unit of Resistance is Ohm (Ω).

➢1 Mega ohm = 10^6 Ohm ➢ 1 Kilo ohm = 10^3 Ohm.
➢1 Milli ohm = 10^{-3} Ohm. ➢1 Micro ohm = 10^{-6} Ohm.

■ Law of Resistance

$$R \propto \frac{\ell}{A} \text{ or } R = \rho\frac{\ell}{A} \quad ...(i)$$

Where, ρ is a constant depending on the nature of the material of the conductor and temperature it is known as specific resistance or resistivity.

■ Factors affecting resistance-

☐ Cross section area

- $R \propto \frac{1}{A}$
- It varies inversely as the cross-section area of the conductor.

☐ Length

- $R \propto l$
- It varies directly as its length l.

☐ Temperature

- It also depends on the temperature of the conductor.

☐ Nature of material

- It depends on the nature of the material.

☐ Behaviour of Resistor

- Resistor is a linear, bilateral and passive element

☐ Units of Resistivity

$$R = \rho\frac{l}{A}, \rho = \frac{AR}{l}$$

$$\rho = \frac{A(\text{meter})^2 \times R(\text{ohm})}{l(\text{meter})} = \frac{AR}{l}\text{ohm-meter}$$

- Hence the unit of resistivity is Ohm-meter (Ω-m).

■ Resistivity of some conductor, semiconductor and insulating materials

Material	Resistivity (Ωm)	Classification
Silver	1.6×10^{-8}	Conductor
Copper	1.7×10^{-8}	
Gold	2.4×10^{-8}	
Aluminium	2.6×10^{-8}	
Tungsten	4.9×10^{-8}	
Germanium	0.65	Semiconductor
Silicon	2×10^{3}	
Porcelain	3×10^{9}	Insulator
Glass	1.7×10^{11}	
Mica	9×10^{12}	
Hard rubber	1×10^{16}	

■ Conductance and Conductivity

- Conductance (G) is reciprocal of resistance.

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

- It offers to the flow of current.

$$R = \rho\frac{\ell}{A} \text{ or } G = \frac{A}{\rho\ell} = \frac{\sigma A}{\ell} \quad ...(i)$$

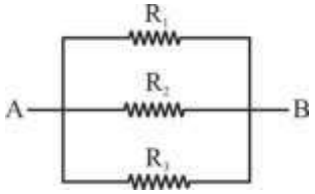
σ = conductivity or specific conductance

- The unit of conductance is Siemens (S) or Mho.
  in equation ……(i)
  The conductivity of a material is given by.

$$\sigma = G\frac{\ell}{A} = \frac{G(\text{Siemens}) \times \ell(\text{meter})}{A\left(\text{meter}^2\right)} = \text{Siemens/metre}$$

- The unit of conductivity is Siemens/meter (S/m).

■ Connection of Resistor

Series connection	➲ Same current flows through all parts of the circuit. ➲ Different resistors have their individual voltage drops. ➲ Voltage drops are additive. ➲ Applied voltage equals the sum of different voltage drops. ➲ Resistance are additive. ➲ Power are additive.  $R_{eq} = R_1+R_2+R_3+.....+R_n$
Parallel connection	➲ Same voltage acts across all parts of the circuit. ➲ Different resistors have their individual current. ➲ Branch current are additive. ➲ Power are additive.  $\frac{1}{R_{eq}} = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+.....+\frac{1}{R_n}$

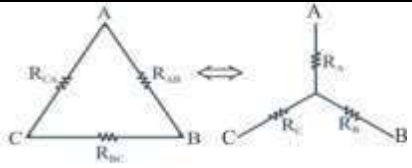
■ Types of resistor

➲ Carbon composition resistor
➲ Deposited carbon resistor
➲ High voltage thick film resistor
➲ Metal film resistor
➲ Metal glaze resistor
➲ Wire wound resistor
➲ Ceramic metal resistor

■ Varistor

- It is made of carborundum crystals.
- It is non-linear, non-ohmic voltage dependent resistor(VDR).

■ Conversion of Resistance

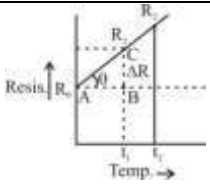


Delta to Star	Star to Delta
$R_A = \frac{R_{AB}\times R_{CA}}{R_{AB}+R_{BC}+R_{CA}}$	$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$
$R_B = \frac{R_{AB}\times R_{BC}}{R_{AB}+R_{BC}+R_{CA}}$	$R_{BC} = R_B + R_C + \frac{R_B R_C}{R_A}$
$R_C = \frac{R_{BC}\times R_{CA}}{R_{AB}+R_{BC}+R_{CA}}$	$R_{CA} = R_C + R_A + \frac{R_C R_A}{R_B}$

For same value of resistance-

$$R_\Delta = 3R_y$$

■ Effect of Temperature on Conductor, semiconductor and Insulator

Effect	➢ When the temperature increases then resistance also increases. ➢ For metal temperature coefficient of resistance (α) is positive. ➢ For semiconductor and insulator temperature coefficient of resistance (α) is negative. ➢ For alloys temperature coefficient of resistance is small and positive.
Formula	 $\alpha_0 = \frac{\text{Slope of Graph}}{\text{Original Resistance}}$, $\alpha_1 = \frac{\text{Slope of Graph}}{R_1}$ $\alpha_0 R_0 = \alpha_1 R_1$ $\boxed{\alpha_1 = \frac{\alpha_0}{1+\alpha_1 t_1}}$ $R_1 = R_0[1+\alpha_0 t_1]$

- In case R_o is not given the relation between the known Resistance R_1 at t_1°C and the unknown resistance R_2 at t_2°C can be found as follows.
  $R_2 = R_o(1 + \alpha_0 t_2)$ and $R_1 = R_o(1 + \alpha_0 t_1)$

$$\frac{R_2}{R_1} = \frac{1+\alpha_0 t_2}{1+\alpha_0 t_1} \qquad \boxed{R_2 = R_1\left[1+\alpha_0\left(t_2 - t_1\right)\right]}$$

- Unit of temperature coefficient (α) of resistance per unit °C.

■ Colour Coding of Resistance

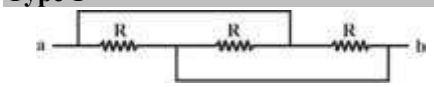
Colour	Value	Multiplier	Tolerance
Black	0	1	–
Brown	1	10	± 1%
Red	2	10^2	± 2%
Orange	3	10^3	± 3%
Yellow	4	10^4	± 4%
Green	5	10^5	± 0.5%
Blue	6	10^6	± 0.25%
Violet	7	10^7	± 0.10%
Grey	8	10^8	± 0.05 %
White	9	10^9	–
Gold	–	10^{-1}	± 5%
Silver	–	10^{-2}	± 10%
(None)	–		± 20%

❖ **Formula for 4 Band Resistor**

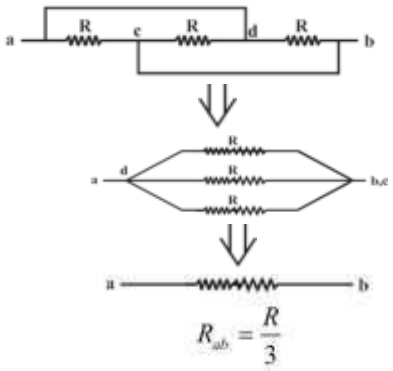
$R = AB \times 10^C \pm \text{Tolerance}$
Where, $A \rightarrow I^{st}$ significant digit
$B \rightarrow 2^{nd}$ Significant digit
$10^C \rightarrow$ multiplier

■ Different Combinations of Resistance

Type-I

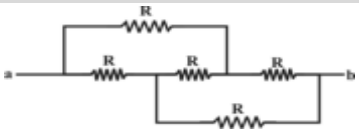


Solution–

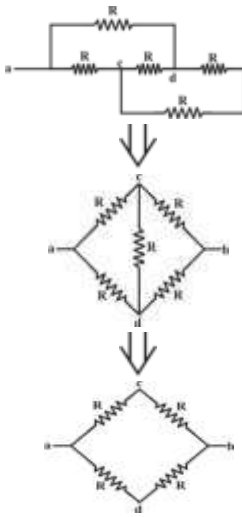


$$R_{ab} = \frac{R}{3}$$

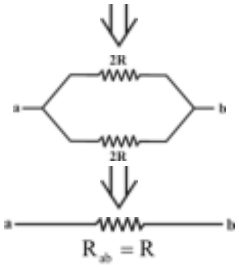
Type-II



Solution

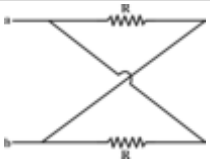


- According to the balance Wheatstone bridge rule, the resistance between C and D will be negligible.

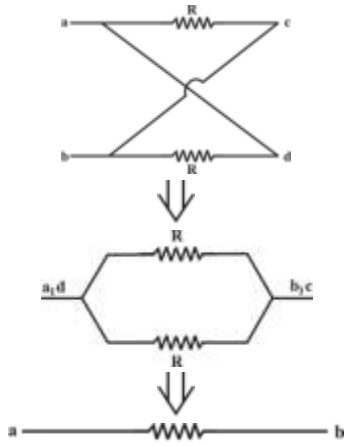


$$R_{ab} = R$$

Type-III

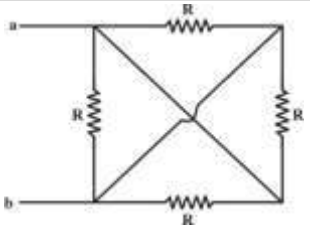


Solution–

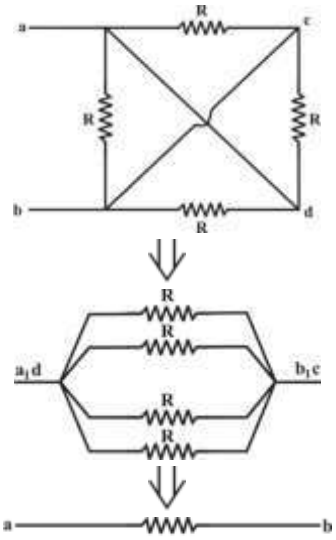


$$R_{ab} = \frac{R}{2}$$

Type-IV

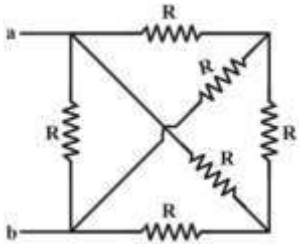


Solution–

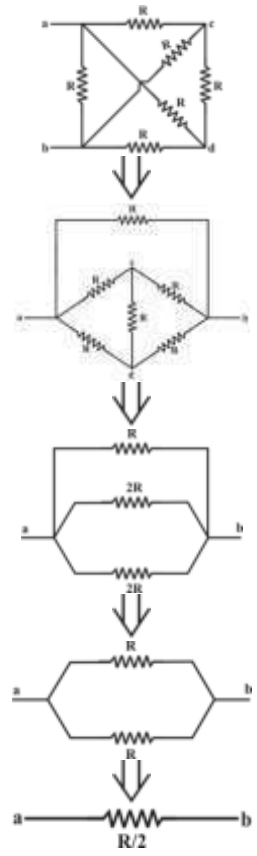


$$R_{ab} = \frac{R}{4}$$

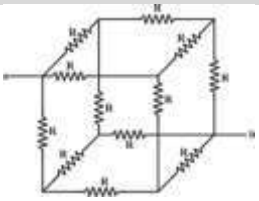
Type-V



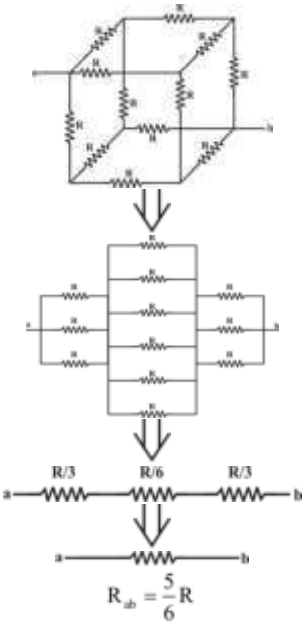
Solution–



Type-VI



Solution–



$$R_{ab} = \frac{5}{6}R$$

■ Insulation Resistance of cable

$$R = \frac{\rho}{2\pi\ell}\log_e\frac{r_2}{r_1} = \frac{2.303\rho}{2\pi\ell}\log_{10}\frac{r_2}{r_1}\ M\Omega$$

■ Some Important Facts Regarding the Conductor

- If the resistance of a conductor is R_1 and its length is increased n times, then the resistance of the conductor (R_2)-

$$\because l_2 = nl_1$$

$$\boxed{R_2 = n^2 R_1} \qquad \therefore a_2 = \frac{a_1}{n}$$

- If the resistance of a conductor is R_1 and its area is increased n times, then the resistance of the conductor (R_2)-

$$\because a_2 = na_1$$

$$\boxed{R_2 = \frac{R_1}{n^2}} \qquad \therefore l_2 = \frac{l_1}{n}$$

- If the resistance of a conductor is R_1 and its diameter is increased n times, then the resistance of the conductor (R_2)-

$$\because d_2 = nd_1$$

$$\boxed{R_2 = \frac{R_1}{n^4}} \qquad \therefore A_2 = n^2 A_1$$

$$\& \ l_2 = l_1/n^2$$

NOTE

- If wire is stretched n times then $R' = n^2R$
- If wire is compressed n times then $R' = \frac{R}{n^2}$
- $R_{AC} = 1.6\ R_{DC}$

■ Inductance

- Inductors are important because they can resist sudden changes in the current in an electrical circuit.
- Inductance is a property of an inductor (passive component) that is used in most electrical circuit to store energy in the form of magnetic field when electric current flows through it.

☐ Faraday's Law of Electromagnetic Induction

First law	Change of magnetic flux linked to a coil induced an emf across a coil.
Second law	The emf induced across the coil is equal to rate of change of flux in the coil.

$$\boxed{e = -N\frac{d\phi}{dt}}$$

Where, negative sign shows that emf induced always oppose the change in flux.

☐ Faraday's Law For an Inductor

$$\boxed{V_L = L\frac{di}{dt}} \qquad \boxed{i(t) = \frac{1}{L}\int_0^t V_L\,dt + i(0^-)}$$

☐ Types of Inductance

Self Inductance	$\boxed{L = \frac{N\phi}{i} = \frac{V_L}{di/dt} = \frac{N^2}{S} = \frac{\mu_0\mu_r AN^2}{\ell}}$ Where N = no. of turns in the coil, 'A' is cross sectional area and ℓ is the length of the coil. Also, μ_r = Relative permeability, $\mu_0 = 4\pi \times 10^{-7}$ Henry/meter, S = Reluctance
Mutual Inductance	$\boxed{M = \frac{N_2\phi_1}{i_1} = \frac{V_{L_2}}{di_1/dt} = \frac{\mu_o\mu_r N_1N_2\pi r^2}{\ell_1}}$ $\boxed{M = \frac{\mu_o\mu_r N_1N_2A}{\ell_1}}$
Coupling factor of Inductance	$\boxed{K = \frac{M}{\sqrt{L_1L_2}}}$

■ Factor affecting of inductance

☐ Core material

- $L \propto \mu$
- It varies directly as its core material.

☐ Coil area

- $L \propto A$
- A greater coil area result in greater inductance.

☐ Coil length-

- $L \propto \frac{1}{l}$
- The longer the coil length the less inductance.

☐ Number of turn in a coil-

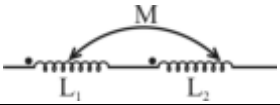
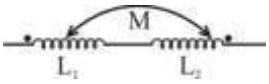
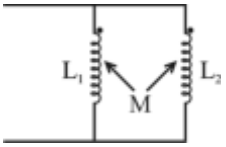
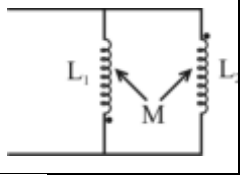
- $L \propto N^2$
- A greater number of turn of coil result in greater inductance.

☐ Behaviour of Inductor

Inductor with initial condition	at $t = 0^+ \rightarrow$ act as a current source at $t = \infty \rightarrow$ act as short circuit
Inductor without initial condition	at $t = 0 \rightarrow$ act as an open circuit at $t = \infty \rightarrow$ act as short circuit

- **Energy stored in Inductor-** $\boxed{E = \frac{1}{2}Li^2}$ Joules

- **Magnetic Coupling of Inductor**

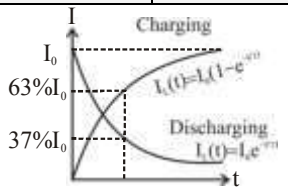
Series Connection of Inductor	
i. Aiding nature	**ii. Opposing nature**
$L = L_1 + L_2 + 2M$ 	$L = L_1 + L_2 - 2M$ 
Parallel Connection of Inductor	
i. Aiding nature	**ii. Opposing nature**
$L_{eq} = \frac{L_1L_2 - M^2}{L_1 + L_2 - 2M}$ 	$L_{eq} = \frac{L_1L_2 - M^2}{L_1 + L_2 + 2M}$ 

- **Transient Equation for Inductor**

$$i_L(t) = i_L(\infty) + \left[i_L(0^+) - i_L(\infty)\right]e^{-t/\tau} \quad t > 0$$

- Charging and **D**ischarging of **I**nductor

Charging	**Discharging**
Current $I_L(t) = I_o\left(1 - e^{-t/\tau}\right)$	Current $I_L(t) = I_o e^{-t/\tau}$
Voltage $V_L(t) = V_o e^{-t/\tau}$	Voltage $V_L(t) = -V_o e^{-t/\tau}$



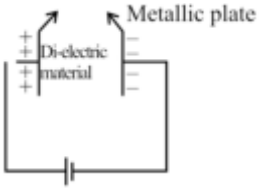
- **Time constant for inductor** $\tau = \frac{L}{R}$ second

■ Behaviour of Inductor

➢	Inductor is linear, bilateral and passive element.
➢	Inductor opposes the sudden change of current. $I_L(0^-) = I_L(0^+)$
➢	Inductor allows the sudden change of voltage.
➢	Inductor is an energy storing element.
➢	Inductor does not dissipate any power, it only stores energy.

■ Capacitance

- A capacitor is a two terminal electrical device that can store energy in the form of an electrical charge.
- The unit of electrical capacitance is the Farad.



- The capacitance of a capacitor is defined as the charge stored per unit voltage (potential difference across its plate).

$$Q \propto V$$

$$Q = CV$$

$$C = \frac{Q}{V}$$

$$\boxed{C = \frac{\varepsilon_0 \varepsilon_r A}{d}}$$

- Power dissipation in the ideal capacitor is zero.
- Capacitor stored energy in the form of electrostatic field.
- Charge stored of capacitor in metal plate only.
- Dielectric is insulating material which increase the capacity of plate to store charge.
- Capacitor does not allow sudden change of voltage because sudden change of voltage required infinite value of current source.

■ Factor Affecting of Capacitance

□ Area a plate-

- $C \propto A$
- When area of capacitor plate increases then capacitance of capacitor increases.

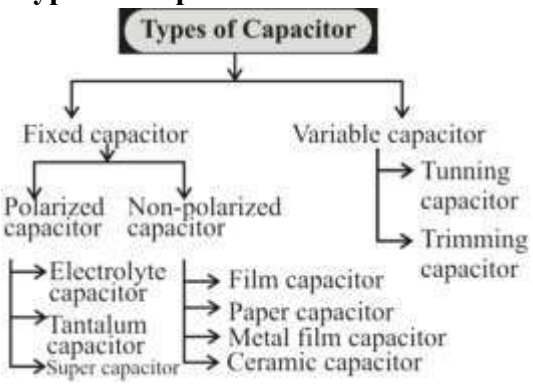
□ Distance between plates-

- $C \propto \frac{1}{d}$
- The capacitance of capacitor is inversely proportional to the distance between plates.

□ Relative permittivity of dielectric

- $C \propto \varepsilon_0$
- When relative permittivity of dielectric increases then capacitance of capacitor increases.

□ Types of Capacitor



- ➢ Ceramic capacitor is used for generation of large power.
- ➢ Electrolyte capacitors are generally used for DC voltage.
- ➢ Electrolytic capacitor is high capacitance to size ratio.
- ➢ Ceramic capacitor is mostly used for coupling and de-coupling.
- ➢ Variable capacitor is called trimmer.

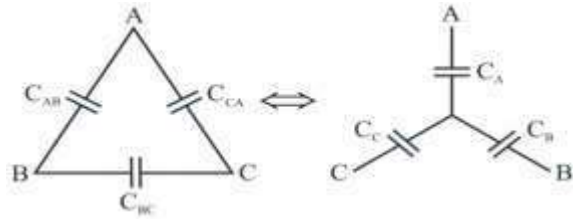
➢ Mica capacitor is used as high accuracy capacitor.

Capacitance of Capacitor	$C = \frac{\varepsilon_o \varepsilon_r A}{d}$ Farad
Capacitance of different Dielectric having different thickness and relative permittivities	$C = \frac{\varepsilon_o A}{\frac{t_1}{\varepsilon_{r_1}} + \frac{t_2}{\varepsilon_{r_2}} + \frac{t_3}{\varepsilon_{r_3}}}$ Farad
When some part of parallel plate capacitor have air medium and some part have another medium then capacitance	$C = \frac{\varepsilon_o A}{\left[d - \left(t - \frac{t}{\varepsilon_r}\right)\right]}$ Farad
When some part of parallel plate capacitor have air medium in horizontal direction and some part have another medium then capacitance	$C = \frac{\varepsilon_o A}{d}\left[\frac{1+\varepsilon_r}{2}\right]$ $= C_{air}\left[\frac{1+\varepsilon_r}{2}\right]$ Farad
Capacitance of cylindrical capacitor 	$C = \frac{2\pi\varepsilon_o\varepsilon_r \ell}{\log_e b/a}$ Farad $C = \frac{2\pi\varepsilon_o\varepsilon_r \ell}{2.303\log_{10} b/a}$ Farad
Capacitance of variable capacitor	$C = \frac{(n-1)\varepsilon_o\varepsilon_r A}{d}$ Farad Where n = no. of plates

■ Combination of Capacitors

Series	$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ... + \frac{1}{C_n}$
Parallel	$C_{eq} = C_1 + C_2 + C_3 + ... + C_n$

■ Conversion of Capacitors



Delta to Star	Star to Delta
$C_A = C_{AB} + C_{CA} + \frac{C_{AB}\,C_{CA}}{C_{BC}}$	$C_{AB} = \frac{C_A\,C_B}{C_A + C_B + C_C}$
$C_B = C_{AC} + C_{BC} + \frac{C_{AC}\,C_{BC}}{C_{AB}}$	$C_{BC} = \frac{C_B\,C_C}{C_A + C_B + C_C}$
$C_C = C_{BC} + C_{AB} + \frac{C_{BC}\,C_{AB}}{C_{AC}}$	$C_{CA} = \frac{C_C\,C_A}{C_A + C_B + C_C}$
For same value of capacitance- $\boxed{C_\Delta = \frac{1}{3C_Y}}$	

■ Charging and Discharging of Capacitor

Charging	Discharging	Time constant for capacitor
Current equation $I_C(t) = I_0 e^{-t/\tau}$	Current equation $I_C(t) = -I_0 e^{-t/\tau}$	$\tau = R_{th} C_{eq}$
Voltage equation $V_C(t) = V_0\left(1 - e^{-t/\tau}\right)$	Voltage equation $V_C(t) = V_0\, e^{-t/\tau}$	
Charge equation $q_c(t) = Q_0\left(1 - e^{-t/\tau}\right)$	Charge equation $q_{c(T)} = Q_0 e^{-t/\tau}$	

■ Transient Equation for Capacitor

$$\boxed{V_c(t) = V_c(\infty) + \left[V_c(0^+) - V_c(\infty)\right]e^{-t/\tau} t > 0}$$

■ Concept of Short Circuit and Open Circuit of Capacitor with Respect to Time

$$i_c = \frac{CdV}{dt}; \qquad V_c(t) = \frac{1}{C}\int_0^t i_c(t)dt + V(0^-)$$

■ Behaviour of Capacitor

With initial condition	at $t = 0^+ \rightarrow$ act as a voltage source at $t = \infty \rightarrow$ act as open circuit
without initial condition	at $t = 0 \rightarrow$ act as short circuit at $t = \infty \rightarrow$ act as open circuit

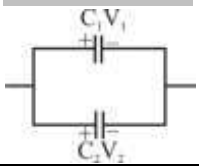
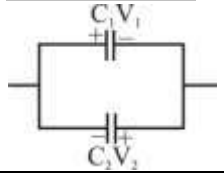
● Some Important Points Regarding to Capacitor

- Capacitor opposes rate of change of voltage. $V_C(0^-) = V_C(0^+)$
- Capacitor Stores the energy in electrostatic field.
- While charging, $I_C(t) = \frac{CdV_C(t)}{dt}$ decreased and $I_C(t)$ must be positive.
- While discharge, $I_C(t) = \frac{CdV_C(t)}{dt}$ decreased but $I_C(t)$ must be negative.
- While a capacitor charge and discharge polarity of dc voltage of capacitor never change.

■ Energy Stored in Capacitor

$$\boxed{E = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}} \text{ Joules}$$

■ Common Potential in Joining Capacitor

Common potential (for parallel)	$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$ 
Connection of two capacitor parallel/anti-parallel	$V = \frac{C_1V_1 - C_2V_2}{C_1 + C_2}$ 

■ Energy Lost in Joining Capacitor

For parallel	$\Delta E = \frac{1}{2}\frac{C_1C_2}{(C_1 + C_2)}(V_1 - V_2)^2$
For anti-parallel	$\Delta E = \frac{1}{2}\frac{C_1C_2}{(C_1 + C_2)}(V_1 + V_2)^2$

Active element	**Passive element**
They can generate electrical energy, amplify signals.	They can not generate electrical energy but can store, dissipate it.
They require an external power supply to operate.	They do not require an external power supply to operate.
Example- Voltage source, current source, FET, MOSFET, diode, op-amp, transistor, SCR etc.	**Example-** Resistor, capacitor, Inductor, transformer, fuses etc.

❒ Concept of Current

- Current is the rate of the flow of electrons.
- It is measured in ampere (A).
- When 1 Coulomb of charge passes through cross section of conductor in 1 second then current is said to be 1 ampere.
  One Coulomb is equal to 6.25×10^{18} charge carriers.

$$Q = it$$

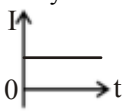
$$i = \frac{Q}{t}$$

- Conventional flow of electric current is from positive to negative terminal.
- Current of voltage are two types-

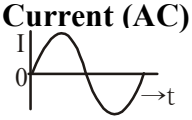
1. Direct current
2. Alternating current

■ Direct Current

- Flows only in one direction.
- Common source Battery or DC generator.

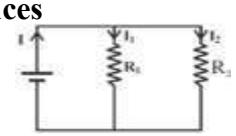


■ Alternating Current (AC)



- Alternating current is a current that changes direction in time.
- Flows in a sine wave pattern.
- Common source-household electrical.
- Current remains same in series circuits.

■ Current Divider Rule for Two Parallel Resistances



According to current division rule-

$$I_1 = \frac{R_2}{R_1 + R_2} I \qquad I_2 = \frac{R_1}{R_1 + R_2} I$$

❒ Concept of Voltage

- The electric potential difference per unit charge between two points in an electric field is called voltage.
- Mathematically voltage is defined as the ratio of the work done to the electric charge.

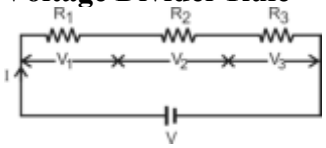
$$V = \frac{W}{Q}$$

- According to Ohm's law product of resistance and current is called voltage.

$$V = IR$$

- SI unit for voltage is the Volt.
- Voltage remains same in parallel combination.

■ Voltage Divider Rule



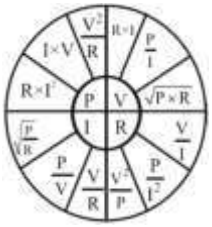
$$R_{eq} = R_1 + R_2 + R_3$$

$$V_1 = \left(\frac{R_1}{R_{eq}}\right)V \quad V_2 = \left[\left(\frac{R_2}{R_{eq}}\right)V\right] \quad V_3 = \left[\left(\frac{R_3}{R_{eq}}\right)V\right]$$

❒ Electrical Power

- Electrical power is the rate at which work is done in an electrical circuit. Its SI unit is Watt. $P = \frac{W}{t}$

Where, P→ Power, W→Work done
t→ time in second



$$P = VI = I^2R = \frac{V^2}{R}$$

- The general unit of power is Joule/second.
- The industrial unit of electrical power is H.P.(Horse power)
- 1 kW= 1000W
- 1 H.P. (metric) = 735.5 Watt or Joule/second
- 1H.P. (British) = 746 Watt or Joule/second.

■ Brightness of different wattages bulbs connected in series or parallel-

If we have bulbs of different wattages; W_1 and W_2 (if $W_1 > W_2$) connected in a circuit the brighter bulb will be W_1 (the higher wattage).

- **In series-** The W_2 bulb will be brighter because it have more power (resistance increases). $P \uparrow = I^2R \uparrow$
- **In parallel-** The W_1 bulb will be brighter because it has more power (resistance decreases). $P \uparrow = \frac{V^2}{R \downarrow}$

❒ Electrical Energy

- It is defined as the work done by the source of electricity to maintain the rate of flow of charge in an electrical circuit.
- The movement of electrons from one point to another point generates the energy.
- The Joule or Watt second is the fundamental unit of electrical energy.
- The SI unit of electrical energy is kWh.
- It is represented by 'E'.
- $E = VIt = I^2Rt = \frac{V^2}{R}t$
- 1 kWh = 3.6×10^6 Joule
- 1 kWh = 860 kilo calories
- The electron volt (eV) is a smallest unit of energy.

■ Joule's law of Heating

According to this law, when a current 'I' passes through a conductor of resistance 'R' for time 't' then the heat developed in the conductor is equal to the product of the square of the current, resistance and time.

$H \propto I^2$, $H \propto R$, $H \propto t$, $H \propto I^2Rt$

$H = I^2Rt$ Joule $= \frac{I^2Rt}{4.18}$ Calories

Exam Pointer

- The most important properties of insulating material used electrically is-. **High resistivity and high dielectric strength**
- $[LT^{-2}]$ is the dimension of which quantities - **Acceleration**
- One angstrom is– **1 Å = 0.1 nm**
- 5400 Kilojoule is– **1.5 kWh**
- The dimensional formula $[ML^2T^{-2}]$ may correspond to - **Torque, Energy, Work**
- The SI unit of which quantity is 'Newton'- **Force**
- 1 kWh = 860 kCal = ... **3600 kJ (3.6×10^6 Joule)**
- 10 $\frac{\text{joule}}{\text{coulomb}}$ is equal to- **10 V**
- 1 Volt is equal to - **1 Joule/Coulomb**
- Which electrical quantities is represented by σ (Sigma) - **Conductivity**
- Components which obey ohm's law known as- **Ohmic components**
- The speed of electricity is– **2,97,842 km/s**
- Specific resistance is the resistance offered between the two ends of material having– **Area of 1 cm^2 and length 1 cm**
- The SI unit of electric charge is - **Coulomb**
- The average resistance of a human body is- **1000 Ω**
- The unit of conductivity is- **Siemens/m or mho/meter**
- The value of temperature coefficient of resistance of a given conductor– **Different at different given temperatures**
- The unit of specific resistance is– **Ohm-meter**
- The unit of electric current– **Ampere**
- 1 coulomb is equivalent to – **1 ampere second**
- The potential difference is – **It is the difference of potential between two points in an electric circuit**
- The unit of electrical energy is– **kWh**
- Formula of energy is– **Power × time**
- The ability of a material to absorb a large amount of energy is defined as its - **Toughness**
- An atom of hydrogen has…….in its first orbit - **1 Electron**
- The resistance of an ideal conductor is - **Zero**
- The dimension of electrical conductivity is - **$[M^{-1}L^{-3}T^3A^2]$**
- The electrical resistivity of very pure silver near 0 Kelvin temperature is - **Very low but measurable**
- The change in the resistance of a conductor per unit original resistance per degree rise in temperature is called– **Temperature coefficient of resistance**
- The hot resistance of an incandescent lamp is about ..... of its cold resistance– **10 times**
- The resultant charge in a body is whenever the number of protons equals the number of electron in it– **Zero charge**
- If one of the parallel resistors in any parallel circuit is removed from the circuit, then the total resistance– **Increases**
- A.....is an fundamental quantity which flows through the material when electrical energy is applied and has a unit..... **Charge, Coulomb**
- The law governing the force between electric charge is known as.- **Coulomb's law**
- The condition for the application of Ohm's law is– **Constant Temperature**
- If 12.25×10^{16} electrons pass through a conductor in 1 s, then how much current (in mA) will– **19.6**
- Static electricity is produced by..... **Both friction and induction**

- The correct Law of ohm's is..... **$V \propto I$ and $V = IR$**
- Electric charge measured in Coulombs has the charge of how many electron– **6.25×10^{18}**
- If the resistor obeys Ohm's law, it is called a– **Linear resistor**
- The ability of a charged particle to do work is known as– **Electric potential energy**
- No current flows through two charged bodies if they have equal– **Potential**
- A group of passive devices only is– **Transformer, Resistor, Capacitor, Inductor**
- What is meant by zero initial condition for a system– **System is at rest and no energy is stored in any of its components**
- Reciprocal of resistivity – **Conductivity**
- Analogous to conductivity is – **Permeability**
- The value of temperature coefficient of resistance (α) depends upon – **Nature of material and temperature**
- Ohm's law is valid for – **All conductors**
- The specific resistance of a copper conductor is..... **More than the specific resistance of silver**
- The force between two charges is true– **A force of repulsion exists between two like Charges**
- The electrons revolve around the nucleus with high velocity. Which type of force acts against centrifugal force– **Electrostatic force of attraction**
- The difference between an atom and an ion is– **Ions are always charged particles while the atoms are neutral as a whole**
- A charge exists on a conductor. The best way to remove this charge is to.... **Ground the conductor**
- Midway between two equal and similar charges, a third equal and similar charge is placed. Then this third charge will..... **Remain in stable equilibrium**
- The electrical conductivity of metals typically of the order of (in $ohm^{-1}m^{-1}$)..... **10^7**
- If an atom losses one or more electrons, it becomes..... **Electrically positive**
- The lines of force due to charged particles are..... **Always curved**
- The charge of a stable atom is – **Uncharged**
- Electric charge of a body is a condition due to – **Deficiency or excess of electrons**
- In any electric circuit the flow of electron constitutes– **An electric current**
- An electric current can be classified as – **Conduction, Convection and Displacement current**
- The effect on electric potential energy of charges when the separation between two charge increases is– **It decreases**
- One commercial unit of electrical energy converted to Joule is equal to– **3.6×10^6 J**
- The three fundamental quantities are– **Mass, Length, Time**
- One kWh of electrical energy equals – **860 kcal**
- A Charged particle of charged q moving with a velocity v along the axis of a current carrying solenoid, The magnetic force on the particle is– **0**
- Whenever a charged particle moves in a Electric Potential– **Particle gets kinetic energy**
- The maximum number of electrons which the valence shell of an atom can have is – **8**
- A hollow sphere of charge does not produce an electric field at– **Interior point**
- Electron are held in atom due to – **Coulombs force**
- The thermal noise is due to random..... **Motion of free electrons**
- Ohm's Law is applicable to – **Resistive Circuits & Reactive Circuits**
- The force of attraction between two charge particles is– **Directly proportional to the amount of charge**
- The value of relative permittivity of vacuum is – **1**
- Electric field is defined as the electric force per unit..... **Charge**
- The total energy of a revolving electron in an atom– **Can never be positive**
- The resistivity of lead is– **$20.8 \times 10^{-8}\ \Omega$ m**
- Current always flow in direction – **Opposite to that of Electron**
- Conduction of electricity through conductor takes place by– **Free electrons**
- Conduction will not occur when bodies are – **At same temperature**
- The excessive neutral current is caused by – **Electronic ballasts**
- Two wires A and B of the same material but of different lengths L and 2L have the radius r and 2r respectively. The ratio of specific resistance will be– **1 : 1**
- Specific resistance of a conductor depends upon – **Composition of conductor material and temperature**
- ..... particle act as a current carrier in a metallic conductor– **Only free electrons**
- When alternating current pass through a conductor– **Portion of conductor near the surface carries more current as compared to the core**
- The charge q_1 exerts a slight force on the charge q_2, if the charge q_3 is brought near them, then the force of q_1 exerted on q_2– **Will be constant**
- The potential inside a charged hollow sphere is – **Same as that on the surface**
- For a hollow charged thin metallic sphere with center O and a point on the surface of sphere as, R, the magnitude of Electric Field and Potential from O to R is respectively– **Zero, Constant**
- Mobility is highest– **Electron**
- Ampere-second could be the unit of – **Charge**
- An electric current is– **The movement of free electrons predominantly in one direction**
- An electric current is the flow of– **Both positive and negative charges**
- The material which offers very low resistance to the flow of electron is known as– **Conductor**

- The resistance of a conductor, when its temperature is increased – **Increases**
- When an electric current flows through a conductor, its temperature rises. This is because of– **Collisions between conduction electrons and atoms**
- Which V-I curve is a straight line according to ohm's law – **Conductors**
- A free electron means– **Valence electrons which are loosely attached to the nucleus**
- Electrically charged atom is generally termed as– **Ion**
- The quality of a good conductor is– **Low specific resistance**
- On application of heat on electrolyte it exhibit– **Negative temperature Coefficient**
- A source of emf is required in order to– **Get the electrons into motion**
- For a two terminal device, resistance decreases when the temperature increases, the device is– **A semiconductor**
- In the case of direct current– **Magnitude and direction of current remains constant**
- In a parallel bank with unequal branch resistances– **The current is highest in the lowest R**
- A tolerance of 20% in the value of carbon resistor is represented by– **Without any band**
- With the rise in temperature, the resistance of carbon– **Decreases**
- A substance whose molecules consist of dissimilar atoms is called– **Compound**
- Boltzman constant represents the variation of voltage with– **Temperature**
- The dimensions of force are – **$[MLT^{-2}]$**
- Which have same dimensional formula – **Work and Energy & Impulse and Momentum**
- The device which does not have frequency dependent properties on its own is– **Resistor**
- n small droplets of same size are charged to the same potential V. If they coalesce to form one drop, then the potential of the drop will be– **$n^{2/3}V$**
- Insulating materials have the function of– **Preventing a short circuit between conducting wires**
- The minimum charge on an ion is– **Equal to the charge of an electron**
- ..... conductor has lowest resistivity at 273K– **Silver**
- Resistance of a material always decreases if– **Number of free electrons available becomes more**
- .....are the materials having electrical conductivity much less than most of the metals but much greater than that of typical insulators– **Semi-conductor**
- All good conductors have high– **Conductance**
- International ohm is defined in terms of the resistance of– **A column of mercury**
- Pure metals generally have– **High conductivity and large temperature coefficient**
- The lightest particle is– **Electron**
- The heaviest particle is– **Proton &Neutron**
- In a copper atom, first orbit contains– **Two electrons**
- A thermistor has– **Negative temperature co–efficient**
- The colour bands on a fixed carbon resistor are red, red, gold, Its value is– **2.2 Ω**
- Current velocity through a copper conductor is– **Of the order of a few μm/s**
- Ohm's law is not applicable to– **Semi–conductors**
- If the number of valence electrons of an atom is less than 4, the substance is usually– **A conductor**
- If the number of valence electrons of an atom is more than 4, the substance is usually– **An insulator**
- If the number of valence electrons of an atom is 4, then the substance is usually– **Semiconductor**
- Electric current is a– **Scalar quantity**
- The electric current in a discharge tube containing a gas is due to– **Electrons, negative and positive ions**
- The quantity of charge that will be transferred by a current flow of 10A over 1 hour period is– **3.6×10^4 C**
- The drift velocity of free electrons is of the order of– **10^{-5} ms^{-1}**
- The thermal speed of electrons is of the order of– **10^6 ms^{-1}**
- Rate of flow of electric charge through a given point is known as– **Current**
- A piece of aluminium (Al) and germanium (Ge) are cooled from T_1 K to T_2 K. The resistance of– **Aluminium decreases and that of germanium increases**
- The induction heat produced in a charge is given by $\frac{V^x}{R}$ where V is voltage induced in the charge and R is the charge resistance. The value of 'X' is - **2**
- Find the resistance, if the colour code on a resistor reads Brown, Black, Red, Gold- **1000 Ω ± 5%**
- Convert 372°C into Kelvin Scale- **645K**
- ..... expressions gives the Joule's law of heating? **$H \propto I^2Rt$**
- Two resistors are said to be connected in series when – **Same current passes in turn through both**
- Two unequal resistance are connected in parallel, then – **Large current flows through smaller resistance**
- Which is true for the parallel connection of resistors- **Total power is equal to sum of individual branch power**
- If two or more components are connected in they have the same potential difference (voltage) across their ends how is connected– **Parallel**
- In which circuits is the total voltage drop equal to the sum of the voltage drops in various element of the circuits - **Series electric circuit**
- The tolerance band of a colour-coded resistor having ±10% tolerance will be of _____colour- **Silver**
- One international ohm is equal to – **1.00049 absolute ohm**
- The SI unit of conductance is – **Siemens**
- The charge on one electron is – **1.602×10^{-19}C**

- 1 Joule of electrical energy equals – **1 Watt.sec**
- An active element in a circuit is one which– **Supplies energy**
- Due to the properties of a conductor, does it pass current– **Conductance**
- The filament of an electric bulb is made up of tungsten because– **Its melting point is high**
- The fuse operate due to the.....effect of current- **Heating**
- The type of resistance has highest value of temperature coefficient is- **Carbon Composition**
- Ideal voltage source should have - **Zero internal resistance**
- …….was based upon the idea that the conduction of electric and thermal current in metals is by electrons - **Drude theory**
- The symbol of current density is– **J**
- If the material has negative temperature coefficient, the resistance…….with increase in temperature. **Decreases**
- A practical current source is equivalent to an ideal current source in parallel with… **Low conductance**
- Is defining the unit of electric current. **Coulomb/sec, ampere and volt/Ω**
- Consider an element represent by the relationship between current i(t) and voltage v(t) as follows $v(t) = i^2(t)$ this device is classified as - **Non-linear time invariant**
- For a given conductor, if the cross-sectional area increases, then– **Resistance of the conductor decreases**
- If the voltage source has a very high internal impedance when compared to the external load impedance, then it can be considered as: **Constant Current Source**
- Usually resistance used in electronic circuitly use - **Ohmic and wattage rating**
- If n identical resistance, each of resistance R are connected in parallel, the equivalent resistance is. **R-equivalent = $\frac{R}{n}$**
- In which circuits the transient currents may not occur– **Pure resistive circuits**
- If the voltage across an element in a circuit is linearly proportional to the current through it, then it is a– **Resistor**
- The ratio of voltage and current in a closed circuit– **Remains constant**
- The precision resistors are – **Wire-wound resistors**
- The slope of the graphical representation of Ohm's law represents ..... components– **Resistance**
- Electric field intensity at any point is equal to– **Potential gradient at that point**
- Inside a conducting sphere, ...remains constant– **Potential**
- If a voltage changes instantly the current through a resistor connected across it– **Changes instantly**
- Under thermal and electrical system analogy, temperature is considered analogous to– **Voltage**
- One mega ohm equals to – **10^6 Ohm**
- If the energy is supplied from a source, whose resistance is 1 Ohm, to a load of 100 Ohms the source will be– **A voltage source**
- Two long parallel conductors carrying currents in opposite directions.....each other – **Repel**
- When a voltage is applied, the direction of electric field is always from.....to.....**Positive, Negative**
- In parallel combination of resistance, the voltage – **Same across each resistance**
- Electrical conductor opposes the flow of current through it – **Resistance**
- Potential difference is measured in – **Volts**
- In series combination of resistance, the current through each resistance is – **Same**
- The internal resistance of an ideal current source is – **Infinite**
- The relationship between Electrical Power and current is– **Non-linear**
- When the current flows through the heater coil, it will illuminate, but the power supply line will not illuminate because– **Resistance of heater coil is more than supply wire**
- As the temperature of pure metal increases, the product of its resistivity and its conductivity– **Remains constant**
- In series-parallel combination of resistance, the minimum number of resistance required is– **Three**
- If two equal resistances connected in series across a certain supply are now connected in parallel across the same supply, the power produced will be..... that of series connection– **Four times**
- Pertains to resistor only – **They can dissipate desirable amount of power**
- Determines total power in a series circuit – **Multiplier of source voltage and current**
- A current mirror can be used as an active load because – **It has high AC resistance**
- In a parallel circuit the potential difference across the resistance– **Is always constant**
- An electromotive force is– **The voltage produced by voltage source**
- A current is said to be direct current when its– **Magnitude remains constant with time**
- For a voltage source – **Terminal voltage cannot exceed the source emf**
- Whenever current is supplied by a source its terminal voltage– **Decreases**
- A conductors provides a path for flow of current in circuit due to property of– **Conductance**
- A circuit contains two unequal resistance in parallel, then– **Potential difference across each is same**
- The resistance R offered by a conductor varies– **Directly as the resistivity and length of the material and inversely as its cross sectional area**
- Reciprocal of resistance is called – **Conductance**
- A practical voltage source consists of an ideal voltage source in– **Series with internal resistance**
- To determine the polarity of the voltage drop across a resistor, it is necessary to know– **Direction of current through the resistor**

- Two resistors are said to be connected in series uniquely if– **Same current passes in turn through both**
- To determine the value of the net resistance (R) for three parallel resistor R_1, R_2, R_3, we can use the equation– $\mathbf{1/R = 1/R_1 + 1/R_2 + 1/R_3}$
- The sum of currents entering a junction is 9A. If the current leaves the junction from 3 different paths having the same resistance, the current leaving from any one of the path will be– **3 A**
- For doubling the current in a circuit of constant resistance the applied voltage must be – **Doubled**
- The combined resistance of two equal resistors connected in parallel is equal to– **1/2 the resistance of one resistors**
- In a four-branch parallel circuit, there are 50 mA of current in each branch. If one of the branches is open, the current in each of the other three branches is – **Uneffected**
- If two or more components are connected in..... then they have the same potential difference (voltage) across their ends – **Parallel**
- An open inductive coil has– **Infinite resistance**
- For a human body the ear to ear resistance is about .....ohm– **100 ohm**
- A resistance having rating 10 ohms, 10 W is likely to be– **Wire wound resistor**
- Resistance above.....is called high resistance– **0.1 Mega ohm**
- Heat in a conductor is produced on the passes of electric current due to– **Resistance**
- The thickness of insulation provided on the conductor depends on– **The magnitude of voltage on the conductor**
- Resistance of a tungsten lamp.....as applied voltage increase– **Increases**
- Which one among Aluminium, Constantan, Mercury, Carbon have highest resistivity– **Carbon**
- Keeping the length constant, the diameter of a wires is reduced to one half. The new resistance will be– **4 times of the original**
- For carbon resistance, The colour for 4 is– **Yellow**
- The length of a conductor is doubled and its area of cross section is also doubled. Then its resistance will be– **Remain unchanged**
- Whether circuit may be AC or DC which is most effective in reducing the magnitude of the current– **Resistor**
- When a low resistance is connected in parallel with a high resistance, the combined resistance is– **Always less than the low resistance**
- In a lamp load when more than one lamp are switched on the total resistance of the load– **Decreases**
- When electric current passes through a bucket full of water, lot of bubbling is observed. This suggests that the type of supply is– **D.C.**
- Resistance of carbon filament lamp.....as the applied voltage increases– **Decreases**
- Bulbs in street lighting are all connected in– **Parallel**
- In resistance colour coding the value of 5 is represented by– **Green colour**
- In.....resistance increases with increase temperature– **Metals**
- The resistance of perfect insulator is– **Infinite**
- The P.T.C. resistor is called– **Sensistors**
- Constantan wire is used for making rheostat because– **No change in resistance when temperature varies**
- When a voltage source is connected to a load, its terminal voltage falls due to– **High source impedance**
- In a series circuit with unequal resistances– **The highest resistance has the highest voltage drop**
- Electric shock is– **Sometimes fatal**
- Voltage dependent resistors are usually made from– **Silicon carbide**
- Voltage dependent resistors are used– **To supress surges**
- When a voltage of one volt is applied, a circuit allows one microampere current to flow through it. The conductance of the circuit is– **1 μ-℧**
- The minimum requirements for causing flow of current are– **A voltage source and a conductor**
- In absence of 150 Ω resistor it can build with– **Two 50 Ω in series and two 100 Ω parallel**
- With the rise in temperature the insulating property of an insulator– **Weakness**
- If the voltage across a load is to be dropped, a resistor should be placed in– **Series**
- For a dc voltage an inductor– **Is virtually a short circuit**
- In a parallel combination of three resistances, the total resistance of a circuit is– $\dfrac{R_1R_2R_3}{R_1R_2 + R_2R_3 + R_1R_3}$
- If the diameter of a metal wire of a given length is doubled, its resistance will– **Be 1/4 th time**
- If a number of resistors are connected in parallel, the reciprocal of the combined resistance is equal to the– **Sum of the reciprocal of the individual resistances**
- 1 Mega ohm, 1 Watt resistance is likely to be a– **Carbon resistor**
- In an electric circuit electrons flows from a point of– **Lower potential to higher potential**
- When n numbers resistances of each value r are connected in parallel, then the resultant resistance is x. When these n resistances are connected in series. total resistance is– $\mathbf{n^2x}$
- Four resistance R_1, R_2, R_3 & R_4 are connected in series across a 220 V supply. The resistances are such that, $R_1 > R_2 > R_3 > R_4$. The least power consumption will be in– $\mathbf{R_4}$
- EMF in a circuit– **Maintains potential difference**

- A resistance of 5 ohms is further drawn so that its length becomes double. Its resistance will now be– **20Ω**
- For a fixed supply voltage the current flowing through a conductor will increase when it– **Length is reduced**
- The substances which have a large number of free electrons and offer a low resistance are called– **Conductors**
- ..... happenes to the resistance of a conductor if its length is increased three times and diameter is halved– **Resistance is increased 12 times**
- For current to flow, a circuit must be– **Complete**
- Temperature coefficient of resistance is defined as– **Increase in resistance per ohm per ^{0}C**
- For a series as well as a parallel circuit– **Powers are additive**
- A resistor R_1 dissipates the power P when connected to a certain generator. If resistance R_2 is put in series with R_1, the power dissipated by R_1– **Decreases**
- Two resistances R_1 and R_2 are connected in series across the voltage source where $R_2 > R_1$. The largest drop will be across– **R_2**
- The hot resistance of the bulb's filament is higher than its cold resistance because the temperature co-efficient of the filament is– **Positive**
- Varistors are– **Non-linear resistors**
- Insulating materials have the function of– **Preventing a short circuit between conducting wires and leakage current**
- In a conductor, current density is the– **Current flowing per unit area**
- Formula of specific resistance is– $\rho = \frac{R.a}{\ell}\Omega\text{-m}$
- The resistivity of insulators at room temperature is– **Between 10^9 to 10^{18} ohm cm**
- Which expression is electric field strength– **$E = D/\varepsilon$**
- In M.K.S. system one Kilo Watt is equal to– **1.35 HP**
- Which material has 95% electrical conductivity - **Silver**
- The element which is capable of delivering energy by its own is known as– **Active element**
- Potential Difference is– **Scalar Quantity**
- In power control circuit the resistor used are– **Wire wound resistor**
- A rheostat differs from potentiometer in the respect that it– **Has higher wattage rating**
- Find unit of power is – **Watt**
- The rate of doing work is called – **Power**
- One calorie heat energy is equal to the electrical energy of - $\frac{10^{-3}}{860}$**kWh**
- Neutral is a circuit conductor that normally carries .....back to the source- **Current**
- Electron volt is the unit of – **Energy**
- Essential condition for the transfer of heat from body to another by means of conduction– **Both the bodies must be at different temperatures**
- The C.G.S. unit of heat is– **Calorie**
- 1 newton is the same as– **10^5 dynes**
- One B.O.T. unit is – **1 kWh**
- SI symbol given by SI system for thermodynamic temperature– **K**
- ..... energy does a 100 watt bulb consume in day – **2400 Wh**
- Electric current passing through the circuit produces– **Magnetic effect, Luminous effect, Thermal effect**
- If the efficiency of a machine is to be high, what should be low– **Losses**
- A heater with short circuited heating element is tested with a series test lamp, the test lamp will– **Glow normally**
- An electron having mass 'm' kg and charge 'e' coulomb travels from rest through a potential difference of 'V' volts. It has a kinetic energy of– **eV Joules**
- One newton meter is same as – **One joule**
- The S.I. unit of electrical energy is – **Joule**
- 'Erg' is a unit of measurement for – **Energy**
- Sparking occurs when a load is switched off because the circuit has high– **Inductance**
- When resistance element of a heater fuses and then we reconnect it after removing a portion of it, the power of the heater will– **Increase**
- If I, R and t are the current, resistance and time respectively, then according to joule's law heat produced will be proportional to– **I^2Rt**
- If w is energy, t is time and q is charge in an element then the voltage across the element is– $\frac{dw}{dq}$
- One unit of electrical energy equals – **1 KWh**
- Insulation resistance is expressed by – **Mega ohm**
- Conduct the electricity easily – **Sea water**
- Production of heat due to current is related by which law– **Joule's law**
- The resistors are normally specified by– **Nominal value of the resistor, tolerance limit for the resistance value, loading capacity in watts**
- For testing appliances, the wattage of test lamp should be– **High**
- For determining of sign for emf a rise in potential should be considered– **Both positive and negative**
- The heating element of an electric heater should be made with a material which should have– **High specific resistance and high melting point**
- Ampere-hour is the unit of– **Energy**

Important Objective Questions asked in various Exams.

1. In a capacitor, if a charge of 1 coulomb accumulates on each plate when a potential difference of 1 volt is applied across the plates, then the capacitance will be _____.

(a) 1 microfarad (b) 1 farad
(c) 1 nano-farad (d) 1 picofarad

SSC JE-06.06.2024, Shift-II

Ans. (b) : Given,

Q = 1 Coulomb

V = 1 Volt, C = ?

We know that,

$$C = \frac{Q}{V}$$

$$C = \frac{1}{1} = 1\,\text{Farad}$$

$$\boxed{C = 1\,\text{Farad}}$$

2. In case of electrical installations, if cable conductors are spiralling, then the resistance/unit length will _____.

(a) increase (b) decrease
(c) become zero (d) remain the same

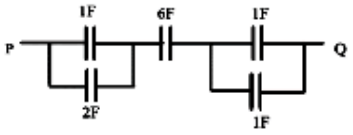
SSC JE-06.06.2024, Shift-II

Ans. (a) : In case of electrical installations, if cable conductors are spiralling, then the resistance per unit length will increase.

When cable conductors are spiralling the effective length of the conductor increases due to the spiralling pattern. As a result the resistance per unit length of the conductor increases.

$$\boxed{R = \frac{\rho \ell}{A}\Omega}$$

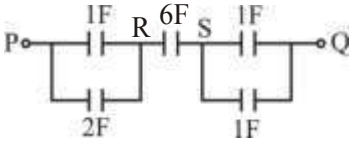
3. The total capacitance between points P and Q in the figure is:



(a) $\frac{46}{6}$F (b) 1 F
(c) 11 F (d) 10 F

SSC JE-06.06.2024, Shift-II

Ans. (b) : Given,



C_{PR} = 1+2 =3F

C_{SQ} = 1+1 =2F

Here all capacitances are connected in series, so

$$\frac{1}{C_{PQ}} = \frac{1}{3} + \frac{1}{6} + \frac{1}{2}$$

$$\frac{1}{C_{PQ}} = \frac{2+1+3}{6}$$

$$\Rightarrow \quad \boxed{C_{PQ} = 1F}$$

4. The energy consumed by a 5Ω resistor carrying a 20A current in 10 minutes will be ____.

(a) 120 KJ (b) 1200 KJ
(c) 2000 J (d) 120 J

SSC JE-06.06.2024, Shift-II

Ans. (b) : Given,

R = 5Ω, I = 20A

t = 10 minutes = 10×60 = 600 seconds

So, The energy consumed by 5Ω resistor,

$H = I^2Rt$

$H = (20)^2 \times 5 \times 600$

$$\boxed{H = 1200KJ}$$

5. How is the resistance of a wire related to the length of the wire?

(a) Not related
(b) Directly proportional
(c) Proportional to square of length
(d) Inversely proportional

SSC JE-06.06.2024, Shift-II

Ans. (b) : The resistance of a wire is directly proportional to the length of the wire.

Resistance (R) = $\boxed{\frac{\rho \ell}{A}\text{ohm}}$

Where,

R = Resistance of the wire

ℓ = Length of the wire

ρ = Resistivity

A = cross-sectional area

6. In a parallel circuit, if 'n' resistors, each of 'R' Ω, are connected in parallel, then the total resistance is equal to _____.

(a) R/n (b) R×n
(c) R+n (d) $(R^2)/n$

SSC JE-06.06.2024, Shift-II

Ans. (a) : When 'n' resistors, each of 'R' ohm are connected in parallel, then the total resistance,

$$\Rightarrow \quad \boxed{R_{eq} = \frac{R}{n}\Omega}$$

- When 'n' resistors, each of 'R' ohm are connected in series , then the total resistance,

$$\boxed{R_{eq} = nR}\,\Omega$$

7. In an inductor, if the coil is wound on an insulating bobbin, without any magnetic material as core, then the inductor is called _____ .

(a) iron-cored inductor
(b) air-cored inductor
(c) ferrite-cored inductor
(d) variable inductor

SSC JE-05.06.2024, Shift-III

Ans. (b) : In an inductor, if the coil is wound on an insulating bobbin, without any magnetic material as core, then the inductor is called air-cored inductor.

• Air core inductor, is an inductor without a magnetic core, but rather supported with only air inside of the coil. Coils are generally produced with copper material, insulated wire, stripped and non-stripped ends and tinned or bare ends.

8. Ten capacitors, each of capacitance 20 μ F, are first connected in series and then in parallel. The ratio of the equivalent capacitance in series to the equivalent capacitance in parallel is:

(a) 1/200 (b) 1/250
(c) 1/100 (d) 1/400

SSC JE-05.06.2024, Shift-III

Ans. (c) : Given,
Capacitance of each capacitor (C) = 20μF
No. of capacitor (n) = 10
When 'n' number of equal capacitor are connected in series and parallel then equivalent capacitance are respectively-

$$C_{series} = \frac{C}{n}, \quad C_{parallel} = nC$$

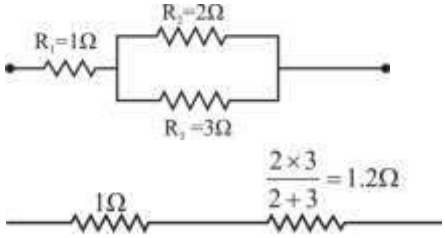
$$\frac{C_{series}}{C_{parallel}} = \frac{\frac{C}{n}}{nC} = \frac{1}{n^2} = \frac{1}{(10)^2} = \frac{1}{100}$$

9. If $R_1 = 1\ \Omega$, $R_2 = 2\ \Omega$, $R_3 = 3\ \Omega$, R_2 and R_3 are connected in parallel and the combination is in series with R_1, then the total resistance will be _ _ _ _ _ .

(a) 1.5 Ω (b) 1.2 Ω
(c) 2.2 Ω (d) 2.8 Ω

SSC JE-05.06.2024, Shift-III

Ans. (c) : Given,
$R_1 = 1\Omega$, R_2 2Ω, $R_3 = 3\Omega$



$R_T = 1+1.2 = 2.2\Omega$

10. In resistors, if the temperature is increased, then the resistance of alloys will _____ .

(a) remain the same (b) decrease
(c) become zero (d) increase

SSC JE-05.06.2024, Shift-III

Ans. (d) : In resistors, if the temperature is increased then the resistance of alloy will increase.

● Resistance is directly proportional to temperature which means whenever temperature increases, the resistance of resistor will also tend to increase.

$$\boxed{R_T = R_0(1+\alpha\Delta T)}$$

11. A voltage source of $V(t) = (10t^3 – 5t + 10)$ Volt is applied across a 10F capacitor, the current through the capacitor at t = 2 sec is _____.

(a) 1000 A (b) 1160 A
(c) 1150 A (d) 1100 A

SSC JE-05.06.2024, Shift-III

Ans. (c) : Given,
$V(t) = (10t^3 – 5t + 10)$ volt
capacitor (C) = 10F
time(t) = 2sec

Current through capacitor $(i) = C\frac{dV}{dt}$

$$i = 10\frac{d}{dt}(10t^3 - 5t + 10)$$

$$i = 10(30t^2 – 5)$$

At, t = 2 sec.
$i = 10(30\times2^2 – 5)$
$i = 10\times115$
$i = 1150A$

12. Eight capacitors of the same value are connected in series. Their equivalent capacitance is 200 μ F, the capacitance of each capacitor is _ _ _ _ _ _ _ _ _ .

(a) 16 μ F (b) 25 μ F
(c) 160 μ F (d) 16×10^{-4} F

SSC JE-05.06.2024, Shift-III

Ans. (d) : Given,
Number of capacitor of the same value (n) = 8
Series equivalent capacitance C_{eq} = 200μF
Capacitance of each capacitor (C) = ?

$$C_{eq} = \frac{C}{n}$$

$$200\mu F = \frac{C}{8}$$

$C = 200\times8\mu F = 1600\mu F$
$C = 16\times10^{-4}F$

13. How much energy in "kilowatt hours" is consumed in operating ten 100-watt bulbs for 20 hours per day in a month (30 days)?

(a) 600 kilowatt-hours
(b) 10000 kilowatt-hours
(c) 5000 kilowatt-hours
(d) 600000 kilowatt-hours

SSC JE-05.06.2024, Shift-III

Ans. (a) : Given,
Rating of bulb (P) = 100W
No. of bulb = 10
Time (t) = 20×30 = 600 hours

Energy = P ×t

$= \frac{10 \times 100 \times 600}{1000}$

Energy = 600 kWh

14. If the distance between the plates of a parallel plate capacitor is increased 10 times and the area is reduced to one-fourth, then its capacitance _____.

(a) becomes $\frac{1}{40}$ times

(b) becomes one half

(c) increases 2.5 times

(d) becomes 40 times

SSC JE-07.06.2024, Shift-III

Ans. (a) : Parallel plates capacitance-

$C_1 = \frac{\varepsilon_0 \varepsilon_r A_1}{d_1}$ …….. (i)

If, $d_2 = 10d_1$

$A_2 = \frac{A_1}{4}$

Then, capacitance $(C_2) = \frac{\varepsilon_0 \varepsilon_r A_2}{d_2}$

$C_2 = \frac{\varepsilon_0 \varepsilon_r A_1 / 4}{10 d_1}$

$C_2 = \frac{1}{40}\left(\frac{\varepsilon_0 \varepsilon_r A_1}{d_1}\right)$

$C_2 = \frac{1}{40} C_1$

15. Which of the following factors will NOT affect the selection of a resistor?

(a) Frequency range

(b) Tolerance

(c) Thermal resistivity

(d) Power rating (in watts)

SSC JE-07.06.2024, Shift-III

Ans. (a) : Frequency range will not affect the selection of a resistor.

Following factor will affect the selection of a resistance-

- Tolerance
- Thermal resistivity
- Power rating (in Watt)
- Voltage rating
- Long-term stability
- High temperature performance.

16. Which of the following factors will NOT affect the selection of an inductor?

(a) Power loss

(b) Dielectric constant

(c) Current rating

(d) Quality factor

SSC JE-07.06.2024, Shift-III

Ans. (b) : Dielectric constant will not affect the selection of an inductor.

Following factors affect the selection of an inductor-

(i) Power loss

(ii) Current rating

(iii) Quality factor

Quality factor (Q) = $\frac{2\pi fL}{R}$

17. In heating effect, if 'I' is the current flowing through the conductor in 't' seconds having a resistance 'R', then the electrical energy supplied is _____.

(a) IR^2t joules (b) I^2Rt joules

(c) I^2R/t joules (d) IR^2/t joules

SSC JE-07.06.2024, Shift-III

Ans. (b) : According to Joules law, the amount of work required to maintain a current of I amperes through a resistance 'R' ohm for t second, then the electrical energy supplied is →

Electrical energy = I^2Rt joules

18. The value of inductance needed to store 4kWh of energy in a coil carrying a 2000A current is:

(a) 7.2×10^6 H (b) 7.2 H

(c) 720 H (d) 72 H

SSC JE-07.06.2024, Shift-III

Ans. (b) : Given that,

Stored energy in a inductor = $4 \times 10^3 \times 3600$ watt-sec.

Current (I) = 2000A

Stored energy = $\frac{1}{2}LI^2$

$4 \times 10^3 \times 3600 = \frac{1}{2} \times L \times 2000 \times 2000$

L = 7.2 H

19. A 4Ω resistor has a specified maximum power dissipation of 784 W. Calculate its maximum current level.

(a) 16 A (b) 14 A

(c) 196 A (d) 10 A

SSC JE-07.06.2024, Shift-III

Ans. (b) : Given that,

Resistance (R) = 4Ω

Maximum power dissipation (P) = 784 W

$I = \sqrt{\frac{P}{R}}$

$= \sqrt{\frac{784}{4}}$

$= \sqrt{196}$

= 14A

20. In case of electrical energy, the joule is also expressed as the _____.

(a) newton-second (b) meter-second

(c) watt-second (d) joule-second

SSC JE-11.10.2023, Shift-III

Ans. (c) : The joule is the SI unit of energy a measure of the capacity to do work or generate heat.

$$\boxed{1 \text{ Joule} = \text{One watt} - \text{second}}$$

21. If 15A current is flowing through a solenoid of inductance 4H, find the magnetic energy stored in the solenoid.

(a) 450 J (b) 540 J
(c) 100 J (d) 1000 J

SSC JE-11.10.2023, Shift-III

Ans. (a) : Given,

I= 15 A, L= 4H

Then,

Energy stored in the solenoid-

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

$$= \frac{1}{2}\times 4\times(15)^2 = \frac{1}{2}\times 4\times 225$$

$$\boxed{E = 450 \text{ Joule}}$$

22. A coil consists of 1000 turns having a cross-sectional area of 0.4 mm^2. The mean length per turn is 40 cm and the resistivity of the wire is 0.02μΩ–m. The resistance of the coil is _____.

(a) 400Ω (b) 20μΩ
(c) 200Ω (d) 20Ω

SSC JE-11.10.2023, Shift-III

Ans. (d) : Given,

Total length $\ell = 1000\times 40$ cm$= 1000\times 0.4$m$= 400$ m

$A = 0.4\ mm^2 = 0.4\times(10^{-3})^2 = 0.4\times 10^{-6} m^2$

$\rho = 0.02\mu\Omega\text{-m} = 0.02\times 10^{-6}\Omega\text{-m}$

then,

$$R = \frac{\rho\ell}{A}$$

$$= \frac{0.02\times 10^{-6}\times 400}{0.4\times 10^{-6}} = 20\Omega$$

23. The capacitance of a parallel plate capacitor having two plates of area A = 200 cm^2 and separated by distance d = 10 cm is given by _____ if the permittivity of medium is 8.854 $\times 10^{-12}$ F/m

(a) 17.7 μF (b) 17.7×10^{-7} μF
(c) 17.7 F (d) 17.7 PF

SSC JE-11.10.2023, Shift-III

Ans. (b) : Given,

$A = 200\ cm^2 = 200\times 10^{-4} m^2$

$d = 10\ cm = 10\times 10^{-2} = 10^{-1} m$

$\varepsilon_0 = 8.854\times 10^{-12}\ F/m$

$$\therefore\quad C = \frac{\varepsilon_0 A}{d}$$

$$= \frac{8.854\times 10^{-12}\times 200\times 10^{-4}}{10^{-1}}$$

$= 1.7708\times 10^{-12} F$

$= 1.77\times 10^{-12}\times 10^{6}\mu F$

$= 17.7\times 10^{-7}\mu F$

24. A constant voltage source is applied between the two ends of a wire. If the length of the wire is doubled and the radius remains the same, then the rate of heat developed in the wire ____.

(a) will be 4 times (b) will be zero
(c) will be halved (d) will remain the same

SSC JE-11.10.2023, Shift-III

Ans. (c) : We know that

$$H \propto \frac{1}{R} \qquad \left\{H = \frac{V^2}{R}t\right\}$$

From question

$$R_1 = \frac{\rho\ell}{A}$$

Again $R_2 = \frac{2\rho\ell}{A}$

then $H_1 \propto \frac{1}{R_1}$.....(i)

& $H_2 \propto \frac{1}{R_2}$.....(ii)

dividing (i) & (ii)

$$\frac{H_1}{H_2} = \frac{R_2}{R_1}$$

$$\frac{H_1}{H_2} = \frac{2\rho\ell}{A}\times\frac{A}{\rho\ell}$$

$$\therefore\quad \frac{H_1}{H_2} = \frac{2}{1}$$

$$\therefore\quad H_2 = \frac{1}{2}H_1$$

So heat developed will be halved.

25. A heater of resistance 300Ω is connected to the main supply for 10 minutes. If the heat produced in the heater during this time is 18 J, then find the current through it.

(a) 10A (b) 100A
(c) 0.10A (d) 0.01A

SSC JE-10.10.2023, Shift-II

Ans. (d) : Given:

R = 300Ω, t = 10 minutes = 600 second

Heat (H) = 18 joule, I =?

We know that,

$H = I^2Rt$

$18 = I^2\times 300\times 600$

$I^2 = 1\times 10^{-4}$

$\Rightarrow\quad \boxed{I = 0.01A}$

26. A wire of resistance 88 Ω is stretched to twice its original length. The resistance of a stretched wire would be _____.

(a) 176Ω (b) 352Ω
(c) 88Ω (d) 22Ω

SSC JE-10.10.2023, Shift-II

Ans. (b) : Given that,

R = 88Ω and length is twice its original length

$$\boxed{R = \frac{\rho \ell}{a}}$$

$V_1 = V_2$

$a_1(\ell) = a_2(2\ell)$

$$a_2 = \frac{a_1 \ell}{2\ell}$$

$$\boxed{a_2 = a_1/2}$$

$$R_1 = \frac{\rho \times 2\ell}{a_1/2}$$

$$R_1 = \frac{4\rho\ell}{a_1} = 4R$$

$R_1 = 4 \times 88$

$$\boxed{R_1 = 352\Omega}$$

27. Calculate the resistance per metre length of a wire of diameter 40 mm and specific resistance of 3.14×10^{-4} Ω-m:

(a) 4 Ω (b) $\frac{1}{4}\Omega$

(c) 40Ω (d) 400Ω

SSC JE-10.10.2023, Shift-II

Ans. (b) : Given that,

D = 40mm

$$r = D/2 = \frac{40}{2} = 20mm$$

Specific resistance (ρ) = 3.14×10^{-4}Ω–m

We know that,

$$R = \frac{\rho \ell}{A}, A = \pi r^2$$

$$R = \frac{\rho \ell}{A}$$

$$\frac{R}{\ell} = \frac{3.14 \times 10^{-4}}{3.14 \times \left(20 \times 10^{-3}\right)^2} = \frac{3.14 \times 10^{-4}}{3.14 \times 400 \times 10^{-6}}$$

$$\frac{R}{\ell} = \frac{100}{400} = \frac{1}{4}$$

From the given option taking ℓ = unity

Then,

$$\boxed{R = \frac{1}{4}\Omega}$$

28. The ability of a capacitor to store charge does NOT depend on the .....

(a) Amount of charge

(b) Distance between the plates

(c) Areas of the plates

(d) Nature of the insulating material

SSC JE-09.11.2023, Shift-III

Ans. (a) : Capacitance $(C) = \frac{\varepsilon_0 \varepsilon_r A}{d}$

Capacitance depends -

1. Distance between the plates
2. Area of the plates
3. Natures of the insulating material

The ability of a capacitor to store charge does not depend on the amount of charge.

29. A capacitor is allowed to accumulate the charge through a 3.5A current. How much time will it require to accumulate a charge of 70μC charge?

(a) 20 sec (b) 20μ sec

(c) 200μ sec (d) 2μ sec

SSC JE-15.11.2022, Shift-II

Ans. (b) Given,

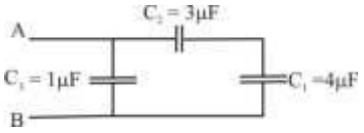
i = 3.5A, Q = 70μC

Q = it

$$t = \frac{Q}{i} = \frac{70 \times 10^{-6}}{3.5}$$

$$\boxed{t = 20\mu sec.}$$

30. Find the equivalent capacitance between A and B.

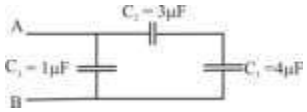


(a) $\frac{19}{7}$F (b) $\frac{7}{19}\mu F$

(c) $\frac{7}{8}\mu F$ (d) $\frac{19}{7}\mu F$

SSC JE-15.11.2022, Shift-II

Ans. (d)



$$C_{AB} = C_3 + C_2 \| C_1$$

$$= 1 + \frac{3 \times 4}{7}$$

$$C_{AB} = \frac{19}{7}\mu F$$

31. Select the correct dual pair of voltage source, current source, inductor and capacitor.

(a) Current source, voltage source, capacitor and resistor

(b) Voltage source, current source, capacitor and inductor

(c) Current source, voltage source, capacitor and inductor

(d) Current source, voltage source, resistor and inductor

SSC JE-15.11.2022, Shift-II

Ans. (c) Dual pair -

Voltage source	-	Current source
Current source	-	Voltage source
Inductor	-	Capacitor
Capacitor	-	Inductor
Mesh	-	Node
Charge	-	Flux Linkage

32. A circuit has an inductance of 20H. If the current in the circuit changes at the rate of 50mA/sec, then self-induced EMF is _____.

(a) 100 V (b) 1 V
(c) 1000 V (d) 1 mV

SSC JE-16.11.2022, Shift-III

Ans. (b) Given that,

$L = 20H$

$\frac{di}{dt} = 50\times10^{-3}\,A/sec$

Self EMF (E) = ?

$E = L\frac{di}{dt}$

$E = 20\times50\times10^{-3}$

$E = 1V$

33. The resistivity of a wire depends on:

(a) Only the radius of the wire
(b) both the length and area of the cross-section of the wire
(c) only the length of the wire
(d) the nature of the material of the wire

SSC JE-16.11.2022, Shift-III

Ans. (d) $R = \rho\frac{\ell}{A}$

Where, $R \rightarrow$ Resistance

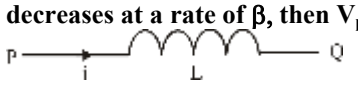
$\rho \rightarrow$ Resistivity

$\ell \rightarrow$ Length

$A \rightarrow$ Area

Resistivity is numerically equal to the resistance of a substance having unit length and unit cross section area. The resistivity of a wire depends on the nature of the material of the wire because it is the intrinsic property of the substance thus it is independent of shape and size of the body i.e. length and area.

34. In the figure shown below, if the current I decreases at a rate of β, then V_P- V_Q is



(a) 0 V (b) $L\times\frac{di}{dt}\times\beta$
(c) - L β (d) + L β

SSC JE-16.11.2022, Shift-III

Ans. (c) Given that:

Current decreasing rate $= \frac{di}{dt} = \beta$

From the above figure.

$V_{PQ} = V_P - V_Q$

$V_{PQ} = -L\frac{di}{dt}$

$\boxed{V_{PQ} = -L\beta}$

35. Which of the following expressions gives the Joule's law of heating?

(a) H α IRt (b) H α IR^2t
(c) H α I^2Rt (d) H α I^2R/t

RRB JE 19.09.2019 Shift-II

Ans. (c) : Joule's law of heating states that when a current (I) passes through a conductor of resistance (R) for time (t) then the heat developed in the conductor is equal to the product of the square of the current, the resistance and time.

or $H = I^2Rt$

Then $H \propto I^2Rt$

36. The SI unit of conductivity is-

(a) Ohm-m (b) Ohm/m
(c) Mho-m (d) Mho/m

DSSSB JE 14.03.2021, Shift-I
NPCIL ST 2019 (Kakrapar)
MPMKVVCL (Bhopal) JE 2018
UPPCL JE 2018, Shift-II
Vizag steel JET 25.10.2018, Shift-II
UPPCL JE 27.08.2018, Shift-I
SSC JE 22.01.2018, Shift-I
HPSSB JE 2017 (Post code-579)
KPTCL JE 2015
SSC JE 2014, Shift-I
PGCIL Diploma Trainee 14.11.2011

Ans. (d) : The SI unit of conductivity is Mho/m.

$\because \quad R = \frac{\ell}{\sigma A}$

So, $\sigma = \frac{\ell}{RA} = \frac{\text{meter}}{\text{ohm}(\text{meter})^2}$

$= (\text{ohm meter})^{-1}$

$= \text{mho/meter} \qquad \because \Omega^{-1} = \text{mho}$

37. Which of the following conductors has the lowest resistivity?

(a) Aluminium (b) Copper
(c) Gold (d) Silver

UPPCL JE 07.09.2021, Shift-I
NPCIL ST 2019 (Kakrapar)

Ans. (d) : Descending order of conductivity is given as follows

Ag > Cu > Au > Al

$\because$ Conductivity $(\sigma) \propto \frac{1}{\text{Resistivity}(\rho)}$

So, Ascending order of resistivity

Ag < Cu < Au < Al

38. Conventional flow of electric current is from:

(a) +ve to –ve (b) –ve to +ve
(c) Phase to neutral (d) Neutral to phase

Kerala PSC Asst: Gr. II Electrical Inspectorate 2015

Ans. (a) : Electric current always flow from positive terminal to negative terminal or it always flow from higher potential to lower potential.

39. A 100-watt light bulb turned on for 8 hours used:

(a) 80 Wh (b) 0.8 kWh
(c) 8 kWh (d) None of the above

BWSSB Code 222, 26.05.2017
DGVCL JE 2016

Ans. (b) : Given,

$$P = 100 \text{ Watt} = \frac{100}{1000} kW = 0.1 \text{ kW}$$

$t = 8$ hour

$E = ?$

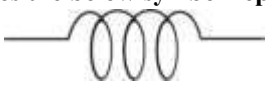
$$\boxed{\underset{[kWh]}{\text{Energy}(E)} = \underset{[kW]}{\text{Power}} \times \underset{[Hour]}{\text{time}}}$$

Total Energy consumed by the bulb $\boxed{E = P \times t}$ kWh

$$E = 0.1 \times 8 \text{ kWh}$$

$$\boxed{E = 0.8} \text{ kWh}$$

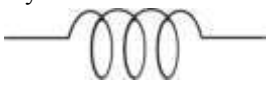
40. What does the below symbol represent?



(a) Transformer (b) Capacitor
(c) Resistor (d) Inductor

ESIC JE 2019

Ans. (d) : Given symbol-



Given symbol represents an inductor. Inductor is a device that store the energy in magnetic field. If a coil have N number of turns and current flow through it is 'I' then inductance can be given by-

$$\boxed{L = \frac{N\phi}{I}}$$

41. Select the option that correctly matches the various measuring parameters with their respective SI units.

1. Resistance	**i. Joule**
2. Capacitance	**ii. Ohm**
3. Energy	**iii. Henry**
4. Inductance	**iv. Farad**

(a) 1-iv, 2-iii, 3-ii, 4-i (b) 1-ii, 2-iv, 3-i, 4-iii
(c) 1-i, 2-iii, 3-ii, 4-iv (d) 1-iv, 2-i, 3-ii, 4-ii

ESIC JE 2019

Ans. (b) :

Measuring Parameters	**SI unit**
Resistance	Ohm
Capacitance	Farad
Energy	Joule

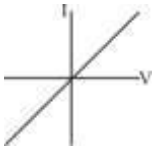
42. The Ohm's law is NOT valid for:

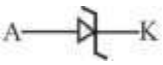
(a) resistors connected in parallel
(b) resistors connected in series
(c) linear inductors
(d) zener diode working in zener region

EESL Engineer (Technical) 2020

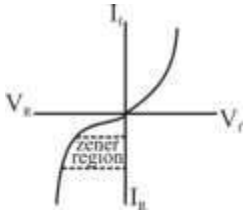
Ans. (d) : Ohm's Law V=IR
According to Ohm's Law
Voltage & current has linear relationship

As shown in characteristic curve



Zener diode symbol 

A zener diode works in reverse bias which does not follow Ohm's law due to its non linear characteristics

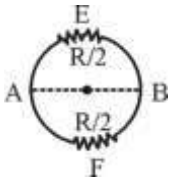


43. A wire of resistance of 6 ohms is bent in the form of a circle, the effective resistance between two points on any diameter is

(a) 6 ohm (b) 12 ohm
(c) 1.5 ohm (d) 9 ohm

KSEB Sub Engineer 2015

Ans. (c) :



Resistance of section $AEB = R_1 = \frac{R}{2}$

Similarly Resistance of section

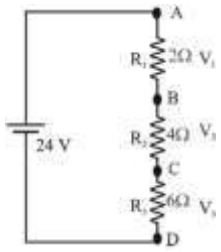
$$AFB = R_2 = \frac{R}{2}$$

These two resistances are in parallel combination

Hence, $R_T = \frac{R}{2} \| \frac{R}{2} = \frac{R}{4}$

$R = 6\ \Omega$ given $\therefore \boxed{R_T = \frac{6}{4} = 1.5\Omega}$

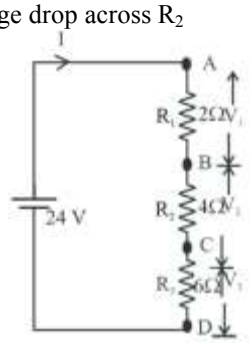
44. The value of V_2 (the voltage drop across R_2) in the circuit shown is:



(a) 4V (b) 8 V
(c) 12 V (d) 16 V

PGCIL SR-I, 22.08.2021
MPPKVVCL JE-2018

Ans. (b) : Voltage drop across R_2



Applying voltage division rule

$$V_2 = \frac{4}{2+4+6} \times 24 = \frac{4}{12} \times 24$$

$$V_2 = 8\,\text{Volts}$$

45. The hot resistance of the filament of a bulb is higher than the cold resistance because the temperature coefficient of the filament is

(a) Negative (b) Infinite
(c) Zero (d) Positive

HPSSSB JE 2018 (Post code 663)

Ans. (d) : The hot resistance of the filament of a bulb is higher than the cold resistance because the temperature coefficient of the filament is positive.

46. Which of the following does not effect the capacitance of a capacitor?

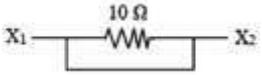
(a) Distance between the plates
(b) Area of the plates
(c) Type of dielectric medium
(d) Thickness of the plates

KPTCL JE 2015

Ans. (d) : Capacitance $(C) = \frac{\varepsilon A}{d}$

ε = dielectric medium, A = Area,
d = Distance between plate
Capacitance (C) does not depends on thickness of plate.

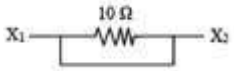
47. The equivalent resistance between X_1 and X_2 is:



(a) 10 Ω (b) greater than 10 Ω
(c) zero (d) less than 10 Ω

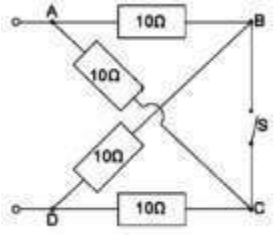
JUVNL JE-2017

Ans. (c) :



When two points of circuit are connected together by a thick metallic wire, they are said to be short circuited. Since 'short circuit' has practically zero resistance.

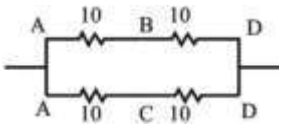
48. In the circuit shown below, determine R_{AD}.



(a) 0.1 Ω (b) 0.05 Ω
(c) 20 Ω (d) 10 Ω

JUVNL JE-2017

Ans. (d) :



$$R_{AB} = \frac{(10+10)\times(10+10)}{(10+10+10+10)} + \frac{400}{40} = 10\Omega$$

49. How much power (in W) will be dissipated by a 5 Ohm resistor in which the value of current is 2 A?

(a) 10 (b) 30
(c) 20 (d) 40

SSC JE 24.01.2018, Shift-II

Ans. (c) : Given
Resistance (R) = 5Ω
Electric current (I) = 2 Amp.
Power (P) = $I^2 R$
= 2 × 2 × 5
Power (P) = 20 watt

50. Which of the following is NOT a type of capacitor?

(a) Ceramic (b) Electrolytic
(c) Film (d) Wire wound

SSC JE 27.01.2018, Shift-I

Ans. (d) : Ceramic, Film and electrolytic are different types of a capacitor, through wire wound is a type of resistor. Wire wound resistance is an electrically inactive element. Manganin or nichrome wire is used to wound over core material of ceramic or glass to construct wire wound resistors. It's power rating is high. It is often used in high power resistor application.

51. The dimensions of a cuboidal metal strip are a = 5 cm, b = 15 cm and c = 10 cm. What is the ratio of resistances R_a : R_b : R_c between the respective pairs of opposite faces?

(a) 1 : 3 : 5 (b) 1 : 3 : 2
(c) 1 : 9 : 4 (d) 1 : 9 : 16

SSC JE 23.01.2018, Shift-I

Ans : (c) $R_a = \frac{\rho \ell}{A}$

When the length is a, then cross section area is b×c for cuboidal strip-

$$R_a = \frac{a}{b \times c} \Rightarrow R_a = \frac{5}{150} = \frac{1}{30}$$

Similarly

$$R_b = \frac{b}{a \times c} \Rightarrow R_b = \frac{15}{50} = \frac{3}{10}$$

and $R_c = \frac{c}{b \times a}$

$$R_c = \frac{10}{75} = \frac{2}{15}$$

$$R_a : R_b : R_c = \frac{1}{30} : \frac{3}{10} : \frac{2}{15}$$

$$\boxed{R_a : R_b : R_c = 1 : 9 : 4}$$

52. The resistivity of a conductor depends upon…..

(a) pressure
(b) temperature
(c) degree of illumination
(d) shape of cross–section

SSC JE 23.01.2018, Shift-II

Ans : (b) The resistivity of conductor depends upon temperature because the value of resistance coefficient changed with change in temperature.

$$R_t = R_0(1+\alpha_0 t)$$

$t = {}^0C$ (in centigrade)

α_0 = Resistance temperature coefficient

53. Specific resistance of a conductor depends upon :

(a) Dimension of the conductor
(b) Composition of conductor material
(c) Resistance of the conductor
(d) Both (a) and (b)

SSC JE 2009

Ans. : (b) Specific resistance of a conductor depends upon composition of conductor material and temperature also.

- Specific resistance does not depend on dimension of the conductor.

- **Resistivity or Specific resistance** - $(\rho) = \frac{RA}{\ell}$

The resistivity of a material is the resistance of a wire of that material of unit length and unit cross-sectional area.

54. Resistance temperature coefficient of copper at 20 °C is

(a) 0.0045/°C (b) 0.0017/°C
(c) 0.00393/°C (d) 0.0038/°C

SSC JE 2013

Ans: (c)

∵ Resistance at temperature T is

$R_T = R_0 (1+ \alpha\Delta T)$

Where,

R_0 = Resistance at 0°C

ΔT = temperature change

α = temperature coefficient of resistance

Copper is a conductor, hence α will be positive. The value of α is 0.00393/°C at 20°C.

55. Which of the following is the dimensional formula for conductivity?

(a) $M^{-1}L^{-3}T^3A^2$ (b) $ML^3T^{-3}A^{-2}$
(c) $M^2L^2T^{-3}A^{-2}$ (d) $ML^2T^3A^{-2}$

PGCIL NR-I, 13.08.2021
SSC JE 25.01.2018, Shift-I
SSC JE 22.01.2018, Shift-I

Ans : (a) We know that : –

$$\boxed{\text{Work} = \text{Force} \times \text{Displacement}}$$

Dimension of work = $[MLT^{-2}]\,[L] = [ML^2T^{-2}]$

Since. $\boxed{W = QV}$ Here $\begin{Bmatrix} Q = \text{Charge} \\ V = \text{electric potential} \end{Bmatrix}$

$$V = \frac{W}{Q} = \frac{W}{I \times t}$$

$$= \frac{[ML^2T^{-2}]}{[AT]} \qquad V = [ML^2T^{-3}A^{-1}]$$

$$\boxed{R = \frac{V}{I}} = \frac{[ML^2T^{-3}A^{-1}]}{[A]} = [ML^2T^{-3}A^{-2}]$$

Thus $\left[\rho = \frac{RA}{\ell}\right]$ Here $\begin{Bmatrix} \rho = \text{Resistivity} \\ A = \text{Area} \\ l = \text{length} \end{Bmatrix}$

$$\rho = \frac{[ML^2T^{-3}A^{-2}][L^2]}{[L]}$$

$$\rho = [ML^3T^{-3}A^{-2}]$$

Dimension of conductivity $(\sigma) = \frac{1}{\rho} = \frac{1}{[ML^3T^{-3}A^{-2}]}$

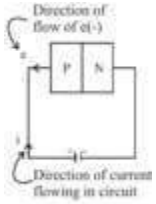
$$= [M^{-1}L^{-3}T^3A^2]$$

56. Which of the following statement is TRUE?

(a) The current always flow in the direction of flow of electrons.
(b) The current always flows opposite to the direction of flow of electrons.
(c) The current always flows from negative terminal to positive terminal.
(d) The electrons always flow from positive terminal to negative terminal.

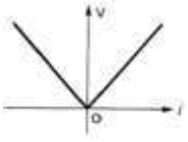
SSC JE 25.01.2018, Shift-I

Ans : (b)



From this figure, we can see that electric current always flows in opposite direction of flow of electrons (e^-)

57. The v-i characteristic of an element is shown in the figure given below. The element is



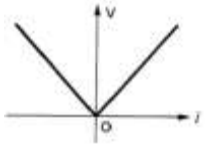
(a) non-linear, active, non- bilateral
(b) linear, active, non-bilateral
(c) non-linear, passive, non-bilateral
(d) non-linear, active, bilateral

OPPSC AE 2021, Paper-I
ESE-2002

Ans. (a) : Non-linear- The circuit which does not follow the homogeneity and superposition principle are called non-linear circuit.

Active circuit- The circuit which have active source and element are called active circuit.

Non- bilateral-The circuit which changes the behaviour when the polarity of source is change called non-bilateral circuit.



In above figure the element is non-linear active and non-bilateral.

58. Who invented the alternating current?

(a) Tesla (b) Faraday
(c) Maxwell (d) Edison

SSC JE 22.01.2018, Shift-II

Ans : (a) Nikola Tesla invented the alternating current. Invention of AC motor was also done by Tesla in 1888. All AC machine like induction motor invented by him so induction motor is also known as Tesla motor.

59. One calorie heat energy is equal to the electrical energy of

(a) $\frac{10^{-3}}{860}$ kWh (b) $\frac{10^{-4}}{860}$ kWh
(c) $\frac{10^{-2}}{86}$ kWh (d) $\frac{10^{-3}}{8.6}$ kWh

UPPCL JE 25.11.2019, Shift-I

Ans : (a) 1kWh = 860 kcal

$1\ \text{kcl} = \frac{1}{860}\text{kWh}$

$1\,\text{calorie} = \frac{10^{-3}}{860}\text{kWh}$

60. The resistance of a copper conductor is --------.

(a) more than the resistance of Aluminium
(b) less than the resistance of silver
(c) more than the resistance of gold
(d) more than the resistance of silver

Vizag Steel JET 25.10.2018, Shift-II

Ans. (d) : The resistance of a copper conductor is more than the resistance of silver.

$\because\ R = \rho\frac{\ell}{A}$

$\therefore R \propto \rho$

Metal	Resistivity on (ohm-m) at Room temp.
Annealed Copper	1.72×10^{-8}
Silver	1.59×10^{-8}
Gold	2.44×10^{-8}
Aluminium	2.65×10^{-8}

61. Which is the passive component in terms of electronics?

(a) Resistor (b) SCR
(c) Transistor (d) Diode

Vizag Steel JET 25.10.2018, Shift-II

Ans. (a) : Passive- It is one which contains no source of e.m.f. in it. e.g.- R,L,C

Active- It is one which contains one or more than one source of e.m.f. along with passive element. e.g. diode, transistor.

62. What is that property of a coil called under which if there is a change in the current flowing through it, a voltage gets induced in the coil itself as well as the neighboring circuit?

(a) Resistivity (b) Inductance
(c) Charging (d) None of the above

UPSSSC JE-2015

Ans. : (b) Inductance is the property of a coil called under which if there is a change in the current flowing through it, a voltage gets induced in the coil itself as well as the neighbouring circuit. Inductor stores energy in magnetic field.

$\text{Energy (E)} = \frac{1}{2}LI^2$

$\text{Inductance (L)} = \frac{\mu_0\mu_r N^2 A}{\ell}$

$\boxed{L = \frac{N\phi}{I}}$

63. A 60 W light bulb has a current of 0.5 A flowing through it. Calculate the number of electrons passing through a cross section of the filament.

(a) $\approx 3.1\times10^{-18}$ electrons /min
(b) $\approx 3.1\times10^{18}$ electrons /s
(c) $\approx 3.1\times10^{-18}$ electrons /s
(d) $\approx 3.1\times10^{18}$ electrons /min

SSC JE 10.12.2020, Shift-II

Ans (b) : Given that-

$I = 0.5A \qquad t = 1\text{sec}, \qquad e = 1.6\times10^{-19}$

$n.e = It$

$n\times1.6\times10^{-19} = 0.5\times1$

$n = \frac{0.5}{1.6\times10^{-19}}$

$\boxed{n = 3.1\times10^{18}\ \text{electrons/s}}$

64. Which of the following is the dimension of inductance?

(a) $\frac{ML^2}{Q^2}$ (b) $\frac{Q^2T^3}{ML^2}$
(c) $\frac{ML^2}{QT^2}$ (d) $\frac{ML^2}{QT^3}$

SSC JE 25.01.2018, Shift-II

Ans : (a) Dimension of Inductance $= \frac{ML^2}{Q^2}$

Since, Inductance $= \frac{\text{Magnetic Flux}}{\text{Current}}$

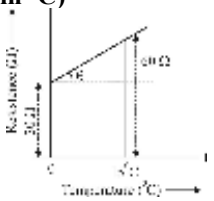
$= \frac{B.A}{i} = \frac{F}{i\ell}.\frac{A}{i} = \frac{FA}{i^2\ell}$ $\left\{\begin{matrix}\text{Where,}\\ F = iB\ell \\ B = \frac{F}{i\ell}\end{matrix}\right\}$

$[F] = [MLT^{-2}]$, $[A] = L^2$, $i = [A]$

$\therefore L = \frac{[MLT^{-2}][L^2]}{[A^2L]} = ML^2T^{-2}A^{-2}$

$L = \frac{ML^2}{T^2A^2} = \frac{ML^2}{Q^2}$ $\{Q = it = [AT]\}$

65. For the graph shown in the figure, find the value of the temperature coefficient of resistance (in ^{0}C)



(a) 0.02 (b) 0.03
(c) 0.05 (d) 0.06

SSC JE 29.01.2018 Shift-II

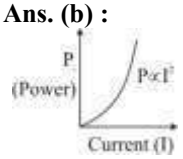
Ans. (d) : Resistance at zero^{0}C (R_0) = 30Ω
Resistance at 15^{0}C (R_{15})= 60Ω
Temperature (t) = 15^{0}C
Temperature coefficient (α_0)=?
Formula:- $\boxed{R_t = R_0(1+\alpha_0 t)}$
$60=30(1+\alpha_0 15)$
$1+\alpha_0 15=2$
$\alpha_0=1/15$
$\boxed{\alpha_0 = 0.066}$

66. The relationship between Electrical Power and current is.....

(a) linear (b) non-linear
(c) constant (d) exponential

SSC JE 29.01.2018 Shift-II

Ans. (b) :



The relation between electrical power and current is shown in the graph.
The relation between electrical power and current is non-linear.
Since, $P = I^2R$
$\boxed{P \propto I^2}$

67. The smallest amount of charge that exists is the charge carried by:

(a) an atom
(b) a neutron
(c) an electron
(d) a combination of an electron and a proton

MPPGCL Plant Assistant 2019

Ans. (c) :	**Charge**	**Mass (gram)**
electron	1.6×10^{-19}C	9.1095×10^{-28}
proton	1.6×10^{19}C	1.6726×10^{-24}
Neutron	0	1.6749×10^{-24}

68. A 40 W bulb is connected in series with a room heater. If now 40 W bulb is replaced by 100 W bulb, heater output will

(a) decrease (b) remain same
(c) heater will burn out (d) increase

UPSSSC JE 31.07.2016

Ans : (d) $P = \frac{V^2}{R}$

$R_1 = \frac{V^2}{P} = \frac{V^2}{40} = 0.025V^2$

If a 40 watt bulb is removed and replaced with a 100 watt bulb.

$R_2 = \frac{V^2}{P} = \frac{V^2}{100} = 0.01V^2$

$R_1 > R_2$

So, if 100 watt bulb is installed then more current flow than before, due to which the output of the heater will increase.

69. Ohm's law in point form in field theory can be expressed as

(a) V = RI (b) $J = \frac{E}{\sigma}$
(c) $J = \sigma E$ (d) $R = \rho\frac{L}{A}$

JPSC AE 10.04.2021, Paper-II
UPSSSC JE 31.07.2016

Ans : (c) Ohm's law in point form in field theory can be expressed as $J = \sigma E$.

70. Let Δq be the net charge passing through an element in a period of Δt. What is the current passing through that element?

(a) $\Delta q \times \Delta t$ (b) $\frac{\Delta t}{\Delta q}$
(c) q (d) $\frac{\Delta q}{\Delta t}$

SSC JE 29.10.2020, Shift-II

Ans : (d) If Δq be the net charge passing through an element in a period of Δt. Then the current passing through that element is–

$i = \frac{\Delta q}{\Delta t}$

The flow of charge in a definite direction is called electric current. It is measured by the time rate of flow of charge through the conductor.

$$\text{Electric current } I = \frac{q}{t}$$

71. According to Joule's law of electrical heating

(a) $H = IR^2t/4.18$ Calories
(b) $H = I^2R^2t^2/4.18$ Calories
(c) $H = I^2R^2t/4.18$ Calories
(d) $H = I^2Rt/4.18$ Calories

HPSSSC JE 2018 Code -387

Ans. (d) : Joule's law states that the quantity of heat generated in a conductor is–

$$H \propto i^2 Rt$$

The relation between calorie and joule is

4.18 joule = 1 calorie.

Hence,

$$H = \frac{i^2Rt}{4.18}\text{cal.}$$

72. A resistor of resistance R is connected to an ideal battery. What will be the impact on dissipated power if the value of R is decreased?

(a) decrease
(b) follows a sine curve
(c) remain uncharged
(d) increase

KPTCL JE 2017

Ans. (d) : The relation between power dissipation and resistance is given by

$P = \frac{E^2}{R}$ i.e. Power dissipation is indirectly proportional to the resistance. Hence if the value of R is decreased, the power dissipation in the circuit will increase.

73. A charge of 360 C is transferred in 2 minutes. The current flowing is:

(a) 180A (b) 60A
(c) 2A (d) 3A

Rajasthan JE (PHED) 2015

Ans. (d) : Given data,

Charge (q) = 360 C

time (t) = 2 minutes = 120 second

current (i) = ?

$\therefore q = it$

$$i = \frac{q}{t} = \frac{360}{120} = 3A$$

74. The flow of electric current in a conductor is due to flow of.....

(a) Electrons (b) Protons
(c) Electrons and ions (d) Charged particles

SSC JE 04.03.2017, Shift-I

Ans : (a) The flow of electric current in conductor is only due to flow of electrons. The direction of flow of current is opposite to direction of flow of electron.

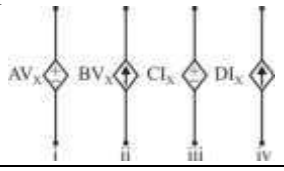
75. A dependent source.....

(a) May be a current source or a voltage source
(b) Is always a voltage source
(c) Is always a current source
(d) Neither a current source nor a voltage source

SSC JE 04.03.2017, Shift-I

Ans : (a) Dependent source are classified as –

(i) Voltage dependent voltage source.
(ii) Voltage dependent current source.
(iii) Current dependent voltage source.
(iv) Current dependent current source.



76. The element which is capable of delivering energy by its own is known as:

(a) Non-liner element
(b) Unilateral element
(c) Active element
(d) Passive element

NMRC JE 2017

Ans : (c) The element which is capable of delivering energy by its own is known as active element.

The elements which supply energy to the network are known as active elements for example -DC generator, AC generator, voltage sources like batteries, current source like photoelectric cells.

77. Two bulbs are rated 100 W, each. If these bulbs are connected in series to the mains supply, 220V, the total power consumed by both the bulbs would be–

(a) 25 Watts (b) 50 Watts
(c) 100 Watts (d) 200 Watts

RRB SSE Secunderabad Green paper, 21.12.2014

Ans : (b) If two bulbs are P_1 & P_2 connected in series combination across the same supply then,

$$\text{Total power } P_T = \frac{P_1 \times P_2}{P_1 + P_2}$$

$$P_T = \frac{100 \times 100}{100 + 100} = 50\,\text{Watt}$$

78. The time rate of flow of electric charge past a given point is known as:

(a) current (b) net charge storage
(c) charge density (d) voltage

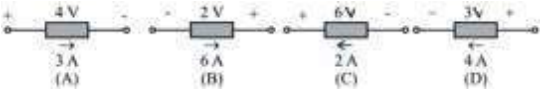
PGCIL Diploma Trainee 13.09.2018

Ans : (a) Electric current is the rate of charge flow past a given point in an electric circuit. Its unit is ampere and coulomb/second.

$$\boxed{i = \frac{dq}{dt}}$$

$\therefore$ i = electric current in Amp.
q = charge in coulomb
t = time per sec.

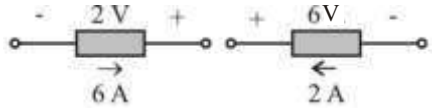
79. Which of the following supplies 12 W?



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

PGCIL Diploma Trainee 13.09.2018

Ans : (d) The current always flows from the positive terminal of the source and enters from the negative terminal of the source. Hence B and C will behave like a source. B and C both supply 12 watt because P = VI = 6×2=12 watt.



80. Given the current i and voltage v of a circuit elements, the power P and energy w are given by :

(a) P = v.i.t and $W = \int_o^t P d\tau$

(b) P = v.i and $W = \int_o^t P d\tau$

(c) $P = \int_o^t P d\tau$ and W = v.i

(d) $P = \int_o^t P d\tau$ and W = v.i.t

PGCIL Diploma Trainee 13.09.2018

Ans : (b) Power = voltage × current

$P = v \times i$

$P = \frac{dw}{d\tau}$

$\text{Energy}(w) = \int_0^t P d\tau$

81. The electrical energy consumed by an appliance of power rating P watts connected across its rated V for t hours is

(a) P/V×t kWh (b) $\frac{P \times t}{1000}$ kWh

(c) Pt kWh (d) $\frac{P \times t}{3600}$ kWh

UKPSC JE 2013, PAPER-II

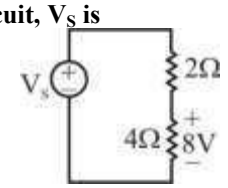
Ans. : (b) Electrical energy consumed

Power→ P watts

W = Pt Wh

$$W = \frac{Pt}{1000} \text{kWh}$$

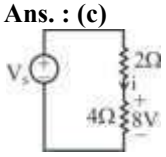
82. In the circuit, V_S is



(a) 8 V (b) 10 V
(c) 12 V (d) 16 V

UKPSC JE 2013, PAPER-II

Ans. : (c)



V_S = ?

Current in 4Ω resistor

$i = \frac{8}{4} = 2 Amp$

2Ω resistor and 4Ω resistor are in series. So supply voltage V_S is equal to sum of voltage across 4Ω and 2Ω.

$V_S = 2\times2+4\times2=12$ volt

$$V_S = 12V$$

83. If the current in an electric bulb drops by 2%, then power decreased by

(a) 1% (b) 2%
(c) 4% (d) 16%

HPSSC JE 2017 (Code-579)

Ans. (c) :

Power (P) = I^2R

$\frac{P_1}{P_2} = \left(\frac{I}{0.98I}\right)^2 \frac{R}{R}$

$\frac{P_1}{P_2} = \left(\frac{1}{0.98}\right)^2$

$P_2 = 0.96\ P_1$

Percentage decreased = $\frac{P_1 - P_2}{P_1} \times 100\%$

$\frac{P_1 - 0.96P_1}{P_1} \times 100\% = 4\%$

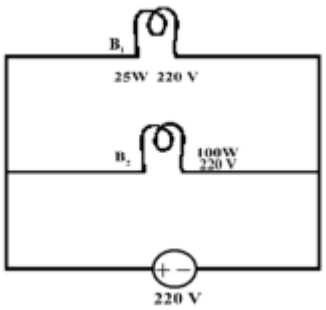
∴ P_2 Power decreased by 4%

84. A 25 W, 220 V bulb and a 100 W, 220 V bulb are joined in parallel and connected to 220 V supply. Which bulb will glow more brightly ?

(a) 25 W bulb
(b) 100 W bulb
(c) Both will glow with same brightness
(d) Neither bulb will glow

HPSSC JE 2017 (Code-579)

Ans. (b) : $R_{B_1} = \frac{V^2}{P} = \frac{(220)^2}{25} = 1936\Omega$



∴ $R_{B_2} = \frac{(220)^2}{100} = 484\ \Omega$

$\downarrow R \propto \frac{V^2}{P\uparrow}$

In parallel circuit low resistance will take more current and glow more bright.

85. Two electric bulbs rated at P_1 watt, V volt and P_2 watt, V volt are connected in series across V volt. The total power consumed is

(a) $P_1 + P_2$ (b) $\sqrt{(P_1P_2)}$

(c) $(P_1 + P_2)/2$ (d) $(P_1P_2) / (P_1 + P_2)$

HPSSC JE 08.08.2021
HPSSC JE 2017 (Code-579)

Ans. (d) :

$$R_1 = \frac{V^2}{P_1}, \qquad R_2 = \frac{V^2}{P_2}$$

$$R_{eq} = V^2\left(\frac{1}{P_1} + \frac{1}{P_2}\right)$$

$$R_{eq} = V^2\left(\frac{P_1 + P_2}{P_1P_2}\right) \quad \text{.....equation (i)}$$

We know that-

$$P_T = \frac{V^2}{R_{eq}} \quad \text{..... equation (ii)}$$

From equation (i) put the value of R_{eq} in equation (ii)

$$P_T = \frac{V^2}{V^2\left(\frac{P_1 + P_2}{P_1P_2}\right)}$$

$$\boxed{P_T = \frac{P_1P_2}{P_1 + P_2}}$$

86. A resistor is rated for 2.5 kΩ, 1 watt. Determine its maximum voltage and current ratings.

(a) 100 V, 100 mA (b) 50 V, 200 mA

(c) 100 V, 10 mA (d) 50 V, 20 mA

SSC JE 24.03.2021, Shift-I

Ans. (d) : Resistor is rated for 2.5 kΩ, 1 watt.

$R = 2.5\ k\Omega = 2500\ \Omega$, $P = 1$ watt

maximum voltage (V_{max})

$$P = \frac{V_{max}^2}{R}$$

$$V_{max} = \sqrt{P \times R} = \sqrt{1 \times 2500}$$

$$V_{max} = \sqrt{2500} = 50$$

$$\boxed{V_{max} = 50V}$$

$$\because P = V \times I_{max} = I_{max}^2 R = \frac{V_{max}^2}{R}$$

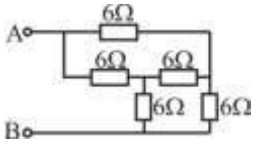
$$\Rightarrow I_{max}^2 R = P$$

$$I_{max}^2 = \frac{1}{2.5 \times 10^3} = \frac{1}{2500}$$

$$I_{max} = \frac{1}{\sqrt{2500}} = \frac{1}{50}$$

$$I_{max} = 20mA$$

87. For the circuit shown, the resistance between A and B terminals will be

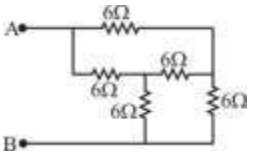


(a) 6 Ω (b) 3.75 Ω

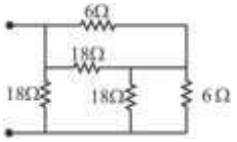
(c) 3 Ω (d) 12 Ω

UPPCL JE 11.02.2018, Shift-I
WBPSC SAE 2004

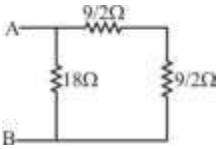
Ans. (a) :



Convert star to Delta.



$R_\Delta = 3\ R$



$$R_{eq} = \left(\frac{9}{2} + \frac{9}{2}\right) \| 18$$

$R_{eq} = 6\Omega$

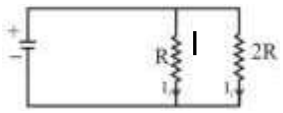
88. Two resistances R and 2 R are connected in parallel in an electric circuit. The thermal energy developed in R and 2 R are in the ratio

(a) 1 : 2 (b) 2 : 1

(c) 1 : 4 (d) 4 : 1

BSNL TTA (JE) 14.07.2013

Ans. : (b)



Resistance R and 2 R are connected in parallel so voltage across both resistance is same.

Thermal energy developed in the resistance R

$$\because H = I^2Rt = \frac{V^2}{R}t$$

$$\therefore H_1 = \frac{V^2}{R}t$$

Heat developed in the resistance 2 R–

$$H_2 = \frac{V^2}{2R}t$$

Thus the ratio of $H_R : H_{2R}$

$$\frac{V^2}{R} \times t : \frac{V^2}{2R} \times t = 2:1$$

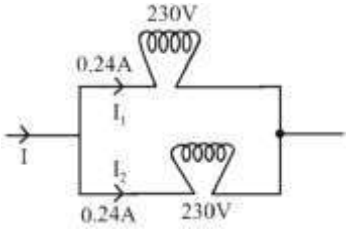
$H_R : R_{2R} = 2:1$

89. A 230 V lamp is rated to pass a current of 0.24 A. If a second similar lamp is connected in parallel to the lamp calculate the supply current required to give the same power output in each lamp.

(a) 0.24 A (b) 1.5 A
(c) 1.9 A (d) 0.48 A

DFCCIL-JE 11.11.2018

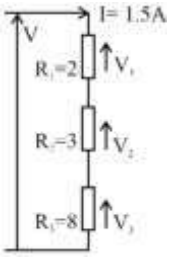
Ans. (d) :



$I_{Rated} = (I_1+I_2)_{Rated}$

$= 0.24 + 0.24 =$ 0.48 Amp

90. For the figure shown below, the value of the supply voltage 'V' is _____ .



(a) 12 V (b) 4.5 V
(c) 19.5 V (d) 3 V

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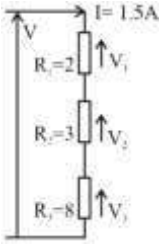
Ans. (c) :



$R_{eq} = R_1+R_2+R_3$

$= 2 + 3 + 8 = 13$

$R_{eq} = 13$

$I = 1.5$ A

$V = I R_{eq} = 1.5 \times 13 = 19.5$ V

91. Unit of electric power is

(a) Kilowatt (b) watt
(c) KW h (d) watt hour

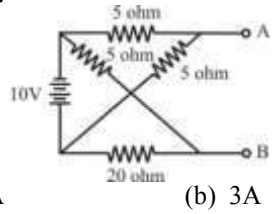
SSC JE 23.01.2018, Shift-II
Nagaland PSC CTSE (Diploma) 2017, Paper-I

Ans. (b) : The SI unit of power is watt

Unit of electrical power = Electrical energy/time period
= Joule/ second
= watt

Note: here in the question SI unit is asked, please don't confuse with kilowatt.

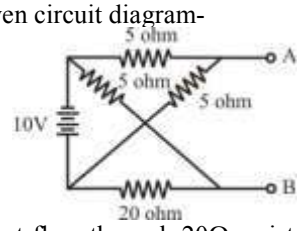
92. The current supplied by the battery shown below is:



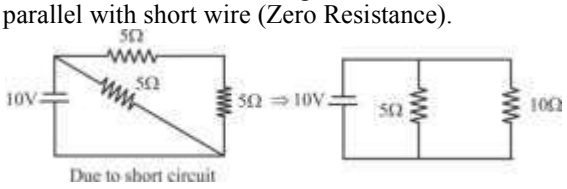
(a) 1.4A (b) 3A
(c) 0.43A (d) 0.4A

DMRC JE 2018, Shift-I

Ans. (b) : Given circuit diagram-



Current will not flow through 20Ω resistor because it is parallel with short wire (Zero Resistance).



$R_{eq} \Rightarrow 5 \parallel 10\Omega$

$$R_{eq} = \frac{5\times10}{5+10} = \frac{10}{3}$$

current supplied by battery-

$$I = \frac{V}{R_{eq}} = \frac{10}{10/3} = \frac{10\times3}{10}$$

I = 3A

93. If a resistance has the following colour code, find the value of resistance.
Gray, Red, Green, Silver

(a) 82kΩ ± 10% (b) 8.2kΩ ± 10%
(c) 82MΩ ± 10% (d) 8.2MΩ ± 10%

DMRC JE 20.02.2020
ESIC JE 2019
NPCIL ST 2019 (Kakrapar)

Ans. (d) :

Colour	Digit	Multiplier	Tolerance
Black	0	1	–
Brown	1	10^1	±1%
Red	2	10^2	±2%
Orange	3	10^3	–
Yellow	4	10^4	–
Green	5	10^5	± 0.5%
Blue	6	10^6	± 0.25%
Violet	7	10^7	± 0.1%
Gray	8	10^8	± 0.05%
White	9	10^9	–
Gold		10^{-1}	± 5%
Silver		10^{-2}	± 10%
Colourless		–	± 20%

Hence, Gray, Red, Green, Silver.

$82\times10^5 \pm 10\%$

or 8.2 MΩ ± 10%

94. A copper conductor has a resistance of 10Ω at 20^0C and RTC of 0.0039 per ^{0}C at 20^0C. Find RTC at 0^0C.

(a) 0.0000423 per ^{0}C (b) 0.00324 per ^{0}C

(c) 0.00423 per ^{0}C (d) 0.000124 per ^{0}C

UPPCL JE 27.08.2018, Shift-I

Ans. (c) : $\because \quad \alpha_t = \dfrac{\alpha_0}{1+\alpha_0 t}$

$$0.0039 = \frac{\alpha_0}{1+\alpha_0 \times 20}$$

$$0.0039 + 0.0039\alpha_0 \times 20 = \alpha_0$$

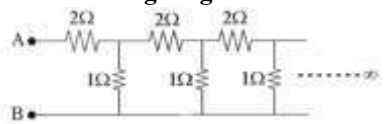
$$\alpha_0 (1 - 0.0039 \times 20) = 0.0039$$

$$\alpha_0 (0.922) = 0.0039$$

$$\alpha_0 = \frac{0.0039}{0.922}$$

RTC at 0°C $\boxed{\alpha_0 = 0.00423 \text{ per°C}}$

95. What is the effective resistance between A and B in the following diagram

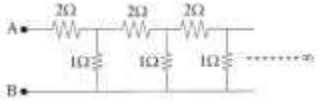


(a) 1Ω (b) $\sqrt{2}\Omega$

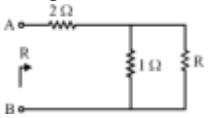
(c) $1+\sqrt{3}\Omega$ (d) $1+2\sqrt{3}\Omega$

ISRO TA 2017

Ans. (c) : Given circuit diagram-



The transformation of given circuit can be reduced to



$$\frac{R}{R+1} + 2 = R$$

$R + 2 (R + 1) = R(R + 1)$

$3R + 2 = R^2 + R$

or $\boxed{R^2 - 2R - 2 = 0}$

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\therefore \ R = \frac{2 \pm \sqrt{4+8}}{2} = \frac{2 \pm 2\sqrt{3}}{2}$$

$\boxed{R = 1 + \sqrt{3}}\ \Omega$

96. If resistance decreases with increase in temperature, resistance has:

(a) Positive temperature Coefficient

(b) Negative temperature Coefficient

(c) Neutral temperature Coefficient

(d) Zero temperature Coefficient

Ans. (b) : A negative temperature coefficient for a material means that its resistance decrease with an increase in temperature

Example–Insulator and semiconductor is negative temperature coefficient.

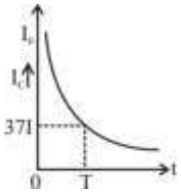
■ Conductors have a positive temperature coefficient of resistivity i.e.– Resistivity increases with the increases in temperature.

97. When the capacitor is fully charged after connecting it to voltage source in a DC circuit, then the current in the circuit____.

(a) increases (b) it remains constant

(c) falls to zero (d) decreases

Ans. (c) : When the capacitor is fully charged after connecting it to voltage source in a DC circuit, then the current in the circuit falls to zero.



■ From the graph of charging condition of capacitor.

(i) Charging current I_c is maximum at start i.e. when capacitor is uncharged.

(ii) As time increases, charging current decreases exponentially and becomes zero when t = ∞ i.e. in about 5 time constant.

■ Under steady state condition, the circuit appears only as a capacitor which means it act as an open-circuit.

$$\boxed{I_c = I_0 e^{-t/\tau}}$$

98. What is the necessity of parallel grouping of capacitors?

(a) To achieve a lower capacitance than what is available in one unit

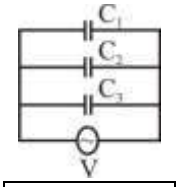
(b) To achieve a higher capacitance than than what is available in one unit

(c) To achieve a higher inductance than what is available in one unit

(d) To achieve a lower inductance than what is available in one unit

Ans. (b) : The necessity of parallel grouping of capacitor is to achieve a higher capacitance than what is available in one unit.

■ When capacitor are connected in parallel than equivalent capacitance will be-



$\boxed{C_{eq} = C_1 + C_2 + C_3}$

■ The SI unit of capacitance is Farad.

■ Capacitor store energy in the form of electric field.

99. A circuit component that opposes the change in circuit voltage is

(a) Resistance (b) Capacitance
(c) Inductance (d) All of the above

Ans. (b) : A circuit component that opposes the change in circuit voltage is capacitance.

$$\boxed{i = C\left(\frac{dv}{dt}\right)}$$

$$dv = \frac{i}{C}dt$$

Taken the integration at both side

$$\int dv = \int \frac{i}{C}dt$$

$$\boxed{v = \frac{1}{C}\int i\,dt}\ \text{Volt}$$

■ A circuit component that oppose the rate of change of current is known as inductance.

$$\boxed{e = L\frac{di}{dt}}\ \text{Volt}$$

100. Power loss in an electrical circuit can take place in

(a) Inductance only
(b) Capacitance only
(c) Inductance and resistance only
(d) Resistance only

Ans. (d) : Power loss in an electrical circuit due to only resistance.

Power loss element → only resistance

Power loss in resistance (P) = I^2R watt

■ Energy loss in resistance = I^2 Rt Joules
= vit Joules

■ Energy storing element in an electrical circuit is Inductance and capacitance

■ Magnetic energy stored in inductance –

$$= \frac{1}{2}LI^2\left[\because L = \frac{N^2}{S}\right]$$

■ Electrical energy stored in capacitance –

$$\frac{1}{2}cv^2 = \frac{1}{2}q.v = \frac{1}{2}\frac{q^2}{c}$$

101. Passive element in a circuit is one which

(a) Receives energy
(b) supplies energy
(c) Both receives and supplies energy
(d) Neither receives nor supplies energy

Ans. (a) : Passive element in a circuit is one which receives energy.

■ There are two type of element.

Passive element		Active element
(i)	Resistor	Voltage source
(ii)	Inductor	Current source
(iii)	Capacitor	Transistor, battery, generator

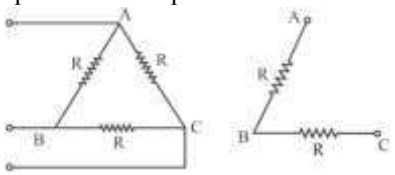
■ A circuit component which can deliver power in an electric circuit for long duration of time is known as active element.

■ A circuit element which only absorbs the power and convert it in heat or stores in electric field or magnetic field is known as passive element

102. In a delta connected network, when resistor is open, the power will be

(a) Zero (b) Reduced to 1/3
(c) Increased by 1/3 (d) Unchanged

Ans. (b) : In a delta connected network, when resistor is open the power consumption will be reduced to 1/3.



■ In a delta connected network, when one resistor is disconnected, the power consumption is reduced by one third.

■ In a star connected network, when one resistor is disconnected the power consumption is reduced by half.

103. Conventional current flow in simple electrical connection is:

(a) From negative terminal to positive terminal
(b) Determined by the load
(c) Not definable
(d) From positive terminal to negative terminal

Ans. (d) : Conventional current flow in simple electrical connection is from positive terminal to negative terminal.

104. In a material, application of voltage will cause a net motion of free charges from one point to another, such movement is called as :

(a) Electric power (b) Electric current
(c) Electric energy (d) Electric field

Ans. (b) : In a material, application of voltage will cause a net motion of free charge from one point to another, such movement is called as electric current.

105. Which is correct equivalent of delta if the star connected resistance are make the relation $R_a = R_b = R_{star}$?

(a) $R_{star}/3$ (b) $(2/3)*R_{star}$
(c) $3\ R_{star}$ (d) $(3/2)*R_{star}$

Ans. (c) : If all branches resistances of the star network are equal to R then each branch in its equivalent delta network is equal to 3R.

$$\boxed{R_{Delta} = 3R_{star}}$$

If $R_a = R_b = R_c$

■ It all the branch resistance of the delta network are equal to R then each branch in its equivalent star network is equal to R/3.

$$\boxed{R_{Star} = R_{Delta}/3}$$

If $R_a = R_b = R_c$

106. The unit of capacitance is

(a) Volts/Coulombs (b) Coulombs/Volt

(c) Ohm-meter (d) None of these

Ans. (b) : The unit of capacitance is Coulombs per volt

$$\boxed{C = \frac{q}{V}} \text{ Coulombs/volt}$$

■ The unit of resistivity is ohm-meter.

$$\boxed{\rho = R\frac{A}{l}} \text{ ohm-meter}$$

107. The capacitance of a capacitor is not affected by

(a) Thickness of the plates

(b) Distance between plates

(c) Area of plates

(d) None of these

Ans. (a) : The capacitance of a capacitor is not affected by thickness of the plates.

Capacitance affected by–

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

where, C = Capacitance

ε_0 = permittivity of free space

ε_r = relative permittivity

A = Area of plate

d = Distance between plates

108. The capacitance of the capacitor is directly proportional to the .....

(a) Material of the plate

(b) Area of the plate

(c) Voltage across the plate

(d) Polarity of the plates

Ans. (b) : The capacitance of the capacitor is directly proportional to area of the plate.

$$\boxed{C = K\frac{\varepsilon_o \varepsilon_r A}{d}}$$

■ Capacitance is inversely proportional to the distance between plates.

$$\boxed{C = \frac{Q}{V}}$$

■ The property of a capacitor to 'store electricity' may be called its capacitance.

109. Power is defined as

(a) The rate at which current flows in a circuit

(b) The product of voltage and resistance in a circuit

(c) The rate at which energy is radiated or dissipated

(d) The accumulation of energy over time

Ans. (c) : The rate at which energy is dissipated is known as power.

■ Power is the rate of doing work.

or it is the work done in unit time.

■ The SI unit of power is watt (w) which is joules per second (j/s).

$$(\text{Power})\, P = \frac{W}{t} = \frac{\text{Work}}{\text{time}}$$

■ 1kWh=1kW×1 hours

= 1000 watt × 3600 second

= 36,00,000

$$\boxed{1\text{kWh} = 3.6\times10^6\,\text{J}}$$

110. The amount of current flowing through a resistance depends on _____.

(a) Applied voltage only

(b) Ohmic value of resistance

(c) Applied voltage and ohmic value of the resistance

(d) None of above

Ans. (c) : The amount of current flowing through a resistance depends on applied voltage and ohmic value of the resistance.

<u>According to Ohm's law</u> - It states that the voltage V across a resistor is directly proportional to the current 'I' flowing through the resistor.

$$\frac{V}{I} = \text{constant}$$

$$\frac{V}{I} = R$$

$$\boxed{V=IR}$$

111. Which device stores electrical energy?

(a) Inductor (b) Capacitor

(c) Thermistor (d) Resistor

Ans. (b) : The device which stores electrical energy is capacitor.

■ Inductor stores magnetic energy in the form of magnetic field.

■ Resistor dissipates electrical energy.

■ Thermistor is a resistor whose resistance is dependent on voltage.

112. The condition of Ohm's law is :

(a) The temperature should be remaining constant

(b) Ratio V/I should be constant

(c) Current should be proportional of voltage

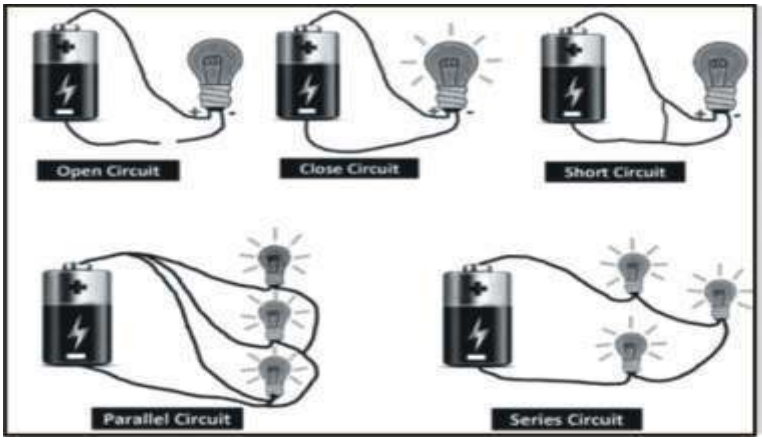
(d) Temperature should vary

Ans. (a) : The condition of ohm's law is that the temperature should be remained constant.

According to ohm's law the ratio of potential difference (V) between any two points on a conductor to the current (I) flowing between them is constant.

i.e. $\frac{V}{I} = \text{constant}$ or $\frac{V}{I} = R$

This linear relationship is only valid for metallic conductors.



2

Circuit Law

Content Detailed

■ Kirchhoff's law ■ Simple Circuit solution using network theorems.

❒ Classification of Network Elements

- **Elements or components:** Resistors, inductors, capacitors, current source, voltage source etc.
- **Node:** Two or more circuit elements are joined.
- **Junction:** Three or more circuit elements are joined.
- **Branch:** Lies between the two nodes.

■ **Active Element**

When an element is capable of delivering energy independently for an infinite duration of time or when it is capable of providing the power gain then it is called as active element.

☛ **Example:**

Voltage source:
Batteries, power supplies, solar cells, fuel cells and piezoelectric generators.

Current source:
Generators, like alternators and DC generators etc.

Transistor:
BJT, MOSFET, FETs and JFET, Diode, thyristor, ICs, and opto electronic device, CRT etc.

■ **Passive Element**

When an element is not capable of delivering the energy for an infinite duration of time or when it is not capable of providing the power gain then it is called as passive element.

☛ **Example:** Resistor, inductor, transformer, capacitor etc.

■ **Unilateral Element**

The voltage current relationship is different for two directions of current flow.

☛ **Example:** Diode, BJT, LEDs etc.

■ **Bilateral Element-**

The voltage current relationship is the same for current flowing in either direction.

☛ **Example:** Resistors, Inductors, Capacitors etc.

■ **Lumped Element**

Lumped elements are considered as the separate elements which are very small in size.

☛ **Example:** Resistor, Inductors, Capacitors etc.

■ **Distributed Element-**

Distributed elements are not electrically separable. These are distributed over the entire length of the circuit.

☛ **Example:** Transmission lines.

■ **Linear Element**

The element that follows additivity and homogeneity property for relationship between excitation and response is called a linear element.

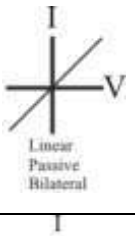
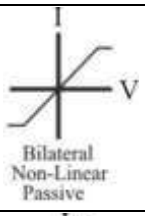
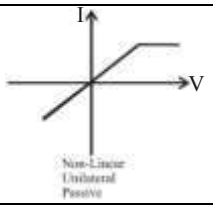
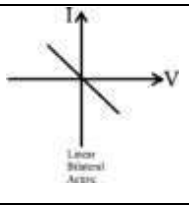
☛ **Example-** Resistance, capacitances, inductance, and linear-dependent sources.

■ **Non-linear Element**

The element that does not follow additivity and homogeneity property for relationship between excitation and response is called a non-linear element.

☛ **Example:** Semiconductor devices, such as transistors and diodes.

■ **I-V Characteristic Curves for Different Element**

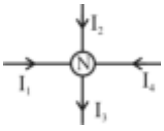
1.		2.	
3.		4.	
5.		6.	

If ratio of voltage to current at any point on characteristic curve is negative then the element is active otherwise it is passive.

❒ Kirchhoff's First law (Current Law) (KCL)

Principle

- Law of conservation of charge.
- It is always defined at a node.



Formula

- Outgoing current = Incoming current.

$$I_3 = I_1 + I_2 + I_4$$

$$\sum I = 0$$

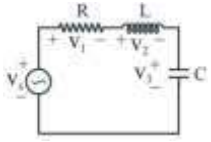
$$I_1 + I_2 + I_4 - I_3 = 0$$

When we analyze a given circuit, we are not sure of the direction of current through a particular element within the circuit. In such cases, we assume a reference direction and perform all the calculations on this assumption. If our assumption is incorrect, calculations will show that the current has a negative sign. The negative sign simply indicates that the current is in fact opposite to the direction selected as the reference.

❒ Kirchhoff's Second Law (Voltage Law) (KVL)

Principle

- Law of conservation of energy.
- It is always defined in a loop or mesh i.e., in a closed circuit.



Formula

$$\sum v = 0$$

$$V_s = V_1 + V_2 + V_3$$

$$V_1 + V_2 + V_3 - V_s = 0$$

- Kirchhoff's law is applicable for active and passive network.
- Kirchhoff's law is applicable in A.C and D.C circuit.
- Kirchhoff's law is applicable in lumped network and time variant network, time invariant network.
- Kirchhoff's law is not applicable to distributed network.
- Number of KCL equation = (n–1)
- Number of KVL equation = b–(n–1)

Where, b = branch in a circuit

n = node in a circuit

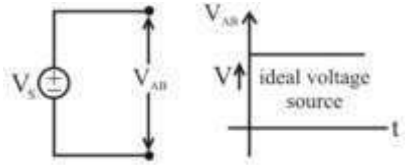
❒ Sources

Sources are classified as voltage sources and current sources. Further it may be classified as independent sources and dependent sources.

■ Independent Voltage Source

An independent voltage source is characterized by a terminal voltage which is completely independent of the current through it.

Ideal independent voltage source

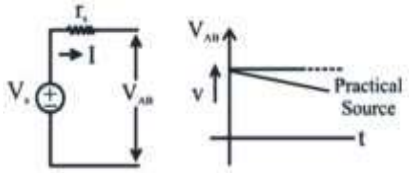


r = 0, where r is internal resistance

$V_{AB} = V_S$

Note: Internal resistance of ideal voltage source is zero.

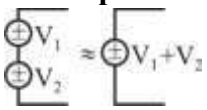
Practical independent voltage source



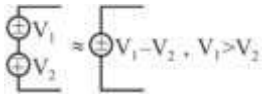
$r_s \neq 0$ $V_{AB} = V_s - Ir_s$

Note: The internal resistance of practical voltage source is not zero

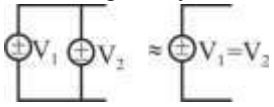
■ Independent voltage source connection



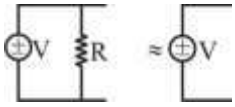
Voltage source connection with same reference polarity.



Voltage source connection with opposite reference polarity.

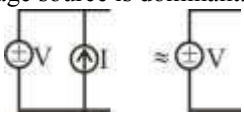


Voltage source parallel connection of identical voltage source.



Voltage source connection with parallel load.

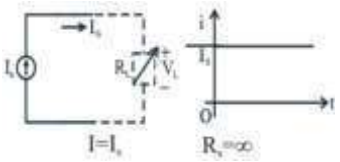
In parallel, voltage source is dominant.



■ Independent Current Source

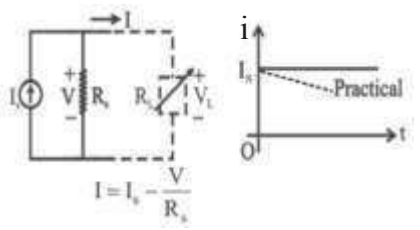
In the independent current source the current through the element is completely independent of the voltage across it.

Ideal Independent Current Source



The internal resistance of an ideal current source is infinite.

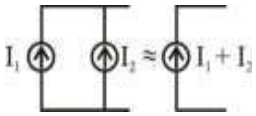
Practical Independent Current Source



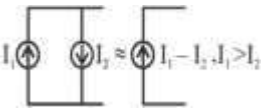
$$I = I_s - \frac{V}{R_s}$$

The internal resistance of practical current source is not infinite.

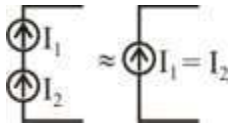
■ Independent current source connection



Current source parallel connection of same reference direction.



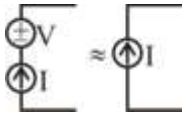
Current source parallel connection of opposite reference direction.



Current source series connection of identical current source.

Current source of series load.

In series, current source is dominant.

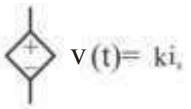
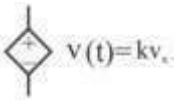
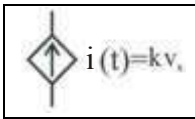
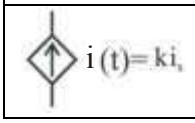


Source	Ideal	Practical
Voltage Source	$R_s = 0$	R_s = Low
Current Source	$R_s = \infty$	R_s = High
Voltmeter	$R_m = \infty$	R_m = High
Ammeter	$R_m = 0$	R_m = Low

Generally, independent sources supply power to the circuit. However, they can be connected into a circuit in such a way that they absorb power from the circuit.

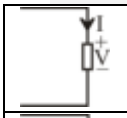
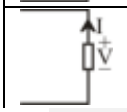
■ Dependent source

Dependent sources are the sources whose output depend on some other voltage or current in a circuit. Both voltage and current types of sources may be dependent, and either may be controlled by a voltage or a current. Thus, there are four types of dependent sources:

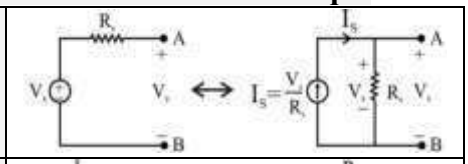
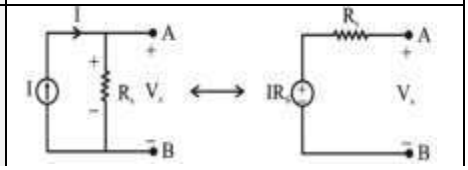
Source	Parameter to control
	Current controlled voltage source
	Voltage controlled voltage source
	Voltage controlled current source
	Current controlled current source

- A different symbol, in the shape of a diamond, is used to represent dependent sources.
- Dependent sources are very useful in describing certain types of electronic circuits.
- A dependent source may absorb or supply power.

■ Power absorbed and delivered by element

	When current is entering into positive terminal, element absorbs power.
	When current is leaving from positive terminal, element delivers power.

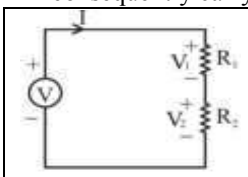
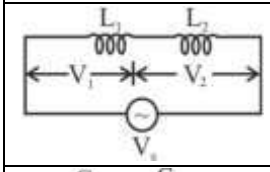
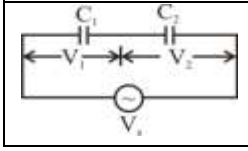
■ Source Transformation Technique

Voltage source to current source conversion	
Current source to voltage source conversion	

Note:-Source transformation is not valid for ideal voltage and current sources. Source transformation is applicable on the dependent source also.

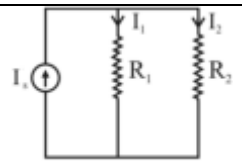
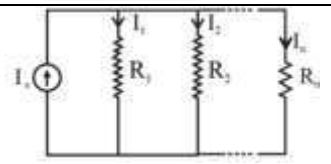
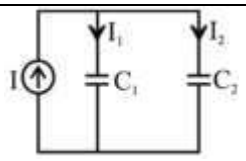
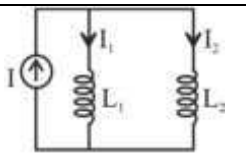
■ Voltage Division Rule

Two or more circuit element are said to be in series if they exclusively share a single node and consequently carry to the same current.

	$V_1 = \frac{R_1}{R_1 + R_2} \times V$ $V_2 = \frac{R_2}{R_1 + R_2} \times V$
	$V_1 = V_s \frac{L_1}{L_1 + L_2}, V_2 = V_s \frac{L_2}{L_1 + L_2}$
	$V_1 = V_s \frac{C_2}{C_1 + C_2}, V_2 = V_s \frac{C_1}{C_1 + C_2}$

■ Current Division Rule

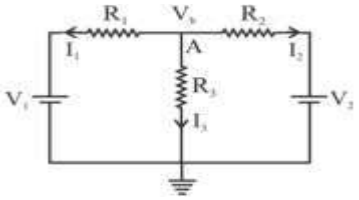
Two or more circuit element are said to be in parallel if the same voltage appear across each of the element.

	$I_1 = \frac{R_2}{R_1+R_2}\times I_s$ $I_2 = \frac{R_1}{R_1+R_2}\times I_s$
	$I_k = \frac{I_s \times \frac{1}{R_k}}{\frac{1}{R_1}+\frac{1}{R_2}+....\frac{1}{R_n}}$
	$I_1 = \frac{IC_1}{C_1+C_2}$ $I_2 = \frac{IC_2}{C_1+C_2}$
	$I_1 = \frac{IL_2}{L_1+L_2}$ $I_2 = \frac{IL_1}{L_1+L_2}$

■ Nodal Analysis

Nodal analysis provides a general procedure for analyzing circuits using node voltages as the circuit variables. Choosing node voltages instead of element voltages as circuit variables is convenient and reduces the number of equation one must solve simultaneous node equations. In nodal analysis, we are interested in finding the node voltages.

Node	Node is a point in a circuit where two or more circuit element are connected together.
Branch	Branch is that part of a network which lies between two nodes.
Mesh	It is a loop that contain no other loop within it.
Loop	It is a closed path in a circuit in which no element or node is encountered more than once.



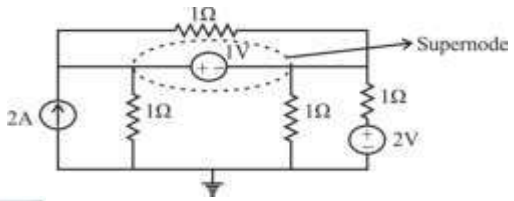
- At node A-

$$\frac{V_b - V_1}{R_1} + \frac{V_b - V_2}{R_2} + \frac{V_b}{R_3} = 0 \ , \quad I_1 + I_2 + I_3 = 0$$

- Nodal analysis is an application of Kirchhoff's current law.
- Nodal → KCL + Ohm's law
- Number of equation in nodal analysis = n-1
  n = Number of nodes

■ Supernode

The two non-reference nodes form supernode if the voltage source (dependent or independent) is connected between two non-reference nodes.

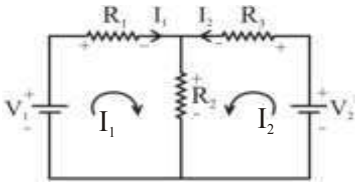


NOTE

- ➲ The voltage source inside the supernode provides a constraint equation needed to solve for the node voltages.
- ➲ A supernode has no voltage of its own.
- ➲ A supernode requires the application of both KCL and KVL.
- ➲ Supernode→ KVL + KCL + Ohm's law

■ Mesh Analysis

Mesh analysis provides another general procedure for analyzing circuits, using mesh currents as the circuit variables. Recall that a loop is a closed path with no node passed more than once. A mesh is a loop that does not contain any other loop within it.

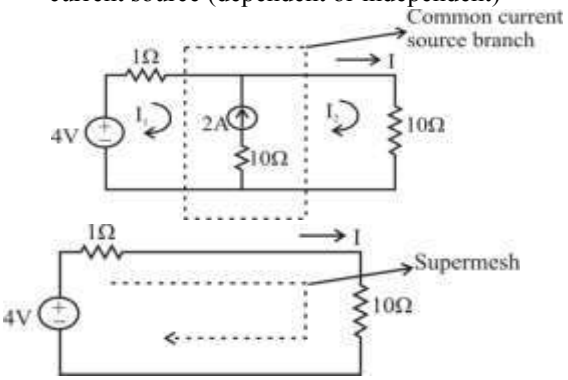


$V_1 - I_1R_1 - (I_1 + I_2)R_2 = 0$, $V_2 - I_2R_3 - (I_1 + I_2)R_2 = 0$

- Mesh analysis is used only for planer network.
- Number of equations in mesh analysis = b – (n–1)
- Mesh→ KVL+ ohm's law

■ Supermesh

A supermesh forms when two mesh have a common current source (dependent or independent)



NOTE

- ➲ The current source in the supermesh provides the constraint equation necessary to solve for the mesh currents.
- ➲ A supermesh has no current of its own.
- ➲ A supermesh requires the application of both KVL and KCL.
- ➲ Supermesh→ KVL+KCL+ Ohm's law

■ Comparison between Nodal analysis and Mesh analysis

- First we compare the number of equations required for each method. If the circuit has fewer nodes than meshes, we should use the node voltage method. If the circuit has fewer meshes than nodes, it will be easier to use the mesh current method.
- If the number of equation for either method is same, then it becomes important that what information (voltage or current) is required. If branch or mesh currents are required, it may be better to use mesh analysis. If node voltages are required, then we should use nodal analysis.

❒ Network Theorems

❒ Types of Network Theorems

- ■ Super position Theorem
- ■ Thevenin's Theorem
- ■ Norton's Theorem
- ■ Tellegen's Theorem
- ■ Millman's Theorem
- ■ Reciprocity Theorem
- ■ Maximum Power Transfer Theorem

The circuit to be analyzed may be simple or quite complex. In case of complex networks the solution procedure may be too tedious and time consuming. Certain techniques for solution of such networks have been developed which reduces the networks to simpler form for quick solution.

Network theorem can solve problems quicker than Kirchhoff's law when calculating currents in a specific branch is required.

■ Superposition Theorem

Principle	The voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone.
Applicable	➲ It is applicable for linear and bilateral network. ➲ It follows the condition of homogeneity. The homogeneity property requires that if the input is multiplied by a constant, then the output (response) gets multiplied by the same constant.
Use	It is used for voltage and current calculation.

❒ Procedure of applying superposition theorem

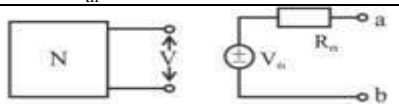
Step-I	Consider one independent source (either voltage or current) at a time. ➢ Other voltage source replaced by short-circuits and current source replaced by open-circuit.
Step-II	Calculate the current or voltage due to the single source using any method (KCL, KVL, nodal or mesh analysis)
Step-III	Repeat the above steps for each source.
Step-IV	Algebraically add the results obtained by each source to get the total response.

❒ Limitation of Superposition Theorem

- Power cannot be calculated.
- It is only applicable to circuits with several sources.
- Circuit with imbalanced bridges cannot use this theorem.

The theorem is not applicable to the network containing non linear element, unilateral element such as diode, BJT.

■ Thevenin's Theorem

Principle	It states that a linear bilateral two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{th} in series with a resistor R_{th}.
Circuit	
Applicable	Linear network that is network with R,L,C and linear control sources of element. Both active as well as passive network
Use	It is used for calculation of electronic circuit. It is also used in vacuum tube circuit.
For Thevenin's Voltage (V_{th})	If the terminals a-b are made open-circuited, no current flows, so that the open-circuit voltage across the terminals a-b must be equal to the voltage source V_{th}.
For Thevenin's Resistance (R_{th})	With the load disconnected and terminals a-b open-circuited, we turn-off all independent sources (voltage source replaced by short-circuits and current source replaced by open-circuits). The input resistance (or equivalent resistance) of the circuit at the terminals a-b must be equal R_{th}. $\boxed{R_{th} = R_{in}}$

❒ Limitation of Thevenin's Theorem

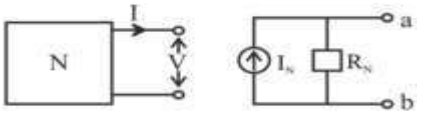
- The theorem is not applicable to the network containing non linear element, unilateral element such as diode, BJT.

When R_{th} takes a negative value. In this case the negative resistance implies that the circuit is supplying power.

- ➲ Basic components of a Thevenin's equivalent circuit AC are- The equivalent voltage source and the equivalent series impedance.
- ➲ Source transformation of Thevenin's theorem is known as Norton theorem.

■ Norton's Theorem

Principle	It states that a linear bilateral two terminal circuit can be replaced by an equivalent circuit consisting of a current source I_N in parallel with a resistor R_N,

Circuit	
Applicable	Linear bilateral and active RLC network.
Use	For circuit analysis simplification and to study circuit's initial condition and steady-state response.
For Norton current (I_N)	To find the Norton current ($I_N = I_{sc}$) connect a short circuit between terminal a and b. Do not set independent sources zero in this method because we have to find short circuit current. Now obtain the I_{sc} through terminal a and b.
For Norton resistance (R_N)	Norton resistance is the input or equivalent resistance seen at the load terminals when all independent source are replaced their internal resistance.

☐ Limitations of Norton's Theorem

- Norton's theorem cannot be applied, if there is a magnetic coupling in load and circuit elements.
- If the load is in series or in parallel combination with dependent sources, then Norton's theorem cannot be applied.

If a circuit contains dependent sources only, i.e. there is no independent source present in the network then its short-circuit current or Norton current will simply be zero

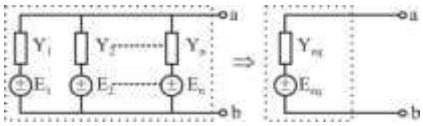
- ➲ If in a circuit $R_{th} = \infty$ then its thevenin equivalent is not possible we can only find its Norton equivalent.
- ➲ If in a circuit $R_{th} = 0$ then its Norton equivalent is not possible we can only find its thevenin equivalent.

■ Tellegen's Theorem

Principle	It states that the summation of instantaneous power delivered is zero for each branch of any electrical network at any instant of time.
Formula	$\sum_{k=1}^{b} P_k = v_k i_k = 0$ b= number of branches
Valid	Linear, non-linear, unidirectional, bidirectional active, passive, time variant and time invariant circuit.
Use	Used to examine difficult network systems like electrical circuits, metabolic and biological networks, chemical processes and pipeline transport networks.

- ➲ For the verification of Tellegen's theorem KVL & KCL equation are used.
- ➲ Tellegen's theorem is based on the law of conservation of energy.

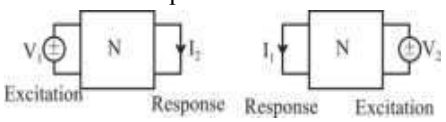
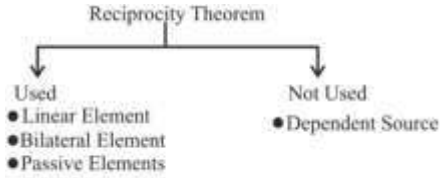
■ Millman's Theorem

Principle	It states that if there are "n" number of voltage sources having magnitude E_1, E_2, E_3 ..... E_n having internal impedance Z_1, Z_2.....Z_n respectively then these sources may be replaced by a single voltage source V_m having equivalent series internal impedance Z_m
Figure	
Equation	$V_m = \frac{V_1Y_1 + V_2Y_2 + V_3Y_3 + ... + V_nY_n}{Y_1 + Y_2 + ... + Y_n}$ $Z_m = \frac{1}{Y_1 + Y_2 + Y_3 + ... + Y_n}$
Used	It is used to compute the voltage at the ends of a circuit made up of only branches in parallel.

☐ Limitation of Millman's Theorem

- Millman's theorem does not cover circuits with impedances among independent sources.
- Millman's theorem does not apply to circuits, where dependent sources complement independent sources.

■ Reciprocity Theorem

Principle	In a linear, passive and bilateral network, the ratio of response to excitation is constant even though the source is interchanged from input terminals to output terminals.
Figure	
Equation	$\frac{V_1}{I_2} = \frac{V_2}{I_1}$
Use	

☐ Limitations of reciprocity theorem-

- Not applicable to circuits with any type of time-varying component.
- Not relevant to circuits with dependent sources, even if they are linear.
- Not applicable to circuits made up of nonlinear components like transistors, diodes etc.

🕮 The ratio of excitation to response is either ohm or mho.

■ Maximum Power Transfer Theorem

Principle

A resistive load connected to DC network receives maximum power when the load resistance is equal to Thevenins equivalent resistance of the network as seen from the load terminal.

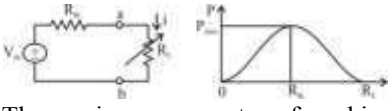
OR

It states that the AC voltage source will deliver maximum power to the variable complex load only when the load impedance is equal to the complex conjugate of source impedance.

Applicable

Only when load is variable otherwise (i.e. load is fixed) choose the minimum internal impedance of the source.

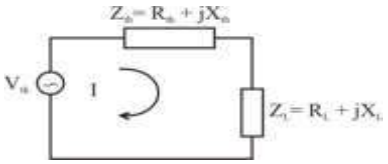
Circuit



The maximum power transferred is-

$$P_{max} = \frac{V_{th}^2}{4R_{th}}$$

Condition for maximum power transfer



- When Z_L has both R_L and X_L but R_L is variable [X_L is constant].

$$\boxed{R_L = \sqrt{R_{th}^2 + (X_L + X_{th})^2}}$$

- When the load impedance is purely resistive in nature-

$$R_L = \sqrt{R_{th}^2 + X_{th}^2}$$

$$\boxed{R_L = |Z_{th}|}$$

- Different conditions for maximum power transfer theorem-

For maximum power transfer $Z_L = Z_s^*$

Case-I : If $Z_s = R_s + jX_s$ and

$Z_L = R_L + jX_L$

$R_L + jX_L = R_s - jX_s$

$\therefore\ R_L = R_s\ \&\ X_L = -X_s$

Case-II : If

$Z_s = R_s + jX_s$ and $Z_L = R_L$

Then $R_L = \sqrt{R_s^2 + X_s^2}$

Case-III: If

$Z_L = R_L$ & $Z_s = R_s$ then $R_L = R_s$

Note: If Z_s (source resistance) is changed then maximum power is transferred to the load, if Z_s= 0.

$$P_{max} = \frac{V_{th}^2}{4R_L} = \frac{V_{th}^2}{4R_{th}}$$

$$\eta_{max} = \frac{P_{out}}{P_{in}} \times 100 = 50\%$$

Application

Maximum power transfer theorem is applied in Radio communications.

Limitations of Maximum power transfer theorem:

- It cannot be used in non-linear and unilateral networks.
- The maximum efficiency is 50% and not applicable for power systems.

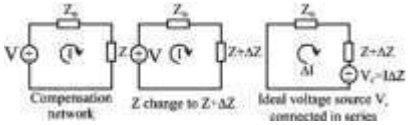
There is distinct difference between drawing maximum power from a source and delivering maximum power to a load. If the load is sized such that its load resistance is equal to the Thevenin resistance of the network to which it is connected, it will receive maximum power from that network. Any change to the load resistance will reduce the power delivered to the load.

■ Compensation Theorem

Principle

If impedance 'Z' of any branch of an network is changed by ΔZ then the incremental current ΔI in such branch is that which will be produced by a compensating voltage source $V_C = I\Delta Z$ the original direction of current I

Figure



Application

Use to obtain the approximate effect of small changes in the elements of an electrical network.

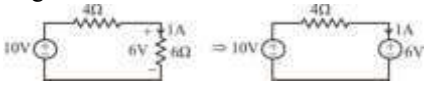
This theorem is used to determine the steady state errors introduced by the measuring instrument and to obtain the null deflection in the galvanometer of the bridge circuit.

■ Substitution Theorem

Principle

Any branch in the network may be substituted by a different branch without disturbing the voltages and current in the entire network provided that new branch has a same set of terminal voltage and current as the original branch.

Example



Use	➢ It can be used for any linear bilateral network with passive elements and multiple energy sources. ➢ The power absorbed by the passive element and its equivalent voltage or current source remains the same. This can be done to simplify the network for further analysis without affecting the rest of the network.
Application	➢ This theorem replaces the circuit's one element with one more element. ➢ This theorem is used to prove numerous other theorems.

☐ Limitation of Substitution theorem-

- In this theorem, when replacing the element, the circuit behaviour should not change.
- This theorem can not be used for solving a network that includes a minimum of two or above sources that are not within series or parallel.

The initial condition of the rest of the circuit remains same, if a network element is replaced by a voltage source having an equal voltage as the voltage across the element at every instant of time.

Exam Pointer

- If there are "n" nodes in the circuit there will be ------- independent to nodal equation– **n-1**
- The average value of the current is the ------- divided by the number of currents- **Sum of all currents**
- In a close loop, the sum of voltage drops across components is equal to- **The applied voltage**
- Which law's is applied for mesh analysis of the network- **Kirchhoff's voltage law**
- Kirchhoff's first law states that a junction in an electric circuit - **ΣI=0**
- According to kirchhoff's voltage law, the algebraic sum of all voltage drop and e.m.f. in any closed circuit in a network is equal to - **Zero**
- The algebraic sum of the electric currents meeting at a junction point is– **Zero**
- Which law is based on the principle of conservation of electric charge– **Kirchhoff's current law**
- Algebraic sum of all currents meeting at a point is zero. Stated law is – **Kirchhoff's first rule**
- Between the branch voltage of a loop, the Kirchhoff's voltage law imposes – **No constraints**
- The nodal method of circuit analysis is based on – **KCL and Ohms law**
- Kirchhoff's current law (KCL) is applicable only to – **Junction in a network**
- Kirchhoff's law states that in a closed loop of a circuit– **The algebraic sum of the potential differences is zero**
- Kirchhoff's voltage law applied to circuit with – **Linear, non-linear, active, passive time variant as well as time invariant elements**
- Mesh analysis is based on – **Kirchhoff's Voltage law**
- For large networks generally – **The node analysis is preferred**
- The laws used in cutsets and tiesets of a network are– **Kirchhoff's laws**
- Kirchhoff's law is applicable to – **A.C. networks, D.C. networks**
- Kirchhoff's second law is based on law of conservation of – **Energy**
- Kirchhoff's Voltage Law is known as – **Energy Conservation**
- Kirchhoff's current law at a junction deals with– **Conservation of charge**
- According to KCL as applied to a junction in a network of conductors – **Algebraic sum of the all currents meeting at the junction is zero**
- Kirchhoff's first and second laws are respectively based on– **Conservation of charge and energy**
- Kirchhoff's voltage law is concerned with– **IR drop, Battery e.m.f.**
- Kirchhoff's voltage laws are NOT applicable to circuits with – **Distributed parameters**
- The branch current method uses ----- **Kirchhoff's current law**
- Kirchhoff's Current law (KCL) is the first law that deals with the conservation of– **Charge**
- According to Kirchhoff's law, the sum of the currents entering a point in the circuit is equal to the– **Sum of the currents leaving that point**
- Total current or charge entering a junction is exactly equal to charge leaving the node which means all the current entering and leaving the junction should be equal to zero. Which circuit law is mentioned in this context **-Conservation of charge**
- Which laws states that the algebraic sum of the current at a node at any instant is zero– **Kirchhoff's current law**
- Which laws states that the algebraic sum of EMFs around a closed loop equal the algebraic sum of IR drops around the loop- **Kirchhoff's Voltage Law**
- Which theorem is advantageous, when we have to determine the current in a particular element of a linear bilateral network particularly when it is desired to find the current which flows through a resistor for its different values- **Thevenin theorem**
- Which linear circuit can be used as an equivalent circuit for a single voltage source and a series resistance- **Thevenin equivalent circuit**
- Thevenin's equivalent circuit consists of – **Voltage source and series impedance**

- According to Thevenin's theorem, electrical network can be reduced to -------- in series with load resistor– **Single emf source and series resistor**
- In Thevenin's theorem, to find Z – **All independent voltage sources are short circuited and all independent current source are open circuited**
- Which statement about electrical network and electrical circuit is CORRECT– **Every electrical circuit is a network but all networks are not circuits**
- Thevenin's theorem cannot be applied to networks that contain elements which are– **Non-Linear**
- As per Thevenin's theorem: If internal impedance are not known, independent voltage and current sources will– **Be replacec by short and open circuit respectively**
- Thevenin's theorem is form of an equivalent circuit **–Voltage**
- Thevenin's theorem reduces a two terminal network to a – **Voltage source in series with an impedance**
- Closed circuit technique are based on – **Thevenins theorem**
- While calculating thevenin resistance (R_{th}), constant current sources in the circuit are – **Replaced by 'opens'**
- In Thevenin's Model the Resistance R_{th} is defined as– **Impedance calculated by replacing voltage/ current source with their impedance**
- In the analysis of a vacuum tube circuit, we generally use Theorem – **Thevenin's**
- While Thevenizing a circuit between two terminals, V_{TH} is equal to – **Open-circuit terminal voltage**
- How can Thevenin's impedance and Norton's impedance be correlated in a AC circuit– **Always the same**
- While calculating R_{th} in Thevenin's theorem and Norton equivalent – **All independent sources are made dead**
- Thevenin's theorem converts a circuit to an equivalent form consisting of – **A Voltage source and a series resistance**
- Norton's equivalent is **-Parallel Circuit**
- Which theorem is the converse of Thevenins theorem – **Norton's theorem**
- According to Norton's theorem, electrical network can be reduced to in parallel with load resistor– **Single current source and parallel load resistor**
- While calculating Thevenin's equivalent in Thevenin's theorem and Norton's equivalent, are made dead — **All independent sources**
- Norton's Theorem is a way to reduce a network to– **An equivalent circuit composed of a single current source, parallel resistance, and parallel load**
- Norton's theorem states that a complex network connected to a load can be replaced with an equivalent impedance – **In parallel with a current source**
- Norton's Theorem results in – **A Current source with an impedance in Parallel**
- Which theorem is also regarded as Dual of Thevenin's Theorem - **Norton's Theorem**
- According to Norton's theorem, the expression for load current is - $\mathbf{I_L = I_{SC} \times \frac{R_{int}}{R_{int} + R_L}}$
- While applying Notorn's Theorem to DC networks, the network is replaced by a – **Current source in parallel with a resistance**
- Which theorem works only for circuits that are reducible to series/parallel combinations for each of the power sources at a time and it only works where underlying equations are linear- **Superposition theorem**
- Superposition theorem is valid for which circuit elements - **Linear bilateral elements**
- When the voltage sources are replaced with short circuits and current sources are replaced with open circuits, leaving dependent sources in the circuit, the theorem applied is– **Superposition Theorem**
- On which concept, the superposition theorem is based – **Linearity**
- Superposition theorem is applicable to – **Linear bilateral network**
- According to Super position theorem. a voltage source of 0 V can be replaced by a – **Short circuit**
- A non–linear network does not satisfy – **Both homogeneity as well as superposition condition**
- The Superposition Theorem is applicable to – **Current, voltage**
- To neglect a voltage source, the terminals across the source are– **Short-circuited**
- A linear element satisfies the properties of – **Superposition and Homogeneity**
- Superposition theorem is used to obtain current or voltage across any conductor of the – **Linear network**
- -------- is applicable to both linear and non linear circuits- **Substitution theorem**
- Superposition theorem is applicable for – **Linear network**
- Superposition theorem is only applicable for determining _____ only– **Voltage and current**
- In electrical circuits states that for a response (voltage or current) in any branch of a bilateral linear circuit having more than one independent source equals the algebraic sum of the responses caused by each independent source acting alone– **Superposition Theorem**

- The Superposition theorem is used when the circuit contains – **Many number of voltage or current source**
- A network has two AC sources of different frequencies. Which method of analysis can be used to find current and voltage of different branches– **Superposition theorem**
- The superposition theorem requires as many circuits to be solved as there are – **Sources**
- In applying superposition theorem, to determine branch currents and voltages– **Voltage sources are shorted and current sources are open circuited**
- What is the true condition for maximum power transfer from source to load as per maximum power transfer theorem- **Source resistance is equal to load resistance**
- When a source is delivering maximum power to the load; the efficiency will be - **50%**
- The maximum power is delivered from a source to a load when the source resistance is – **Equal to load resistance**
- Which expression is the expressed of maximum power theorem – $\mathbf{P_{max} = \frac{V_{Th}^2}{4R_L}}$
- Maximum power transfer from source to load occurs when the load resistance is ……. the internal resistance of the circuit– **Equal to**
- It is not desired to attain the condition of maximum power transfer – **Electric circuits**
- Maximum power transfer theorem states an independent voltage source in series with an impedance Z_{th} delivers a maximum average power to the load impedance Z_L: where in– $\mathbf{Z^*_{th}=Z_L}$
- "Maximum power output is obtained from a network when the load resistance is equal to the output resistance of the network as seen from the terminals of the load". The given statement is associated with– **Maximum power transfer theorem**
- The maximum power transfer theorem is used in – **Electronic circuits**
- Given condition justifies which network theorems – The load impedance should be complex conjugate of the internal impedance of the active network– **Maximum power transfer theorem**
- In a maximum power transfer theorem the internal resistance must be– **Equal to load resistance**
- Enables a number of voltage (or current) source to be combined directly into a single voltage (or current) source– **Millman's theorem**
- Millaman's theorem yields– **Equivalent voltage or current source**
- "This theorem is applicable only to two sources directly connected in parallel. It is not applicable where there are resistance elements between the sources". This theorem is– **Millman's theorem**
- The Tellegan's theorem can be applied to - **Passive, Active, Linear and non-linear, hysteresis and non-hysteresis network**
- Which theorem states that the sum of instantaneous power in 'n' number of branches of an electrical network is zero?– **Tellegen's**
- The theorem which states that in any linear nonlinear, passive, active, time-variant and time-invariant network, the summation of instantaneous powers is zero will be called as–**Tellegen's theorem**
- The maximum power transfer theorem can be applied to - **Both AC and DC circuits**
- Tellegen's theorem is based on the principle of law of – **Conservation of energy**
- According to Tellegen's Theorem, the sum of instantaneous powers for the n branches in a network is always – **Equal to zero**
- Which one of applicable to any network linear or non-linear, active or passive, time varient or invarient as long as Kirchhoff's laws are not violated– **Tellegen's theorem**
- A passive 2-port network is in a steady- state. Compared to its input, the steady state output can never offer– **Greater power**
- Which network analysis states that the algebraic sum of voltage on a closed loop is zero – **Loop current method of analysis**
- Which step for solution of a network utilizing reciprocity theorem is truly stated - **The current in the branch where voltage source was**
- Which is the direct method of network analysis - **Reciprocity theorem**
- A network contains linear resistors and ideal voltage sources. If values of all the resistors are doubled, then the voltage across each resistor is– **Not changed**
- In balanced bridge, if the positions of detector and source are interchanged, the bridge will still remain balanced. This can be explained from which theorem– **Reciprocity Theorem**
- In any bilateral network, if a source of e.m.f. E in any branch produces a current I in any other branch, then same e.m.f. acting in the second branch would produce the same current I in the first branch. This statement is associated with– **Reciprocity theorem**
- The reciprocity theorem is applicable for– **Only single source network**

Important Objective Questions asked in various Exams.

1. Which of the following facts is correct for KCL?

(a) Zero charge accumulation at node
(b) Possibility of charge accumulation at node
(c) Charge accumulation may or may not be possible
(d) Energy may be stored at the node

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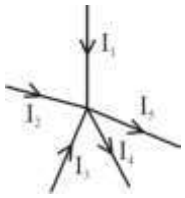
Ans. (a) : Zero charge accumulation at node is the correct statement for KCL.
According to KCL (Kirchhoff's current law), the total current entering a junction or a node is equal to the current leaving the node thus no charge is lost.



$I_1 + I_2 + I_3 = I_4 + I_5$

2. Ten resistors having the same value of resistance i.e. 10 ohm, are connected in parallel. What will be the equivalent resistance of this connection?

(a) 1. 5 ohm (b) 2 ohm
(c) 1 ohm (d) 100 ohm

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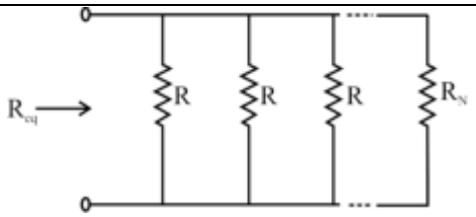
Ans. (c) :



$$R_{eq} = \frac{R}{N}$$

Resistance of each resistor =10Ω
Number of resistor (N) =10

$$R_{eq} = \frac{R}{N} = \frac{10}{10} = 1\Omega$$

3. A battery source of 20 V when connected to a load of 19 Ω draws a current of 1 A. What is the value of internal resistance of battery?

(a) 1 Ω (b) 39 Ω
(c) 0.5 Ω (d) 2 Ω

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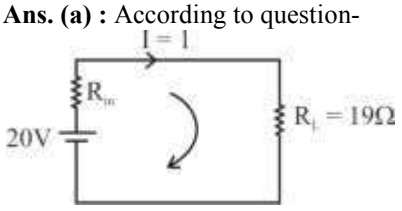
Ans. (a) : According to question-

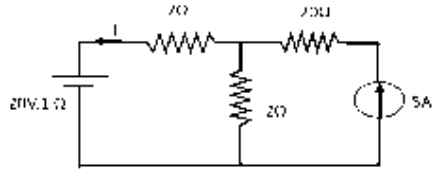


Apply KVL,

$$\frac{20}{19 + R_{in}} = 1$$

$R_{in} = 1\Omega$

4. In the circuit shown here, the 20 V source has an internal resistance of 1 Ω. While the current source is ideal, the value of current I is _____.



(a) 10 A (b) −1A
(c) 1A (d) 5A

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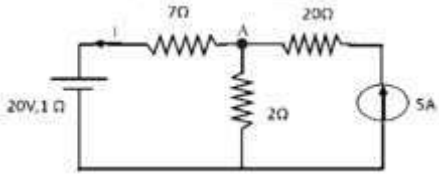
Ans. (b) : According to question-



Applying KCL at node 'A'-

$$5 = \frac{V_A - 20}{8} + \frac{V_A}{2}$$

$V_A = 12V$

$$I = \frac{12 - 20}{8} = \frac{-8}{8} = -1A$$

5. A DC source of EMF E volts and internal resistance R ohms is connected to a variable load and it is adjusted such that the load absorbs maximum power from the source. The maximum power delivered from the source to the load is:

(a) $\frac{E^2}{4R}$ (b) $\frac{2E^2}{R}$
(c) $\frac{E^2}{R}$ (d) $\frac{E^2}{2R}$

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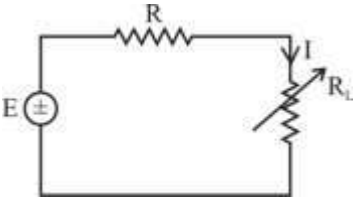
Ans. (a) : A DC source of EMF E volts and internal resistance R is connected to a variable load and it is adjusted such that the load absorb maximum power from the source. The maximum power delivered from the source to the load is $\frac{E^2}{4R}$.



Power dissipated across the load resistance

$$P_L = I^2R_L$$

$$I = \frac{E}{R + R_L}$$

$$P_L = \left(\frac{E}{R + R_L}\right)^2 \times R_L$$

For maximum power transfer from source to load-

$$\frac{dP_L}{dR_L} = 0$$

$$\frac{E^2\left[(R + R_L)^2 - R_L \times 2(R + R_L)\right]}{(R + R_L) = 0} = 0$$

$$(R + R_L)^2 - 2R_L(R + R_L) = 0$$

$$(R + R_L)(R + R_L - 2R_L) = 0$$

$$R - R_L = 0$$

$$R_L = R$$

So, $P_{max} = \frac{E^2}{(R + R)^2} \times R = \frac{E^2}{4R}$

6. Which of the following statements are correct?

(a) Lenz's law is based on the conservation of charge.

(b) Lenz's law gives the direction of induced current.

(c) Lenz's law is based on the conservation of energy.

(a) Both (a) and (c) (b) Both (b) and (c)

(c) Both (a) and (b) (d) (a), (b) and (c)

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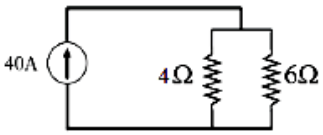
Ans. (b) : According to Lenz's law, the direction of induced emf or current in a circuit is such as to oppose the cause that produces it.

- This law gives the direction of induced emf or induced current.
- Lenz's law is based on the conservation of energy.
- The magnitude of the induced emf is given by Faraday's laws of electromagnetic induction.

Hence, (b) and (c) statements are correct.

7. The power dissipated in the 6Ω resistor is ____.



(a) 3456 W (b) 1024 W

(c) 1536 W (d) 1000 W

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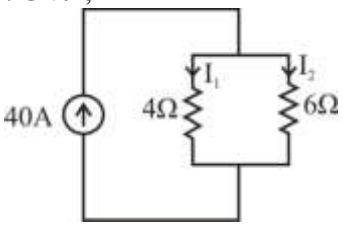
Ans. (c) : Given,



Apply current division rule:

$$I_2 = 40 \times \frac{4}{(4 + 6)} = 16A$$

Hence the power dissipated in the 6Ω resistor is given by,

$$P = I_2^2R$$

$$P = (16)^2 \times 6 = 256 \times 6 = 1536W$$

$$\boxed{P = 1536W}$$

8. If two identical 2A, 2Ω Norton equivalent circuits are connected in parallel with like polarity connected to like polarity, the combined Norton equivalent circuit is:

(a) 0 A, 1 Ω (b) 4 A, 1 Ω

(c) 4 A, 4 Ω (d) 2 A, 4 Ω

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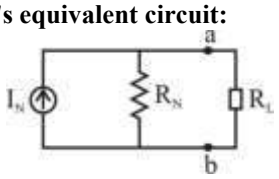
Ans. (b) : Given,

Norton's equivalent circuit:

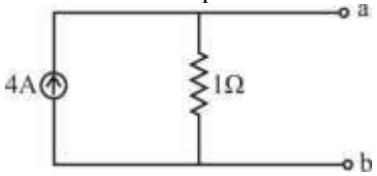


So,

Current gets added hence, $I_N = 2+2 = 4A$

$R_N = (2||2)=1\Omega$

∴ Overall Norton's equivalent circuit is-



9. In an electrical circuit, the sum of EMFs of all the sources met on the way plus the voltage drops in the resistances must be zero. This can be explained by ____.

(a) Ohm's law

(b) Laplace's law

(c) Kirchhoff's voltage law

(d) Kirchhoff's current law

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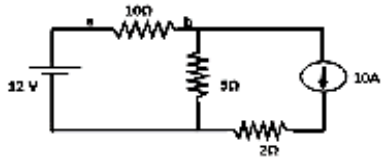
Ans. (c) : In an electrical circuit, the sum of EMFs of all the sources met on the way plus the voltage drops in the resistances must be zero. This can be explained by Kirchhoff's voltage law.

10. The value of Thevenin's voltage across terminal a - b will be .



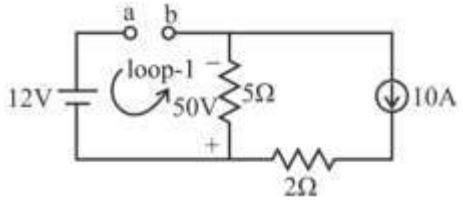
(a) 0 V (b) 12 V

(c) 62 V (d) 50 V

SSC JE-06.06.2024, Shift-II

Ans. (c) : To find the value of Thevenin's voltage across terminal a-b the resistance 10Ω between terminal a-b will be removed.

Now,



Apply KVL in loop-1,

$V_a - 12 - 50 - V_b = 0 \Rightarrow V_a - V_b = 62\text{Volt}$

$\boxed{V_{ab} = 62\,\text{Volt}}$

11. An electrical network contains only one loop and no other mesh. How many KVL equations can be formed for the circuit?

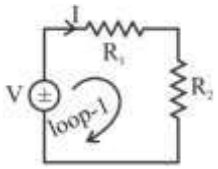
(a) 4 (b) 1

(c) 3 (d) 2

SSC JE-06.06.2024, Shift-II

Ans. (b) : An electrical network contains only one loop and no other mesh, then only one KVL equations can be formed for the circuit.

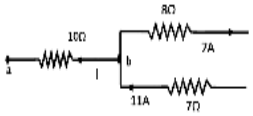
Example:



$V = IR_1 + IR_2$

Here only one KVL equation can be formed

12. The value of voltage V_{ab} in the figure shown below is :

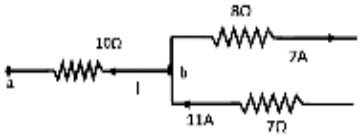


(a) 0 V (b) – 40 V

(c) 40 V (d) –190 V

SSC JE-11.10.2023, Shift-III

Ans. (b) :



KCL at node (b) -

$I + 7 - 11 = 0$

$\boxed{I = 4A}$

Then,

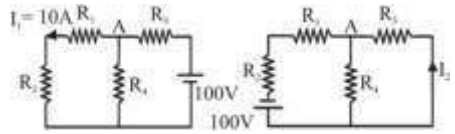
$V_{ba} = I \times 10$

$= 4 \times 10$

$V_{ba} = 40$

$\boxed{V_{ab} = -40\,V}$ $\because V_{ba} = -V_{ab}$

13. The value of the current I_2 if I_1 is equal to 10A, is:

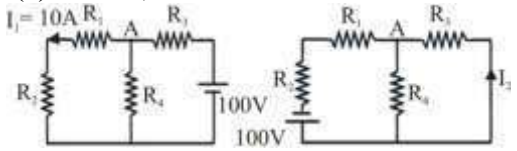


(a) $\frac{100}{R_3}$A (b) 0 A

(c) $\frac{100}{R_2}$A (d) 10 A

SSC JE-11.10.2023, Shift-III

Ans. (d) : Given ,



According to reciprocity theorem-

The ratio between response and excitation remains the same even after the position of response and excitation are interchanged.

Then, $\boxed{I_2 = 10\,\text{Amp}}$

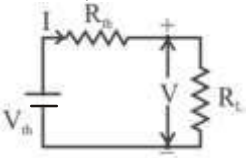
14. A voltage source having some internal resistance delivers a 2A current when a 5Ω load is connected to it. When the load is 10Ω, then the current becomes 1.6A. Calculate the power transfer efficiency of the source for a 15Ω load.

(a) 90% (b) 50%

(c) 100% (d) 10%

SSC JE-11.10.2023, Shift-III

Ans. (b) : Given,



$V_{th} = IR_{th} + V$

$V_{th} = 2R_{th} + 10$ .....(i)

Again $V_{th} = 1.6R_{th} + 16$ .....(ii)

$0.4R_{th} = 6$ Subtracting (i) &(ii)

$R_{th} = \frac{6}{0.4} = \frac{60}{4} = 15\Omega$

Which shows $R_L = R_{th}$

∴ By maximum power transfer theorem power transfer efficiency is equal to 50%.

15. A 64kΩ resistor has a specified maximum power dissipation of 1000 watts. The maximum current that may be passed through the resistor is _____.

(a) 64A (b) 32A

(c) $\frac{1}{8}$A (d) 8A

SSC JE-11.10.2023, Shift-III

Ans. (c) : We know that,

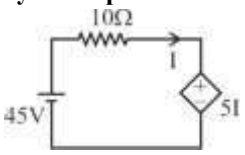
$$\boxed{P = I_{max}^2 R}$$

According to question

Maximum current $I_{max} = \sqrt{\frac{P}{R}} = \sqrt{\frac{1000}{64\times10^3}}$

$= \sqrt{\frac{1}{64}} = \frac{1}{8}A$

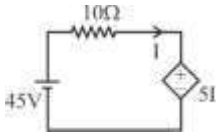
16. In the circuit shown below, the power delivered by the dependent voltage source is:



(a) 0 W (b) –15 W
(c) –45 W (d) 45 W

SSC JE-10.10.2023, Shift-II

Ans. (c) : Given that,



Applying KVL in loop-

$45 - 10I - 5I = 0$

$45 = 15I$

$I = \frac{45}{15}$

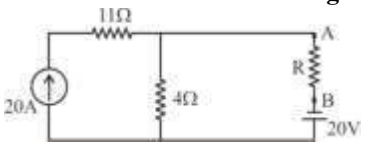
$\boxed{I = 3Amp}$

Power (P) = VI

Power delivered by the dependent voltage source

$= -15\times3 = -45W.$

17. The Thevenin's equivalent voltage across terminal A-B shown in the figure is ———.

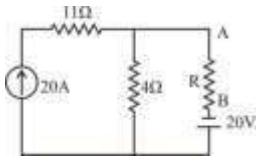


(a) 300 V (b) 10 V
(c) 80 V (d) 100 V

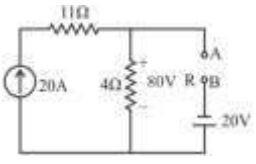
SSC JE-10.10.2023, Shift-II

Ans. (d) :

Given that,



For V_{AB}



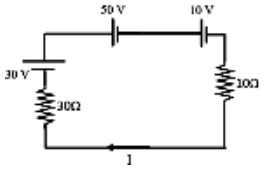
Apply KVL

$V_A - 80 - 20 - V_B = 0$

$V_A - V_B = 100$

$\boxed{V_{AB} = 100V}$

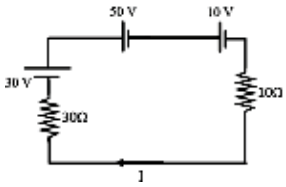
18. The value of the current I in the circuit is.....



(a) 2.25 A (b) –2.25 A
(c) –0.75 A (d) 0.75 A

SSC JE-09.11.2023, Shift-III

Ans. (c) :



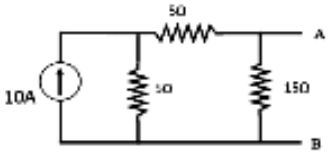
Applying KVL in loop-

$30 - 50 - 10 = 10I + 30I$

$-30 = 40I$

$\boxed{I = -0.75A}$

19. The Norton's equivalent current between the load terminal A-B will be:



(a) 0 A (b) 10 A
(c) 20 A (d) 5A

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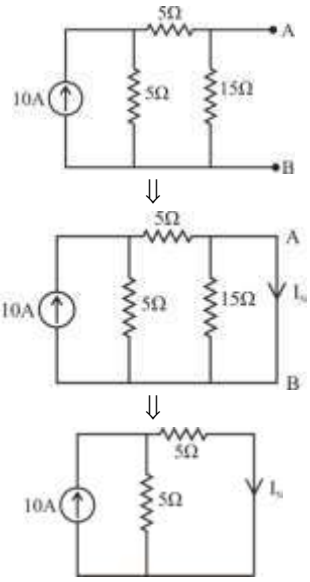
Ans. (d) :



According to current division rule-

$I_N = \frac{5}{5+5}\times10$ $\left[I_2 = \frac{R_1}{R_1+R_2}\times I\right]$

$\boxed{I_N = 5A}$

20. In an electrical network, if the quantity of source is controlled by another voltage or current present in the circuit, such a source is called.....

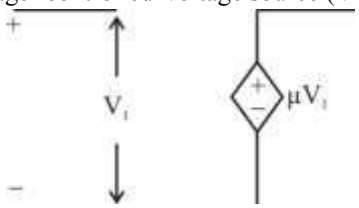
(a) Ideal source (b) Non-ideal source
(c) Independent source (d) Dependent source

SSC JE-09.11.2023, Shift-III

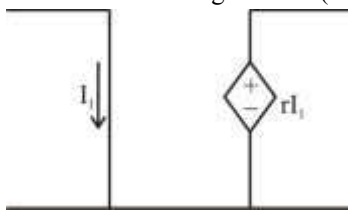
Ans. (d) : In an electrical network, if the quantity of a source is controlled by another voltage or current present in the circuit, such a source is called dependent source.

Type of dependent source-

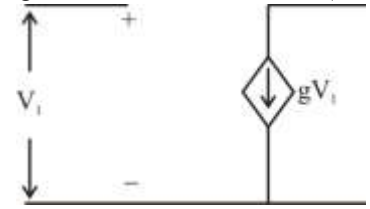
(i) Voltage- controlled voltage source (VCVS)



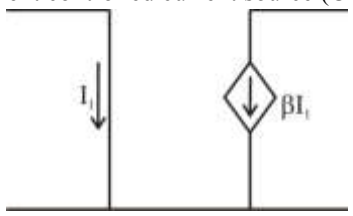
(ii) Current-controlled voltage source (CCVS)



(iii) Voltage controlled current source (VCCS)



(iv) Current controlled current source (CCCS)



21. Which of the following is true regarding reciprocity theorem?

(a) The difference between response and excitation remains the same
(b) The product of response and excitation remains the same
(c) The sum of response and the excitation remains the same
(d) The ratio of the response to the excitation remains the same

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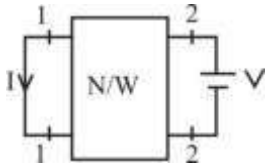
Ans. (d) : If any linear passive, Bilateral network excited with only a single source, then the ratio of response to excitation remains constant if the position of source and load are interchanged.

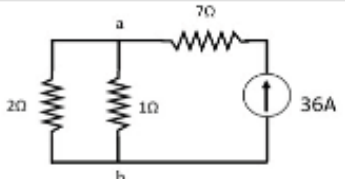


From reciprocity theorem = $\frac{\text{Response}}{\text{Excitation}}$ = constant

$$\boxed{\frac{I_1}{V_1} = \frac{I_2}{V_2}}$$

- This theorem is not applicable when network consist dependents source.
- This theorem is valid for network with only single source.

22. The current through the 2Ω resistor is:



(a) 1A from a to b (b) 12A from a to b
(c) 25A from b to a (d) 10A from b to a

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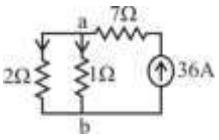
Ans. (b) :

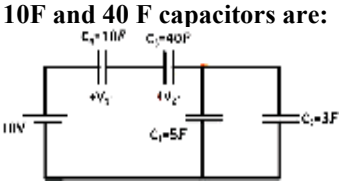


According to current division rule-

Current in 2Ω resistor ($I_{2\Omega}$) = $\frac{1}{2+1} \times 36 = 12A$

$I_{2\Omega}$ = 12A (from a to b)

23. For the circuit shown below, the voltage across 10F and 40 F capacitors are:



(a) 4 V and 1V, respectively
(b) 1V and 4V, respectively
(c) 400 V and 1600 V, respectively
(d) 10 V and 40 V, respectively

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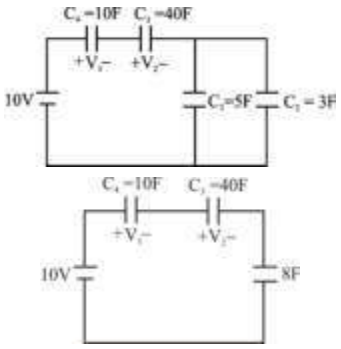
Ans. (a) :



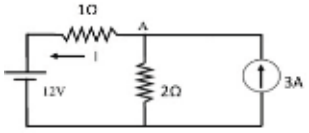
Applying voltage division rule-

$$V_1 = \frac{\frac{1}{10}}{\frac{1}{10}+\frac{1}{40}+\frac{1}{8}} \times 10$$

$$= \frac{\frac{1}{10}}{\frac{4+1+5}{40}} \times 10 = \frac{40}{100} \times 10 = 4V$$

$$V_2 = \frac{\frac{1}{40}}{\frac{4+1+5}{40}} \times 10 = \frac{10}{10} = 1V$$

24. In the circuit shown below, the value of the current I is.....



(a) 2A (b) –2A
(c) 4A (d) 0A

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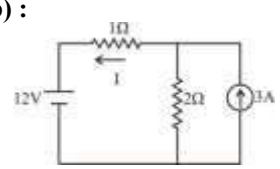
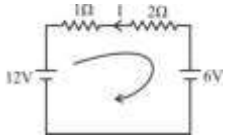
Ans. (b) :



Convert current source to voltage source-

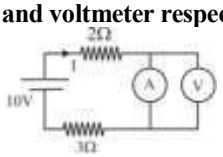


Applying KVL in loop-

$$I = -\frac{(12-6)}{1+2}$$

$$\boxed{I = -2A}$$

25. In the circuit shown below, the reading of the ideal ammeter and voltmeter respectively will be-



(a) 2A and 8V (b) 0A and 8V
(c) 0A and 0V (d) 2A and 0V

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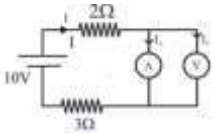
Ans. (d)

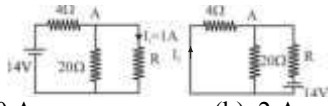


$I_A = \frac{10}{5} = 2A$

$V = 0 \quad (\because R_m = 0$ for ideal ammeter$)$

Because the internal resistance of an ideal voltmeter is infinity and internal resistance of an ideal ammeter is zero.

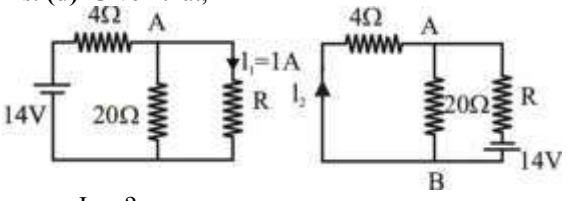
26. If I_1 in the given circuit is 1A, what will be the current I_2 in the 2nd circuit ?



(a) 10 A (b) 2 A
(c) 3 A (d) 1 A

SSC JE-16.11.2022, Shift-III

Ans. (d) Given that,



$I_2 = ?$

from the reciprocity theorem :-

$$\frac{(\text{Response})_1}{(\text{Excitation})_1} = \frac{(\text{Response})_2}{(\text{Excitation})_2}$$

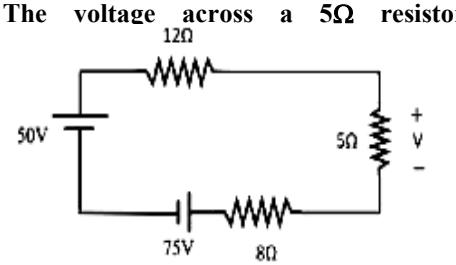
$$\frac{I_1}{V_1} = \frac{I_2}{V_2}$$

$$\frac{1}{14} = \frac{I_2}{-14}$$

$\boxed{I_2 = -1A}$ from A to B

$\boxed{I_2 = 1A}$ from B to A

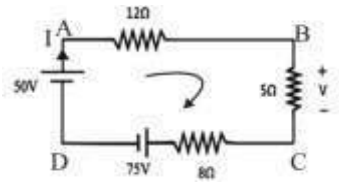
27. The voltage across a 5Ω resistor is :



(a) -5V (b) 25V
(c) 10V (d) 5V

SSC JE-16.11.2022, Shift-III

Ans. (a)



Applying KVL in loop DABCD

$-50 + I(12 + 5 + 8) + 75 = 0$

$25I = -25$

$\boxed{I = -1A}$

Hence Voltage across 5 Ω resistor is

$V = -1 \times 5$

$\boxed{V = -5V}$