NUZVID POLYTECHNIC

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As Per C-23

BASIC ELECTRICAL TECHNOLOGY&EE-106

Material

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I. SHORT ANSWER QUESTIONS

1. State ohms law &mention any four limitations of it.

Ans: **Ohm's law:** ohm's law states that at constant temperature the current flowing through the conductor is directly proportional to potential difference i.e; I α P.D

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

Limitations of ohm's Law:-

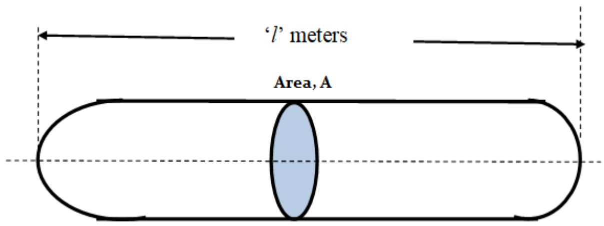
Ohm's law is not applicable for following

- For semi-conductors
- For vacuum tubes
- For arc lamps
- For gas filled tubes

2. What are the laws of resistance?

Ans: **Resistance:-**

- Resistance is the property of resistor, which opposes the flow of electric current.
- Resistance is denoted by the letter "R" and the unit for resistance is Ohm's.
- The resistance is directly proportional to length of the conductor i.e; R α l
- and is inversely proportional to cross sectional area of that conductor i.e; R α $\frac{1}{a}$



∴ Resistance, R α $\frac{l}{a}$

$$R = \rho \frac{l}{a} \text{ ohm's}$$

3. Determine the Resistance of A 564m Length of Aluminum Conductor Whose Rectangular Cross Section Is 4cm By 2cm. Take P = 2.826 X 10^{-8} Ohm-Meter.

Ans: Given data

Length, l = 564m

Cross sectional area, a = 4CM x 2 CM

$= 8\ CM^2$

$= 8 \times 10^{-4}\ M^2$

ρ = 2.826 x 10^{-8} ohm-meter

Require data

Resistance(R) = ?

Resistance, $R = \rho \frac{l}{a}$

$= 2.826 \times 10^{-8} \frac{564}{8 \times 10^{-4}}$

$= 0.0199233\ \Omega$

∴ Resistance, R = 19.9233 mΩ

4. Write any four comparisons among Conductor, Insulator & Semi-Conductor

Ans:

S.No.	Conductor	Insulator	Semi-conductor
1	The materials which allow electrical current through them very easily are known as conductors.	The materials which does not allow electrical current through them are known as insulators.	The materials which allows electrical current partially through them are known as semi-conductors.
2	Good conductor of electricity	Bad conductor of electricity	Partial conductor of electricity
3	Electrical conductivity is very high	Electrical conductivity is negligible	Electrical conductivity is very less
4	They have positive temperature co-efficient of resistance	They have negative temperature co-efficient of resistance	They have negative temperature co-efficient of resistance
5	Ex: Copper, aluminum, tungsten, Silver etc.	Ex: Paper, wood, glass, plastic etc.	Ex: Germanium, silicon, selenium, carbon etc.

5. Define resistance, Specific resistance, Conductance and Conductivity.

Ans: Resistance:-

- The property of material which opposes the flow of electric current is nothing but resistance. Resistance is the property of resistor.
- Resistance is denoted by the letter 'R' and is measured in Ohm's.

$$\text{Resistance, } R = \frac{V}{I} \text{ ohm's}$$

$$R = \rho \frac{l}{a} \text{ ohm's}$$

Specific Resistance:-

- Specific Resistance also called as "Resistivity".
- Resistivity is the electrical resistance per unit length and per unit of cross-sectional area at a specified temperature.

$$\text{Specific resistance, } \rho = R \frac{a}{l} \quad \Omega\text{-m}$$

Conductance:-

★ The reciprocal of resistance is nothing but conductance.
★ Conductance is denoted by the letter 'G'and is measured by ℧ (mho).

$$\text{Conductance, } G = \frac{1}{R} \quad ℧$$

Conductivity:-

★ The reciprocal of resistivity is nothing but "conductivity".

$$\text{Conductance, } G = \sigma \frac{a}{l} \quad ℧$$

$$\sigma = G \frac{l}{a} \quad ℧/m$$

6. Define Current, Potential Difference and Voltage

Ans: **Voltage:** voltage is defined as the energy required to moves the unit charge from one point to another point.

Potential difference: It is defined as the amount of energy used by one coulomb of charge in moving from one point to other.

$$\boxed{\text{Potential difference} = \frac{\text{Energy}}{\text{Charge}}} \text{ Volts.}$$

Current: Flow of electrons is nothing but "Current". Current is denoted by the letter 'I' and is measured in Amperes.

$$\text{Current, I} = \frac{\text{Charge (Q)}}{\text{Time (t)}} \text{ Amperes}$$

7. Calculate the value of current through a resistance of 100 ohms. If it is connected across a battery of 1.5volts

Ans: Given data

Resistance, R =100Ω

Voltage, V= 1.5Volts

Require data

Current =?

$$\text{Current, I} = \frac{\text{Voltage}}{\text{Resistance}}$$

$$= \frac{1.5}{100}$$

$$= 0.015 \text{ Amps}$$

$$\boxed{\text{Current, I} = 15} \text{ mA}$$

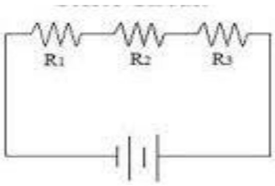
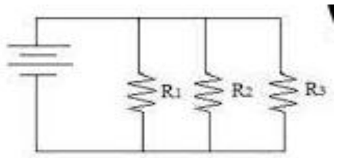
8. Define temperature co-efficient of resistance and give its units.

Ans: It is defined as the ratio between change in resistance per t^0 C to normal resistance. It is denoted by the letter 'α' and unit is inverse unit of temperature i.e. $(°C)^{-1}$.

$$\boxed{\text{Temperature co-efficient of resistance, } \alpha = \frac{R_t - R_0}{R_0 t}} \; °C^{-1}$$

9. Compare Series and Parallel Connection

Ans:

S.No.	Series Connection	Parallel Connection
1	The Finishing terminal of First resistor is connected to starting terminal of next resistor. this connection is called "**Series Connection**"	All the starting terminals are connected at one point and all the finishing terminals are connected at another point. this connection is called "**Parallel Connection**"
2	The Circuit diagram for Series conection is 	The Circuit diagram for Parallel conection is 
3	Total Resistance, $R_{total} = R_1 + R_2 + R_3$	Total Resistance, $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
4	In this connection the voltage is divided based on resistance	In this connection the voltage is same
5	In this connection the Current is same	In this connection the Current is divided.

10. Write a short notes on Current Division Rule

Ans:

- Current division rule is used for find the current in any resistor in a Parallel circuit.
- Current in any resistor is

$$\text{Current in any resistor} = \text{Total current} \times \frac{\text{Opposite Resistance}}{\text{Total Resistace}} \quad \text{Amps}$$

11. Write a short notes on Voltage Division Rule

Ans:

- Voltage division rule is used for find the Voltage at any resistor in a Series circuit.
- Voltage in any resistor is

$$\text{Voltage at any resistor} = \text{Total Voltage} \times \frac{\text{Same Resistance}}{\text{Total Resistace}} \quad \text{Volts}$$

12. Define Active and Passive Element

Ans: **Active Element**:-

- ✓ An element which gives electrical energy to the circuit is called Active Element.
- ✓ Eg: Voltage Source, Current Source, Battery, Generator, etc.

Passive Element:-

- ✓ An element which receives electrical energy from the circuit is called Passive Element.
- ✓ Eg: Resistor, Inductor, Capacitor, etc.

13. Define Node, Branch and Loop

Ans: **Node:** If two or more circuit elements are joined at a point is called 'Node'.

Branch: The path directly connecting between two nodes is called 'Branch'.

Loop: The Closed path of a circuit is called 'Loop'.

14. Define KCL and KVL

Ans: **Kirchhoff's Current Law (KCL):** The algebraic sum of all the currents meeting at a point is equal to zero.

$$\sum I = 0$$

Kirchhoff's Voltage Law (KVL): In a closed circuit algebraic sum of potential rise is equal to algebraic sum of potential drop.

$$\sum \text{Potential Rise} = \sum \text{Potential Drop}$$

15. Define Work and mention the SI units

Ans: **Work:** Work is said to be done when a force acting on a body causes it to move. It is denoted by the letter 'W' and is measured in 'Joules or N-m'.

$$\text{Work done} = \text{Force(F)} \times \text{Displacement(d)} \quad \text{Joules}$$

Electric Work: The work is said to be done in an electrical circuit, when a current of 'I' ampere passes through it for 't' seconds against a potential difference of 'V' volts.

$$\text{Electric Work done} = V \times I \times t$$

$$\boxed{W = VIt} \text{ watt-sec}$$

16. Define Power and mention the SI units

Ans: **Power:** It is defined as the rate of doing work is nothing but Power.It is denoted by the letter 'P' and is measured in newton-meter/sec or joule/sec.

$$\text{Power} = \frac{\text{Work done}}{\text{Time}} \quad \text{joule/sec}$$

- ✓ The practical unit of mechanical power is horse power. Horse power may be MHP (Metric Horse Power) or BHP (British Horse Power).

  1MHP = 735.5 watts

  1BHP = 746 watts

Electrical Power: It is defined as the rate at which work is done in an electrical circuit.

$$\text{Power, } P = \frac{\text{Work done Elect rical circuit}}{\text{Time}} \quad \text{watts}$$

$$P = \frac{VIt}{t}$$

$$\boxed{P = VI} \text{ watts}$$

17. Define Energy and mention the SI units

Ans: **Energy:** It is defined as the capacity of doing work is called "Energy". It is denoted by the letter 'E' and is measured in 'Joules'.

Electrical Energy: It is defined as the total amount of work done in an electrical circuit.

$$\text{Electrical Energy} = \text{Power} \times \text{Time}$$

$$\boxed{E = VIt} \text{ Watt-sec}$$

18. Define thermal efficiency.

Ans: It states that the ratio of utilized heat to the total heat produced by the element.

Thermal efficiency is represented as 'η_{th}'

$$\text{Thermal efficiency, } \eta_{th} = \frac{\text{utilized heat}}{\text{total heat produced}}$$

19. State joule's law.

- Ans: Joule's law states that "the amount of heat produced is directly proportional to electrical energy expended". i.e; $H \alpha I^2Rt$

$$\text{Heat, } H = \frac{I^2Rt}{J}$$

Where J = Mechanical equivalent of heat or joules constant = 4.2 calories

$$\boxed{\text{Heat, } H = \frac{I^2Rt}{4.2}} \text{ cal}$$

20. Write the power ratings for any ten home appliances.

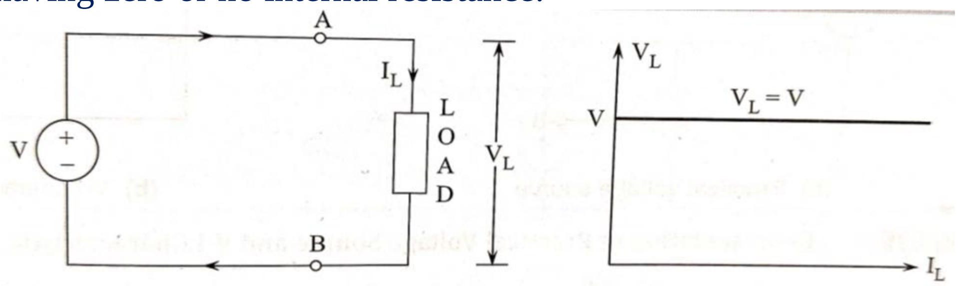
Ans: The following are the power ratings of different appliances

S.NO.	APPLIANCE	RATING
1	Incandescent Lamp	60 to 300 Watts
2	Fluorescent lamp	40to150 Watts
3	Television set	80to 500 Watts
4	Refrigerators	150 to 500 Watts
5	Electric iron	200 to 1000 Watts
6	Air conditioner	500 to 4500 Watts
7	Water heater	1000 to 4000 Watts
8	Compact Fluorescent Lamp(CFL)	10 to 42 Watts
9	Light Emitting Diode(LED)	5 to 40 Watts
10	Ceiling Fan	80 to 100 Watts

21. Write short notes on ideal voltage source and ideal current source.

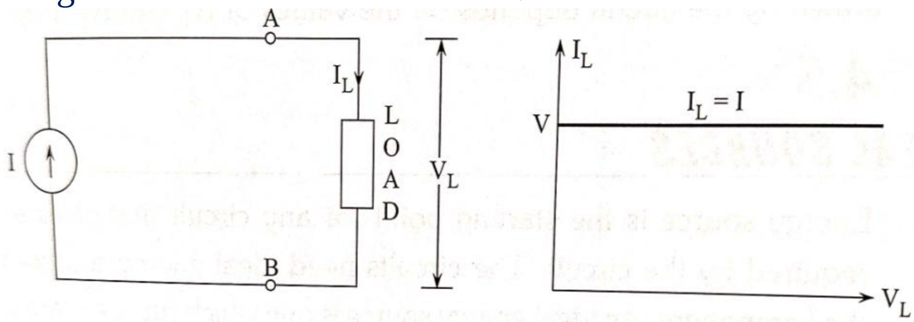
Ans: **Ideal Voltage Source**:-

- ❖ In an ideal voltage source the output voltage is constant.
- ❖ It means it having zero or no internal resistance.



Ideal Current Source:-

- ❖ In an ideal current source the output current is constant.
- ❖ It means it having zero or no internal resistance.

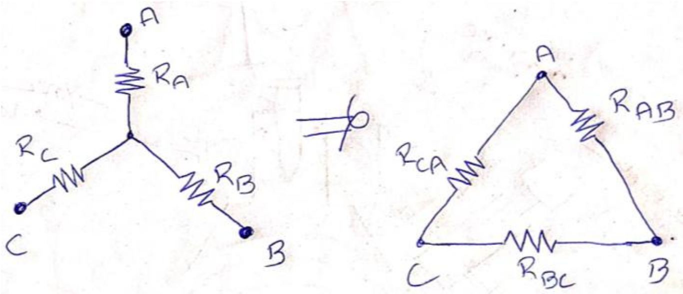


22. Write the formula for star to delta transformation.

Ans:- $R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$

$R_{BC} = R_B + R_C + \frac{R_B R_C}{R_A}$

$R_{CA} = R_C + R_A + \frac{R_C R_A}{R_B}$

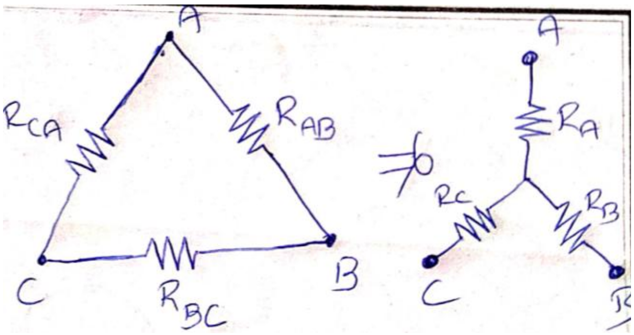


23. Write the formula for delta to star transformation.

Ans:- $R_A = \frac{R_{AB}\, R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$

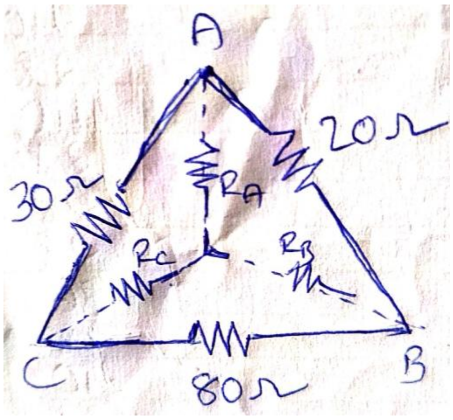
$R_B = \frac{R_{AB}\, R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$

$R_C = \frac{R_{BC}\, R_{CA}}{R_{AB} + R_{BC} + R_{CA}}$



24. Three resistances 20 Ω, 80 Ω and 30Ω are connected in delta. Find the equivalent resistance in star.

Ans: The given three resistances are 20 Ω, 80 Ω &30Ω



$R_A = \frac{20 \times 30}{20+80+30}$

$= 4.61538\ \Omega$

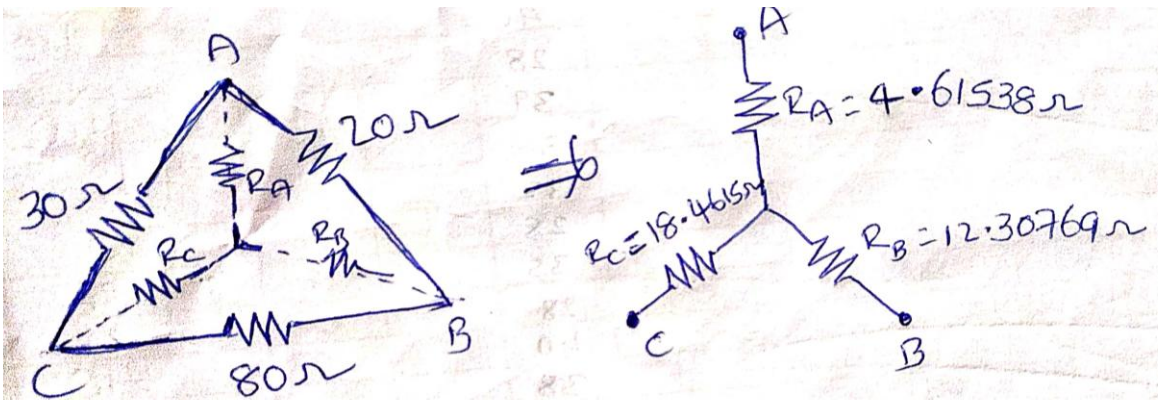
$R_B = \frac{20 \times 80}{20+80+30}$

$= 12.30769\Omega$

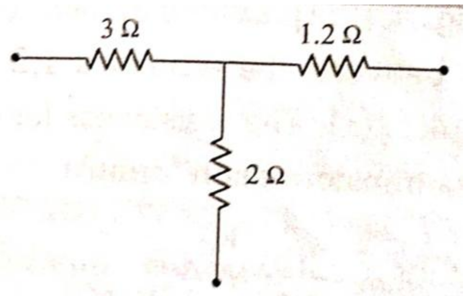
$R_C = \frac{80 \times 30}{20+80+30}$

$= 18.46153\Omega$

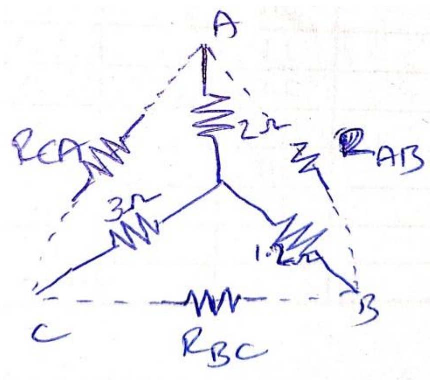
∴ Equivalent star network is



25. Find the equivalent delta network for the network shown below.



Ans: the given network is modified as



$$R_{AB} = 2 + 1.2 + \frac{2 \times 1.2}{3}$$

$= 2.56\ \Omega$

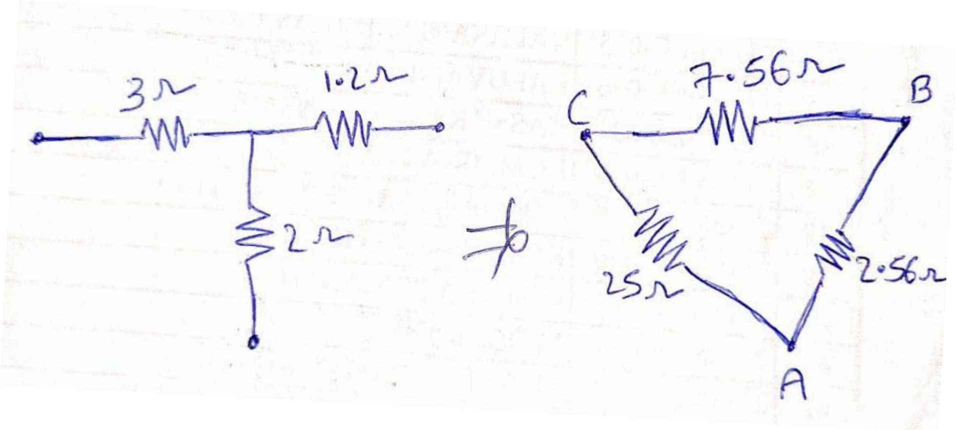
$$R_{BC} = 1.2 + 3 + \frac{1.2 \times 3}{2}$$

$= 7.56\ \Omega$

$$R_{CA} = 3 + 2 + \frac{3 \times 2}{1.2}$$

$= 25\ \Omega$

∴ Equivalent Delta network is



26. State super position theorem

Ans: It states that "in a linear network containing more than one source, the response at any element is the algebraic sum of the responses due to each source acting alone with all other sources set to be zero".

27. State Thevenin's theorem.

Ans: It states that in a linear and bilateral network consists of several sources and resistances can be replaced by a single equivalent voltage source i.e; Thevenin's equivalent voltage (V_{th}) in series with a single equivalent resistance i.e; Thevenin's equivalent resistance (R_{th}).

28. State Norton's theorem

Ans: It states that in a linear and bilateral network consists of several sources and resistances can be replaced by a single equivalent current source i.e; Norton's equivalent current (I_N) in series with a single equivalent resistance i.e; Norton's equivalent resistance (R_N).

29. State maximum power transfer theorem

Ans: It states that the maximum power is transferred from source to load when load resistance is equal to internal resistance.

$$\boxed{R_L = R_{th}}$$

30. Derive the condition for maximum power transfer theorem.

Ans:

The load current, $I_L = \frac{V_{th}}{R_{th} + R_L}$

Power consumed by the load, $P_L = I_L{}^2 R_L$ watts

$$= \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 R_L$$

$$= \frac{V_{th}{}^2 R_L}{(R_{th} + R_L)^2}$$

The power, P_L becomes maximum when differentiate of P_L with respect to R_L and is equal to zero.

$$\frac{d}{dR_L}(P_L) = 0$$

$$\frac{d}{dR_L}\left(\frac{V_{th}{}^2 R_L}{(R_{th} + R_L)^2}\right) = 0$$

$$\frac{(R_{th} + R_L)^2 \frac{d}{dR_L}(V_{th}{}^2 R_L) - (V_{th}{}^2 R_L)\frac{d}{dR_L}(R_{th} + R_L)^2}{((R_{th} + R_L)^2)^2} = 0$$

$$\frac{V_{th}{}^2 (R_{th} + R_L)^2 - (V_{th}{}^2 R_L) 2 (R_{th} + R_L)}{(R_{th} + R_L)^4} = 0$$

$$V_{th}{}^2 (R_{th} + R_L)^2 - 2(V_{th}{}^2 R_L)(R_{th} + R_L) = 0 (R_{th} + R_L)^4$$

$$V_{th}{}^2 (R_{th} + R_L)[R_{th} + R_L - 2R_L] = 0$$

$$R_{th} - R_L = 0$$

$$-R_L = -R_{th}$$

$$\boxed{R_L = R_{th}}$$

II. LONG ANSWER QUESTIONS

31. Derive an expression for resistance at any temperature (or) Derive an expression $R_t = R_0(1 + \alpha_0 t)$

Ans:

- Consider a conductor having resistance R_0 at 0^0C.
- If the temperature is increases to t^0C then the Resistance also increases to R_t
- The increase in resistance is $\Delta R = R_t - R_0$
- The increase in resistance is
  - Directly proportional to initial resistance i.e; $\Delta R \propto R_0$ ----→ 1
  - Directly proportional to the rise in temperature. i.e; $\Delta R \propto t$ ----→ 2
  - Depends on the nature of the material

∴ $R_t - R_0 \propto R_0 t$ ----→ 3

$$R_t - R_0 = \alpha_0 R_0 t$$

- Where α_0 = proportionality constant (or) Temperature co-efficient of resistance at 0^0C From the above eq'n $R_t = R_0 + \alpha_0 R_0 t$
- Resistance at any temperature

$$\boxed{R_t = R_0(1 + \alpha_0 t)}\ \Omega$$

32. A heater element is made of nichrome wire having resistivity of 45 x 10^{-6} Ω-cm. The diameter of the wire is 0.13cm. Calculate the length of the wire required to get a resistance of 3.4Ω.

Ans:

Given data	Require data
Resistivity, $\rho = 45 \times 10^{-6}$ Ω-cm	Length = ?
Diameter, d= 0.13cm	
Resistance, R = 3.4Ω	

$$\text{Resistance, } R = \rho \frac{l}{a}$$

$$\text{Length, } l = \frac{R \times a}{\rho}$$

$$\text{Area, } a = \pi r^2$$

$$= \pi \left(\frac{0.13}{2}\right)^2$$

$$= 0.01327\ cm^2$$

$$l = \frac{R \text{ x } a}{\rho}$$

$$= \frac{3.4 \text{ x } 0.01327}{45 \text{ x } 10^{-6}}$$

$$= 1002.62 \text{ cm}$$

Length, l=100.262 m

∴ Length of the wire is 100.262 m

33. Derive an expression for temperature coefficient of resistance at any temperature.

(or)

Derive an expression $\alpha_t = \frac{\alpha_0}{1+\alpha_0 t}$

Ans:-

- The temperature co-efficient (α) of resistance is not constant but depends on initial temperature.
- The resistance measured at 0^0C then α has ‘ α_0’
- If the temperature is increases to t^0C then α is ‘α_t’
- The conductor is heated from point-A to point-B, The initial temperature is 0^0C, the resistance at point-B is

$$R_t = R_0(1 + \alpha_0 t) \quad \text{---}\rightarrow 1$$

- If the conductor is cooled from t^0C to 0^0C, hear the initial point is ‘B’and final point is ‘A’. Hence there is a decrease in temperature of $-t^0$C. the resistance at point-A is

$$R_0 = R_t(1 + \alpha_t(-t))$$

$$R_0 = R_t(1 - \alpha_t t) \quad \text{---}\rightarrow 2$$

$$R_0 = R_t - R_t\,\alpha_t t$$

$$R_t\,\alpha_t t = R_t - R_0$$

$$\alpha_t = \frac{R_t - R_0}{R_t t} \quad \text{--}\rightarrow 3$$

Now substitute eq’n 1 in eq’n 3

$$\alpha_t = \frac{R_0 + R_0\alpha_0 t - R_0}{R_0(1+\alpha_0 t)\,t}$$

$$= \frac{R_0\alpha_0 t}{R_0(1+\alpha_0 t)\,t}$$

$$\alpha_t = \frac{\alpha_0}{1+\alpha_0 t}$$

∴ Temperature co-efficient of resistance at any temperature, $\alpha_t = \frac{\alpha_0}{1+\alpha_0 t}$

Note:-

1. If the temperature is t_1^0C , the temperature co-efficient of resistance is, $\alpha_1 = \frac{\alpha_0}{1+\alpha_0 t_1}$
2. If the temperature is t_2^0C , the temperature co-efficient of resistance is, $\alpha_2 = \frac{\alpha_0}{1+\alpha_0 t_2}$

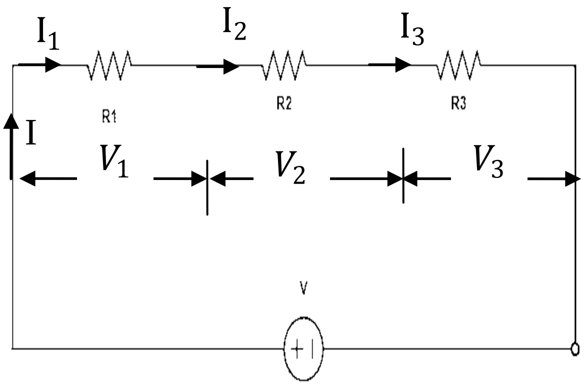
34. Derive an expression for equivalent resistance when three resistances are connected in series

Ans:

- If the finishing end of the first element is connected to the starting end of the next element. This combination is known as "Series Connection".
- Let three resistances R_1, R_2 and R_3 are connected in series across the voltage source 'V' volts as shown in fig.
- In the series connection same current 'I' flows through each resistor

  i.e; $I_1 = I_2 = I_3 = I$
- Let V_1, V_2 and V_3 are the voltage drop across resistors R_1, R_2 & R_3 respectively.

  ∴ Total voltage, $V = V_1 + V_2 + V_3$



- But According to ohm's law

  Voltage, V = IR volts

  $V_1 = IR_1$

  $V_2 = IR_2$

  $V_3 = IR_3$

Then, $V = IR_1 + IR_2 + I R_3$

$= I (R_1 + R_2 + R_3)$

$\frac{V}{I} = R_1 + R_2 + R_3$

∴ The Equivalent or Effective resistance or total resistance, $R_{Eq} = R_T = R_1 + R_2 + R_3$ Ω

- If the circuit consists of 'n' number of resistors are connected in series. Then

The Equivalent resistance or total resistance,

$$R_{Eq} = R_1 + R_2 + R_3 + R_4 + \text{------------} + R_n \ \Omega$$

Note: In series circuit if any problem occurs in the system, then the entire system will stop.

35. Derive an expression for equivalent resistance when three resistances are connected in parallel

Ans:-

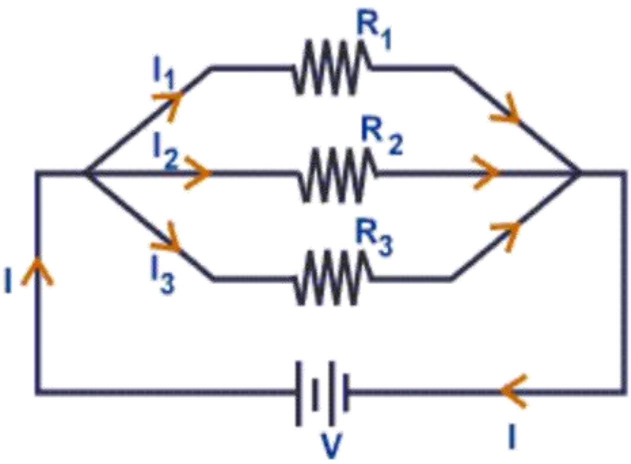
- Parallel connection means all the starting points are joining at a pint and all the finishing points are joined at another point. This combination is know as "Parallel connection".
- In this connection current can be divided based on resistance.
- Let R_1, R_2 and R_3 are the three resistors are connected in parallel across a voltage source as shown in fig.
- In the parallel connection voltage across each element is same.

i.e; $V_1 = V_2 = V_3 = V$

- Let I_1, I_2& I_3 are the currents flowing through the resistances R_1,R_2&R_3 respectively.

Total current, $I = I_1 + I_2 + I_3$

But according to ohm's law



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

$$I_1 = \frac{V_1}{R_1}$$

$$I_2 = \frac{V_2}{R_2}$$

$$I_3 = \frac{V_3}{R_3}$$

$$I = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

But $V_1 = V_2 = V_3 = V$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

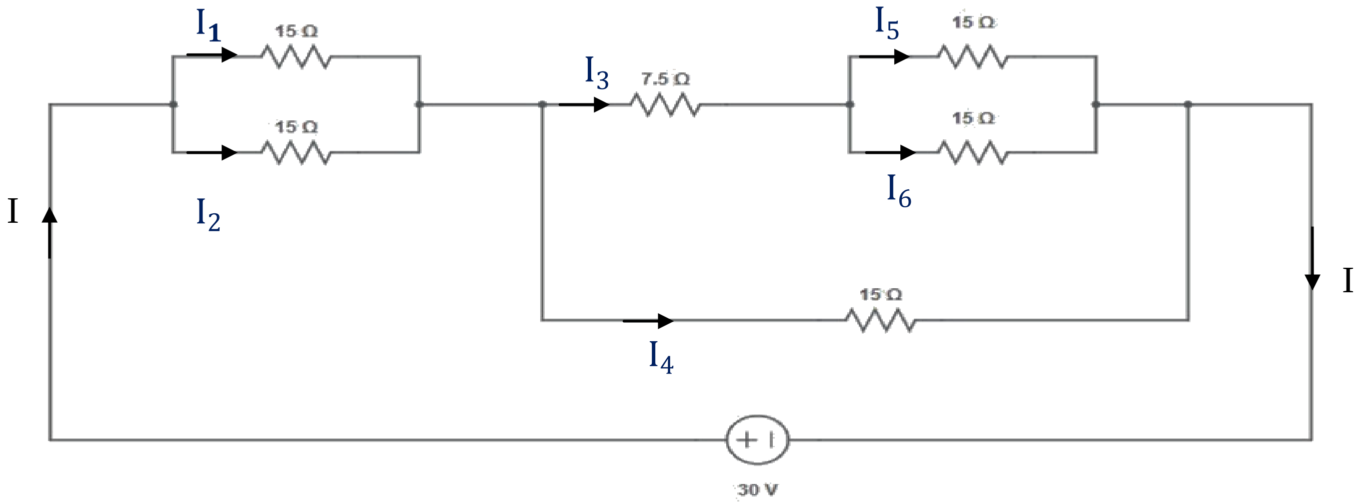
$$\frac{V}{R_{Eq}} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{1}{R_{Eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

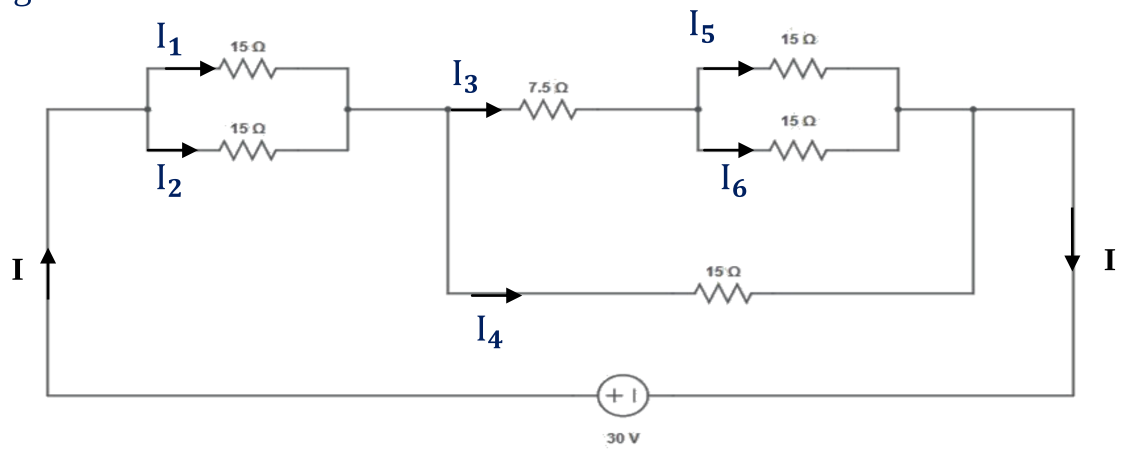
∴ Equivalent resistance or total resistance, $\boxed{\frac{1}{R_{Eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$ Ω

❈ If the circuit consists of 'n' number of resistors are connected in parallel then, Equivalent resistance or total resistance, $\frac{1}{R_{Eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \text{----------} + \frac{1}{R_n}$ Ω

36. Determine the total resistance and current through each resistance of the circuit shown below.



Ans: The given circuit is



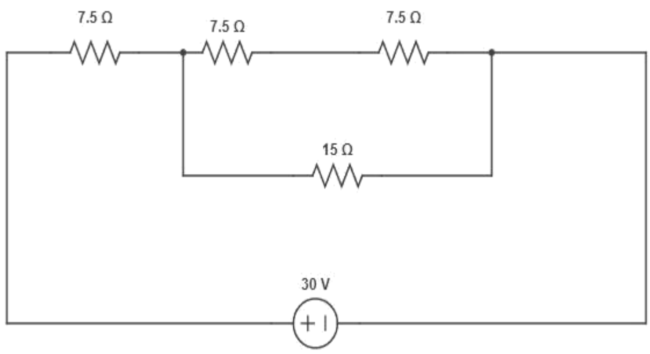
From the given circuit 15Ω &15Ω resistors are connected in parallel. Then,

$$R_{total} = \frac{R_1 R_2}{R_1 + R_2}$$

$$= \frac{15 \text{ X} 15}{15 + 15}$$

$$= 7.5\Omega$$

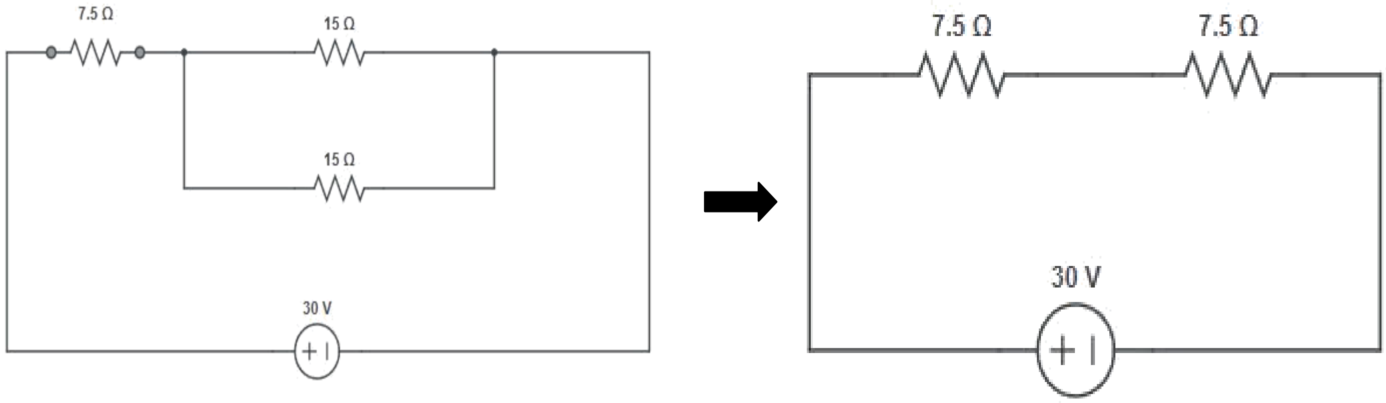
Then the given circuit can be modified as



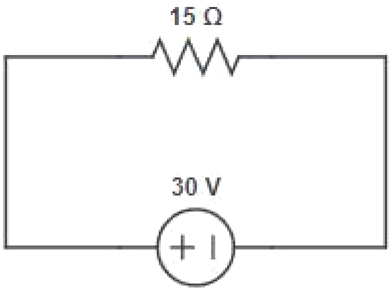
7.5Ω & 7.5Ω resistors are connected in series. Then total resistance is

$$R_{total} = R_1 + R_2$$
$$= 7.5 + 7.5$$
$$R_{total} = 15\Omega$$

Then the circuit can be modified as



∴ Equivalent resistance, $R_{Eq} = 7.5 + 7.5 = 15\ \Omega$

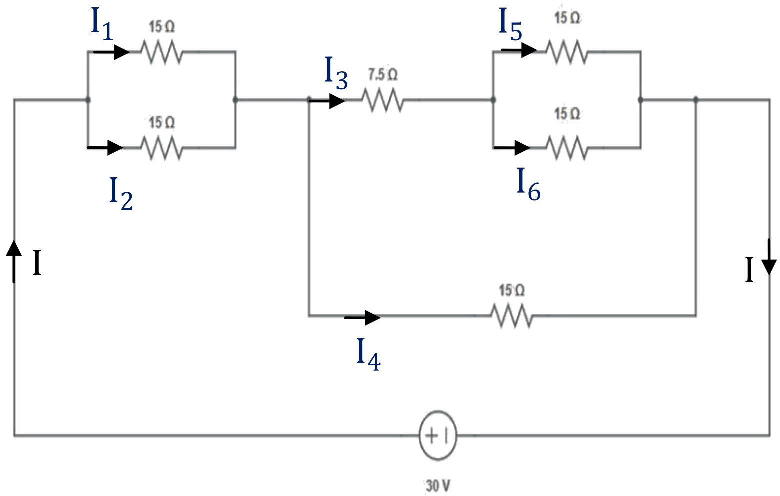


Total Current, $I = \frac{30}{15}$

$$I = 2 \text{ Amps}$$

From the give circuit,

According to current division rule



$$I_1 = I \text{ x } \frac{15}{15+15}$$
$$= \frac{2 \ X\ 15}{30}$$
$$\boxed{I_1 = 1 \text{ Amps}}$$
$$I_1 = I_2 = 1 \text{ Amps}$$
$$I_3 = (I_1 + I_2) \text{ x } \frac{15}{7.5+7.5+15}$$
$$= \frac{2\ X\ 15}{30}$$

$I_3 = 1$ Amps

$I_4 = I_3 = 1$ Amps

$I_5 = I_3 \text{ x } \frac{15}{15+15}$

$= \frac{1 \, X \, 15}{30}$

$I_5 = 0.5$ Amps

$I_6 = I_5 = 0.5$ Amps

37. When two resistance 10Ω and 20Ω incandescent lamp are connected in series across a supply of 220V. Determine the current flowing in each resistance and voltage drop across each resistance.

Ans: **Given data**

$R_1 = 10\Omega$

$R_2 = 20\Omega$

V = 220 volts

Required data

Current in each Resistor =?

Voltage drop in each Resistor =?

R_1 & R_2 are connected in series,

then Equivalent resistance, $R_{Eq} = R_1 + R_2$

$= 10+20$

$R_{Eq} = 30\ \Omega$

Total current, $I = \frac{220}{30}$

$I = 7.33$ Amps

In the series circuit the current is same in all resistors

i.e; $I_1 = I_2 = I = 7.33$ Amps

According to voltage division rule

Voltage across resistor, R_1 is

$V_1 = 220 \text{ X } \frac{10}{10+20}$

$V_1 = 73.33$ volts

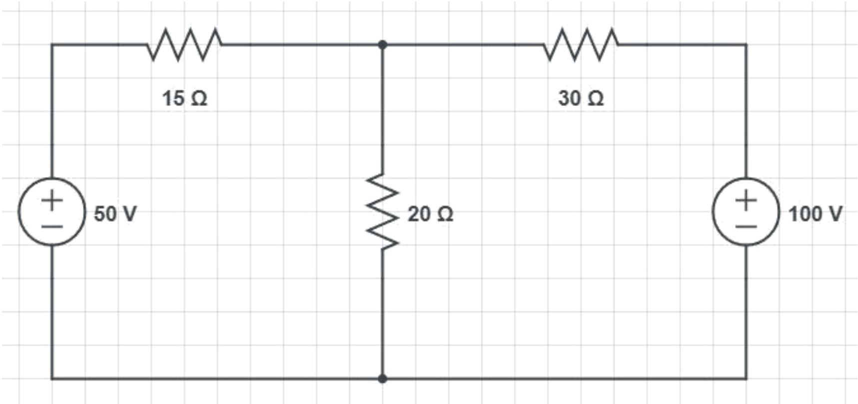
Voltage across resistor, R_2 is

$V_2 = V - V_1$

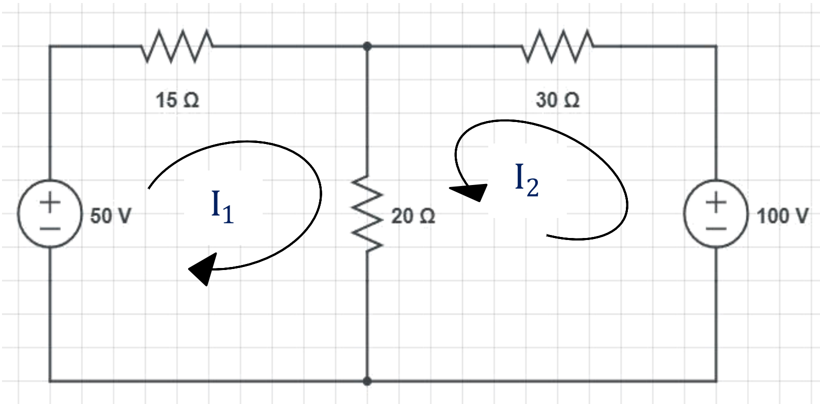
$= 220 - 73.33$

$V_2 = 146.67$ volts

38. Using Kirchhoff's laws, find the current in all resistors in the circuit shown below.



Ans: Apply KVL to the loop-1



∑ Potential Rise = ∑ Potential Drop

$$50 = 15I_1 + 20\,(I_1 + I_2)$$

$$15I_1 + 20I_1 + 20I_2 = 50$$

$$35I_1 + 20I_2 = 50 \quad \text{---}\!\!\rightarrow 1$$

Apply KVL to the loop-2

∑ Potential Rise = ∑ Potential Drop

$$100 = 30I_2 + 20\,(I_2 + I_1)$$

$$30I_2 + 20I_2 + 20I_1 = 100$$

$$20I_1 + 50I_2 = 100 \quad \text{---}\!\!\rightarrow 2$$

By solving above two equations we will get the currents I_1 & I_2

$$I_1 = 0.37037 \text{ Amps}$$

$$I_2 = 1.85185 \text{ Amps}$$

Current flowing through 15Ω resistor is

$$\boxed{I_{15\Omega} = I_1 = 0.37037} \text{ Amps}$$

Current flowing through 30Ω resistor is

$$\boxed{I_{30\Omega} = I_2 = 1.85185} \text{ Amps}$$

Current flowing through 20Ω resistor is

$I_{20\Omega} = I_1 + I_2 = 0.37037 + 1.85185$

$I_{20\Omega} = 2.22222$ Amps

39. A wheastone bridge ABCD is arranged as follows: AB= 2Ω; BC= 3Ω; CD= 4Ω; DA=5Ω. A resistor of 6Ω is connected between B&D. A 10V battery of internal resistance 2Ω is connected between A&C. Calculate the branch currents and current supplied by the battery by using Kirchhoff's laws.

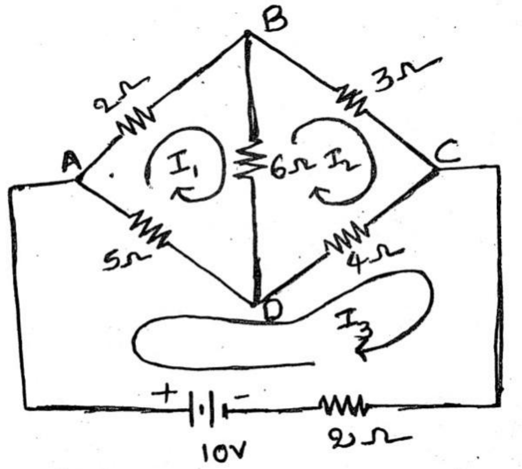
Ans: Apply KVL to the loop-1

$\sum$ Potential Rise = $\sum$ Potential Drop

$0 = 2I_1 + 6(I_1 - I_2) + 5(I_1 - I_3)$

$2I_1 + 6I_1 - 6I_2 + 5I_1 - 5I_3 = 0$

$13I_1 - 6I_2 - 5I_3 = 0 \quad \dashrightarrow 1$



Apply KVL to the loop-2

$\sum$ Potential Rise = $\sum$ Potential Drop

$0 = 3I_2 + 4(I_2 - I_3) + 6(I_2 - I_1)$

$3I_2 + 4I_2 - 4I_3 + 6I_2 - 6I_1 = 0$

$-6I_1 + 13I_2 - 4I_3 = 0 \quad \dashrightarrow 2$

Apply KVL to the loop-3

$\sum$ Potential Rise = $\sum$ Potential Drop

$10 = 2I_3 + 5(I_2 - I_3) + 4(I_2 - I_1)$

$2I_3 + 5I_2 - 5I_3 + 4I_2 - 4I_1 = 10$

$-5I_1 - 4I_2 + 11I_3 = 10 \quad \dashrightarrow 3$

By solving above three eq'ns then we get the currents I_1, I_2 and I_3

$I_1 = 1.28985$ Amps

$I_2 = 1.188405$ Amps

$I_3 = 1.92753$ Amps

$\therefore$ Current flowing through AB branch, $I_{AB} = I_1 = 1.28985$ Amps

Current flowing through BC branch, $I_{BC} = I_2 = 1.188405$ Amps

Current flowing through CD branch, $I_{CD} = I_3 - I_2 = 1.92753 - 1.188405$

$I_{CD} = 0.73912$ Amps

Current flowing through DA branch, $I_{DA} = I_3 - I_1 = 1.92753 - 1.28985$

$I_{DA} = 0.63768$ Amps

Current flowing through BD branch, $I_{BD} = I_1 - I_2 = 1.28985 - 1.188405$

$I_{BD} = 0.10144$ Amps

Current supplied by the battery is $I_3 = 1.92753$ Amps

40. Two lamps of rating 220V, 40W and 220V, 60W are connected in series across 220V supply. Calculate (i) Voltage across each lamp; (ii) Power consumption. What will be the power consumption if the two lamps are connected in parallel?

Ans: **Given data**

Lamp-1: 40W, 220V

Lamp-2: 60W, 220V

Supply voltage = 220V

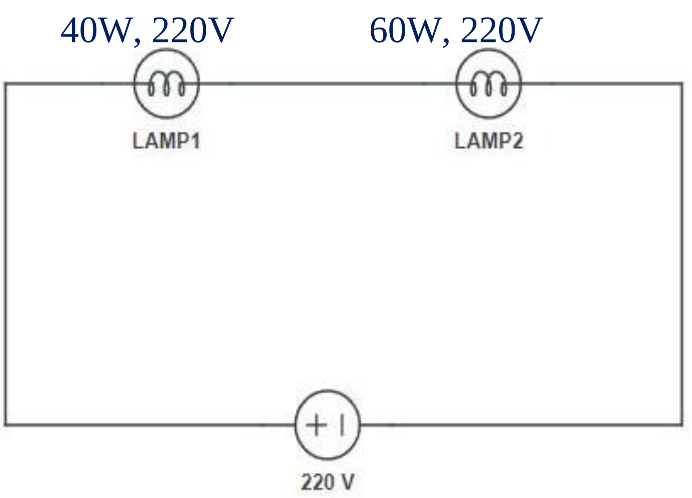
Required data

Resistance of each lamp =?

Total Current =?

Power drawn from supply =?

Power consumed when lamps in parallel =?



For Lamp-1:-

Resistance, $R_1 = \frac{V_1^2}{P_1}$

$= \frac{220^2}{40}$

$= 1210\ \Omega$

For Lamp-2:- Resistance, $R_2 = \frac{V_2^2}{P_2}$

$= \frac{220^2}{60}$

$= 806.66666\ \Omega$

Total resistance, $R_{Eq} = R_1 + R_2$

$= 1210 + 806.66666$

$R_{Eq} = 2016.66666\ \Omega$

Voltage across Lamp-1, $V_{L1} = IR_1$

$= \frac{220 \text{ X } 1210}{2016.66666}$

Voltage across Lamp-1, $V_{L1} = 132$ Volts

Voltage across Lamp-2, $V_{L2} = IR_2$

$= \frac{220 \text{ X } 806.66666}{2016.66666}$

Voltage across Lamp-2, $V_{L2} = 88$ Volts

Total power drawn from supply, $P = \frac{V^2}{R}$

$= \frac{(220)^2}{2016.66666}$

$P = 24$ Watts

Power consumed when two lamps are in parallel:-

Total resistance, $R_{Eq} = \frac{R_1 R_2}{R_1 + R_2}$

$= \frac{1210 \text{ X } 806.66666}{1210 + 806.66666}$

$= 484\ \Omega$

Total power drawn from supply, $P = \frac{V^2}{R}$

$= \frac{(220)^2}{484}$

$P = 100$ Watts

41. Calculate the bill of electricity charges for the following loads fitted in an electrical installation.

i. 10 lamps 60watt each working 5hour a day.

ii. 5 ceiling fans 120watt each working 10hours a day.

iii. 2KW heater working 4hours a day.

iv. 2HP motor with efficiency 80% working 4hours a day

Calculate the monthly bill at 50 paise/unit, if the meter rent per month is Rs. 5/-.

Ans:

$$\text{Efficiency} = \frac{\text{Output power}}{\text{Input power}}$$

$$\frac{80}{100} = \frac{2 \text{ X } 735.5}{\text{Input power}}$$

$$\text{Motor input power} = \frac{2 \text{ X } 735.5}{0.8}$$

$$= 1838.75 \text{ Watts}$$

S.No.	Load	Wattage in watts	Quantity	Total Power (Watts)	Working Hours in a day	Energy consumption in a day (watt-hour)
1	Lamps	60	10	60*10 = 600	5	600*5 = 3000
2	Ceilling Fan	120	05	120*5 = 600	10	600*10 = 6000
3	Heater	2000	01	2000*1 = 2000	4	2000*4 = 8000
4	Motor	1838.75	01	1838.75*1 = 1838.75	4	1838.75*4 = 7355
					Total	24355

Total energy consumed by the house in month = Total energy consumed by the house in day X no. of days in a month

= 24355 X 30

= 730650 Wh

= 730.650 KWh

= 730.650 units (∵1 KWh = 1 Unit)

Then Total energy consumed by the house in month = 730.650 Units

Cost on the energy consumption in month = Total energy consumed by the house in month X Charge per unit

= 730.650 X 0.50

= 365.325/-

Total Electricity bill in the Month = ₹ Cost on the energy consumption in month + meter rent

= 365.325+ 5

= 370.325/-

∴ Total Electricity bill in Month = ₹370.325/-

42. An electric kettle is rated 1.5KW, 230V takes 5minutes to bring 1kg of water to boiling point from 15^0 C. Find the efficiency of the kettle.

Ans: **Given data** | **Required data**

Power rating of kettle, P= 1.5KW

Voltage of kettle, V=230Volts

Time, t= 5Min.

Mass of water, m= 1Kg

Initial temp., $\theta_1 = 15^0C$

Final temp., θ_2= Boiling point

Efficiency of the kettle =?

Efficiency of kettle, $\eta = \frac{\text{Kettle output}}{\text{Kettle Input}} \times 100$

Kettle output = Energy Output = Heat received by the water

$= ms\,(\theta_2 - \theta_1)$ K.Cal

Assume the Specific heat of the water S = 1 K.Cal/Kg/^{0}C

Boiling point of water, $\theta_2 = 100\ ^0C$

Kettle output = 1 X 1 X 10^3 X 1(100-15)

= 85000 Cal

= 85 K.Cal

Kettle output = Energy Input = Electrical energy supplied to kettle

= Wattage X Time

= VIt

= 1.5 X 10^3 X 5 X 60

= 450000 Watt-sec or Joule

$= \frac{450000}{4200}$

= 107.14285 K.Cal

Efficiency of kettle, $\eta = \frac{85}{107.14285} \times 100$

$\eta = 79.33\%$

43. An electric heater rated at 1KW, 230V has to raise the temperature of 1.5 liters of water from 15^0C to boiling point. Find the time taken by the heater if its efficiency is 80%.

Ans: **Given data** | **Require data**

Power rating of kettle, P= 1KW

Voltage of kettle, V=230Volts

Mass of water, m= 1.5 lit. = 1.5 Kg

Initial temp., $\theta_1 = 15^0C$

Final temp., θ_2= Boiling point

Time taken by the heater =?

Efficiency of kettle, η=80%=0.8

Efficiency of kettle, $\eta = \frac{\text{Kettle output}}{\text{Kettle Input}}$ x 100

Kettle output = Energy Output = Heat received by the water

= ms $(\theta_2 - \theta_1)$ K.Cal

Assume the Specific heat of the water S = 1 K.Cal/Kg/^{0}C

Boiling point of water, θ_2 = 100 ^{0}C

Kettle output = 1.5 X10^3 X 1 X 1(100-15)

= 127.5 K.Cal

Kettle output = Energy Input = Electrical energy supplied to kettle

= Wattage X Time

= VIt

= 1 X 10^3 X t

= 1000t Watt-sec or Joule

$= \frac{1000t}{4200}$

= 0.2380t K.Cal

Efficiency of kettle, $\eta = \frac{127.5}{0.2380t}$

$$0.8 = \frac{127.5}{0.2380t}$$

$$T = \frac{127.5}{0.2380 \text{ X } 0.8}$$

= 669.64 Sec

= 11Min.16Sec

$\therefore$ Time taken by the heater is 11Min.16Sec

44. Explain the electric cooker with a neat sketch.

Ans: "An electric cooker is a simple heat producing device used for cooking food".

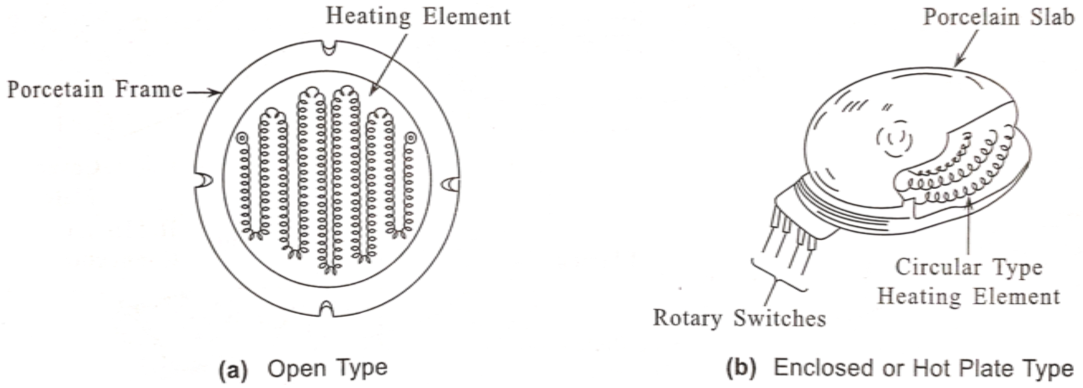


Fig. Cooker

Construction:-

- ❖ It mainly consists of a heating element and heater plate as shown in Fig.
- ❖ The heating element is made of high resistance nichrome wire.
- ❖ There are two types of electric cooker are in common use, they are: (i) Open type and (ii) Enclosed type (or) hot plate type.
- ❖ In open type the spirally wound heating element is placed inside the grooves of a porcelain moulded frame designed for the purpose as shown in Fig.(a).
- ❖ The enclosed type consists of one (or) two circular types of heating elements which are embedded in between two porcelain (or) fire clay slabs as shown in Fig.(b).
- ❖ It is provided with a special rotary switch to control the temperature of hot plate.

Working:-

- ➢ When it is connected to the supply, electric current flows through the heating element becomes extremely hot and produces heat.
- ➢ Hence, it works by converting electrical energy into heat energy.
- ➢ They are designed with power rating of 1 to 2 KW at 230 V.

45. Draw the incandescent lamp and label the parts.

Ans: The lamp in which the light is produced directly by the heating of the filament is known as "filament (or) incandescent lamp". This works on the principle of heating effect of electric current.

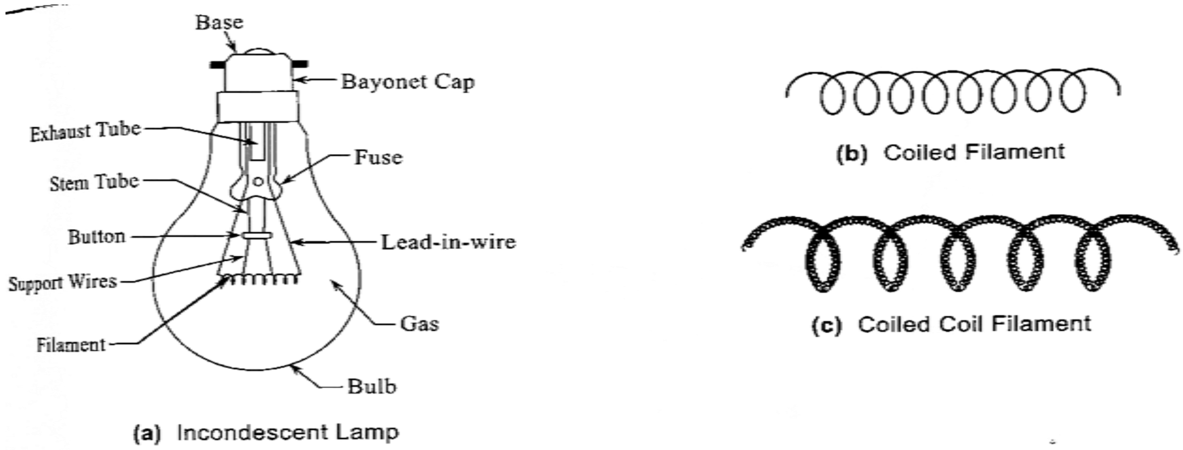


Fig. Incandescent Lamp

Construction:-

- ❖ The filament lamp consists of a glass bulb having a fine metallic wire known as filament within it.
- ❖ The glass bulb is filled with inert gases such as argon to prevent oxidation of filament.
- ❖ The filament used is mostly made of tungsten, because it has an abnormally high melting point (3400° C).

- The filament is made of long length of thin metal to give very high resistance The filament is wound as single coil (or) coiled coil in order to fit it all in a small space within the bulb as shown in Fig.

Working:-

- The filament lamp produces light as a result of the heating effect of electric current.
- When an electric current is passes through the filament, it raises the temperature of the filament and heat energy will be generated at low temperature.
- The inert gas conducts the heat generated by the filament to the glass bulb from where the heat is radiated into the atmosphere.
- As the temperature of the filament increases due to heating, it radiates heat as well as light energy.
- The rated life of filament lamp is 1000 working hours.
- These are available in different power ratings such as 15 W, 24 W, 40 W, 60 W, 100 W etc.,

Important Note

Q.No.	Target Date	Submitted Date	Faculty Signature	Q.No.	Target Date	Submitted Date	Faculty Signature
01				24			
02				25			
03				26			
04				27			
05				28			
06				29			
07				30			
08				31			
09				32			
10				33			
11				34			
12				35			
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