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Name: ....

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Subject: .... Year: ....

Chapter 01: Ohm's law, Power and Energy

Ohm's law: Ohm's law states that when all physical condition and temperature remain constant, the current flowing in a circuit is directly proportional to the applied potential difference and inversely proportional to the resistance in the circuit.

Explain:

According to ohm's law at constant temperature the current flowing through a conductor is directly proportional to the potential difference. If I is the current flowing through a conductor and v is a potential difference then according to ohm's law,

$$I \propto V$$

Now,

$V \propto I$ [At constant temperature]

$V = IR$

where R is a ~~resistance~~ constant called resistance of the conductor. The value of this constant depends on the nature, length, area of cross section and temperature of the conductor.

$$\therefore R = V/I$$

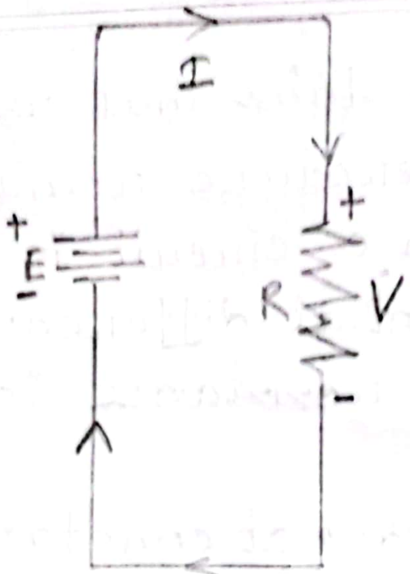
Here,

V = Potential Difference

I = Current

R = Resistance

→



Here, all quantities of equation ($I = E/R$) appear in the simple electrical circuit in this figgure. A resistor has been connected directly across a battery to establish a current through the resistor and supply.

$$E = I/R \quad (\text{Volts}, V)$$

$$R = E/I \quad (\text{ohms}, \Omega)$$

*** The ~~sybol~~ symbol E is applied to all source of voltage.

*** The symbol V is applied to all voltage drop across the components of the network.

Example-4.1: Determine the current resulting from the application of a 9V battery across a network with a resistance of $2.2\,\Omega$

Sol: Here,

Voltage, $V_R = 9V$

Resistance, $R = 2.2\,\Omega$

$\therefore$ current, $I = V_R/R = \frac{9V}{2.2\,\Omega} = 4.09A$

Power: The term power is applied to provide an indication of how much work (energy) can be accomplished in a specified amount of time, that is power is a rate of doing work. Since energy is measured in joules (J) and time in seconds (s), power is measured in joules/second (J/s). The electrical unit of measurement for power is the watt (W) defined by

$$1 \text{ watt (W)} = 1 \text{ joule/second (J/s)}$$

$\therefore$ Power, $\boxed{P = W/t}$ [Watts or Joule/second (J/s)]

[1 horsepower $\cong$ 746 watts]

Again,

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

$$= \frac{VQ}{t}$$

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

$\therefore W = VQ$

$Q = It$

$\therefore I = Q/t$

$\therefore \boxed{P = VI}$

$\rightarrow$ $P = VI$

$= V(V/R)$

$\therefore \boxed{P = \frac{V^2}{R}}$

$\rightarrow$ $P = VI$

$\Rightarrow P = IR \cdot I$

$\therefore \boxed{P = I^2 R}$

Example-4.9: Determine the current through a 5KΩ resistor when the power dissipate by the element is 20mW.

Sol: Here,

Resistance, $R = 5K\Omega$

$= 5000\Omega$

Power, $P = 20mW$

$= 20 \times 10^{-3} W$

Now,

$P = I^2 R$

$\Rightarrow I^2 = P/R$

$\Rightarrow I = \sqrt{P/R}$

$= \sqrt{\frac{20 \times 10^{-3}}{5 \times 10^3}}$

$= \sqrt{4 \times 10^{-6}}$

$\therefore I = 2 \times 10^{-3} A$

Energy is the capacity of a physical system to do work.

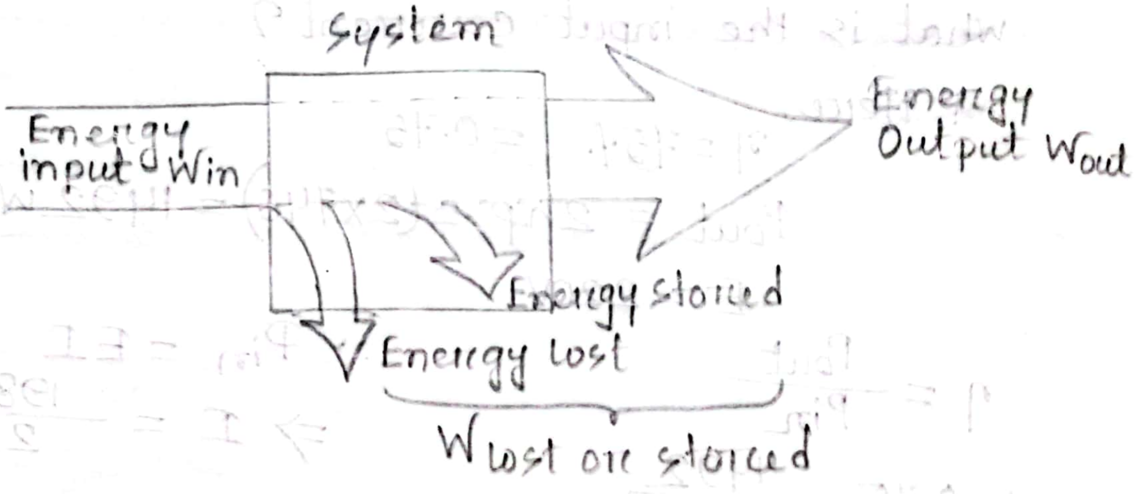
Energy: The energy (W) lost or gained by any system is therefore determined by

$$W = Pt \quad [\text{Wattseconds, Ws or joules}]$$

$$\boxed{\text{Energy (Wh)} = \text{Power (W)} \times \text{time (h)}}$$

$$\boxed{\text{Energy (KWh)} = \frac{\text{Power (W)} \times \text{time (h)}}{1000}}$$

Efficiency: Effeciency is a comparison of the energy output to the energy input in a given system. It is defined as the percentage ratio of the output energy to the input energy, given by the equation. Here, the output energy level must always be less than the applied energy due to losses and storage within the system. The best one can hope for is that Wout and Win are relatively close in magnitude.



Energy flows through a system

conservation of energy requires that
Energy input = energy output + energy lost or stored by the system

$\therefore W_{in} = W_{out} + W_{stored\ or\ lost\ by\ the\ system}$

$W_{in}/t = W_{out}/t + W_{stored\ or\ lost\ by\ the\ system}/t$

$\therefore P_{in} = P_{out} + P_{lost\ or\ stored}$

$$\text{Efficiency}, \eta = \frac{\text{Power output}}{\text{Power input}} \times 100\%$$

$$\boxed{\therefore \eta = \frac{P_{out}}{P_{in}} \times 100\%}$$

In the terms of the input and output energy,

$$\boxed{\text{Efficiency}, \eta = \frac{W_{out}}{W_{in}} \times 100\%}$$

Example-4.15: A 2hp motor operates at an efficiency of 75%. What is the power input in watts? If the applied voltage is 220V, what is the input current?

Sol: Here,

$\eta = 75\% = 0.75$

$P_{out} = 2hp = (2\times746) = 1492$ Watt

$E = 220V$

$$\eta = \frac{P_{out}}{P_{in}}$$

$$\Rightarrow 0.75 = \frac{1492}{P_{in}}$$

$\therefore P_{in} = 1989.33\ W$

$\therefore P_{in} = EI$

$$\Rightarrow I = \frac{1989.33}{220}$$

$\therefore I = 9.04A$

Example-4.16: What is the output in horsepower of a motor with an efficiency of 80% and an input current of 8A at 120V?

Sol: Here,

$$\eta = 80\% = 0.80$$

$$P_{in} = VI$$
$$= (120 \times 8) = 960\ W$$

$$\therefore \eta = \frac{P_{out}}{P_{in}}$$

$$\Rightarrow 0.80 = \frac{P_{out}}{960}$$

$$\therefore P_{out} = 768\ W = \frac{768}{746} = 1.03\ hp$$

Example-4.17: If $\eta = 0.85$, determine the output energy level if the applied energy is 50 Joule.

Sol: Here,

$$\eta = 0.85$$
$$W_{in} = 50\ J$$

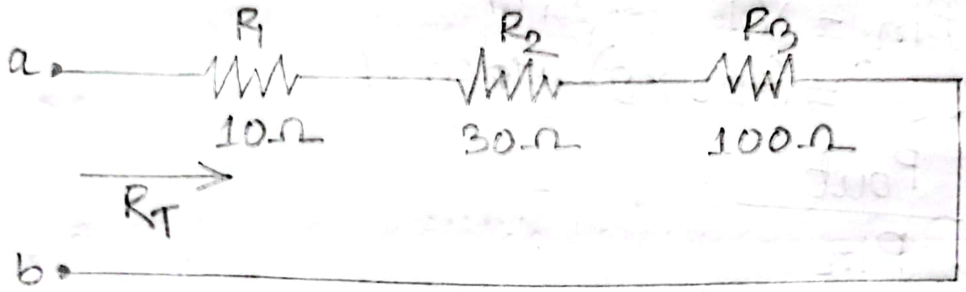
$$\eta = \frac{W_{out}}{W_{in}}$$

$$\Rightarrow 0.85 = \frac{W_{out}}{50}$$

$$\therefore W_{out} = 42.5\ J$$

Chapter 02: Series dc Circuits

Series Resistors: Before the series connection is described, first recognize that every fixed resistor has only two terminals to connect in a configuration, it is therefore referred to as a two-terminal device.



Series connection of Resistors

For resistors in series,

→ The total resistance of a series configuration is the sum of the resistance levels.

In equation from for any number (N) of resistors,

$$R_T = R_1 + R_2 + R_3 + R_4 + \cdots + R_N$$

→ The more resistors we add in series, the greater the resistance, no matter what their value.

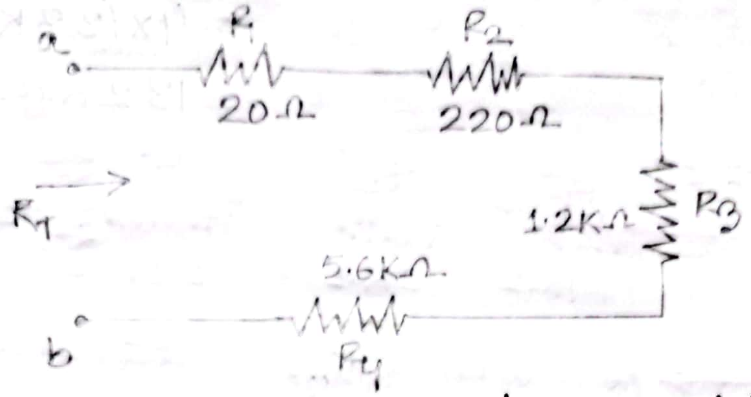
→ The largest resistor in a series combination will have the most impact on the total resistance.

∴ The total resistance, $R_T = R_1 + R_2 + R_3$

$$= (10 + 30 + 100)$$

$$= 140\ \Omega$$

Example-5.1:



Determine the total resistance of the series connection in this figure.

Sol: The total resistance, $R_T = R_1 + R_2 + R_3 + R_4$

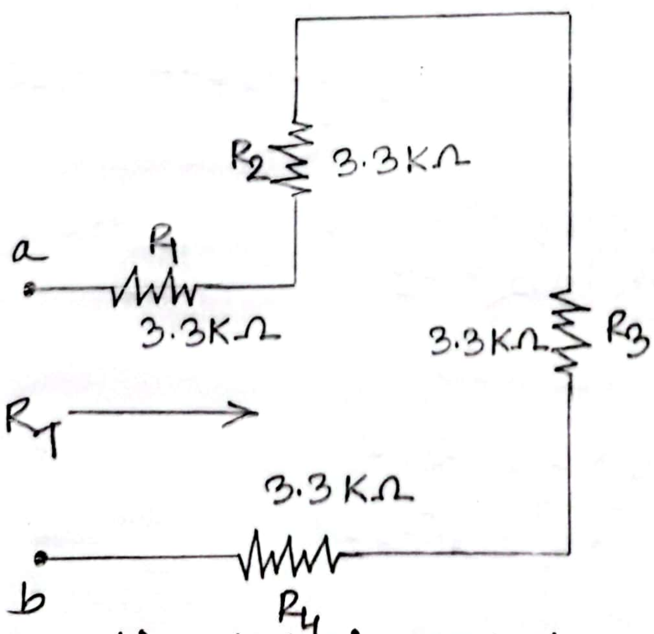
$$= 20 + 220 + 1.2\times10^3 + 5.6\times10^3$$

$$= 7040\,\Omega$$

$$= 7.04\,K\Omega$$

→ For the special case where resistors are the same value, ~~that~~ than, $R_T = NR$

Example-5.2:



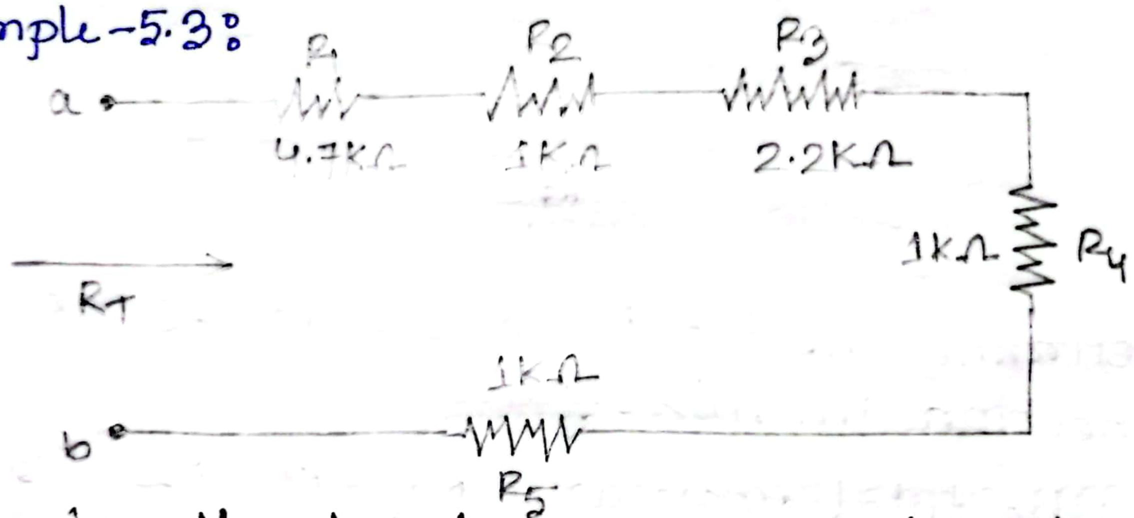
Determine the total resistance of the series connection

Sol: The total resistance, $R_T = NR$

$= 4 \times (3.3 \, K\Omega)$

$= 13.2 \, K\Omega$

Example-5.3:



Determine the total resistance for the series resistors in figure.

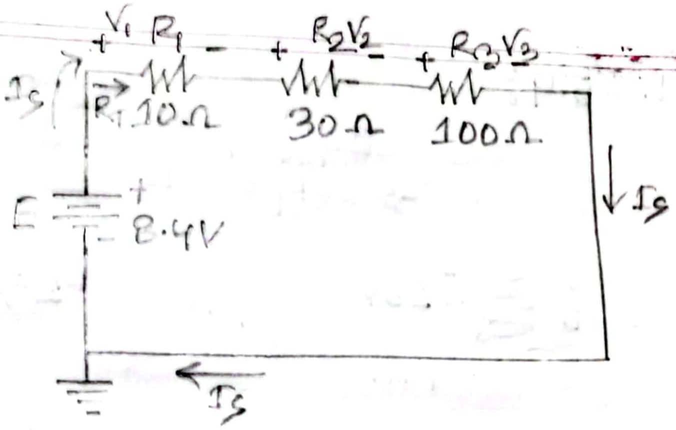
Sol:

The total resistance, $R_T = R_1 + R_3 + NR_2$

$= 4.7 + 2.2 + (3 \times 1) K\Omega$

$= 9.9 \, K\Omega$

Series circuit :



→ A circuit is any combination of elements that will result in a continuous flow of charge or current, through the configeration.

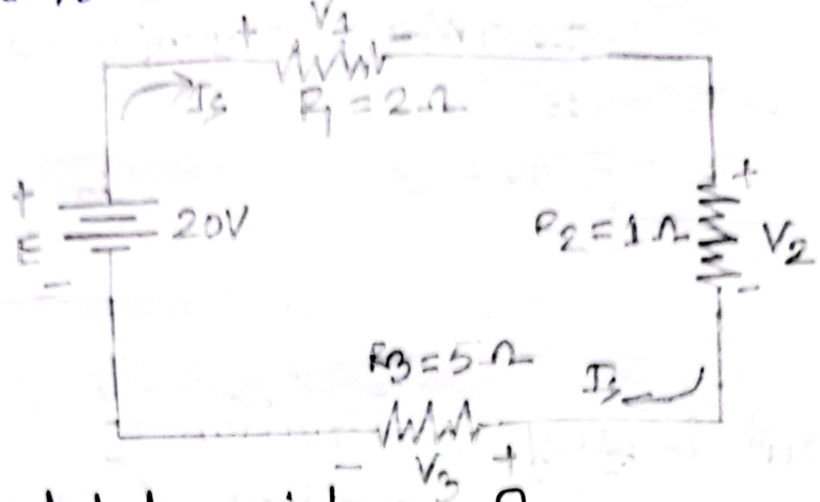
→ For series dc circuits the direction of conventional current in a series dc circuit is such that it leaves the positive terminal of the supply and returns to the negative terminal as shown in figure.

→ The current is same at every point in a series circuit.

→ In any configeration, if two elements are in series, the current must be the same. However, if the current is the same for two adjoining elements, the elements are may or may not be in series.

→ Source Current, $I_S = \frac{\text{Source Voltage, } E}{\text{Total resistance } R_T}$

Example-5.4:



(a) Find the total resistance?
(b) Calculatting the source current, I_s?
(c) Determine the voltage across each resistor?

Sol:

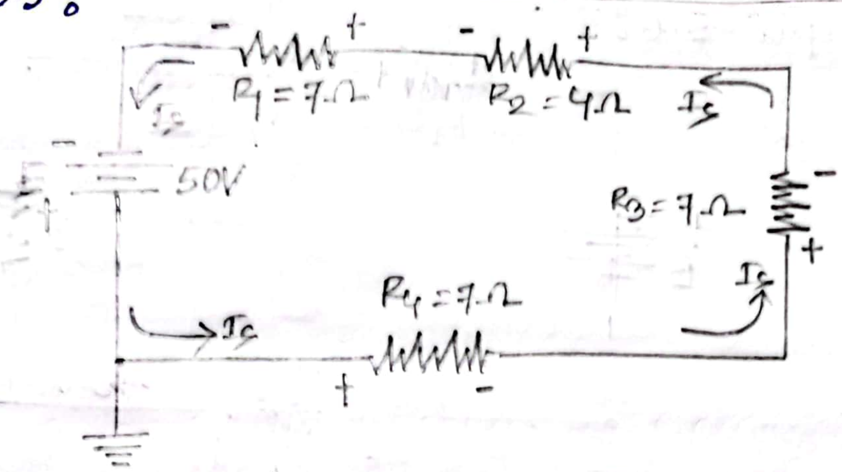
(a) Total Resistance, $R_T = R_1 + R_2 + R_3$
$= (2+1+5) = 8\Omega$

(b) Here,
Source Voltage, $E = 20V$
Total Resistance, $R_T = 8\Omega$
$\therefore$ Source Current, $I_s = E/R_T$
$= 20V/8\Omega$
$= 2.5A$

(c) Here, $I_s = I_1 = I_2 = I_3$

$V_1 = I_s R_1 = (2.5 \times 2) = 5V$
$V_2 = I_s R_2 = (2.5 \times 1) = 2.5V$
$V_3 = I_s R_3 = (2.5 \times 5) = 12.5V$

Examples 5.5:



(a) Find the total resistance, R_T

(b) Determine the source current I_S and indicate its direction in the circuit.

(c) Find the voltage across R_2 and indicate its polarity on the circuit.

Sol:

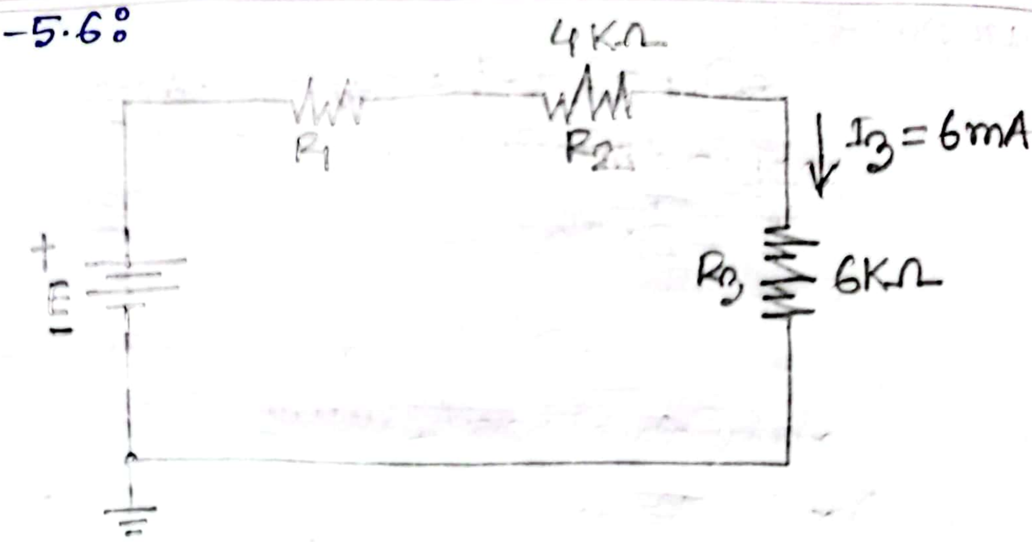
(a) Total resistance, $R_T = R_1 + R_2 + R_3 + R_4$
$= 7 + 4 + 7 + 7$
$= 25\Omega$

(b) Source current, $I_S = E / R_T$
$= 50/25 = 2A$

(c) $I_S = I_1 = I_2 = I_3 = I_4$

$\therefore$ voltage, $V_2 = I_S R_2$
$= (2 \times 4)$
$= 8V$

Example - 5.6:



$R_T = 12K\Omega$, $I_3 = 6mA$

→ Calculate R_1 and E from the circuit?

Sol:

Here,

$R_T = 12K\Omega = 12 \times 10^3 \Omega$ | $I_3 = I_1 = I_2 = I_T$

$I_3 = 6mA = 6 \times 10^{-3} A$

$R_T = R_1 + R_2 + R_3$

$\Rightarrow 12 \times 10^{3} = R_1 + (6+4) \times 10^3$

$\Rightarrow (12 \times 10^3) - (10 \times 10^3) = R_1$

$\therefore 2 \times 10^3 = R_1$; $R_1 = 2K\Omega$

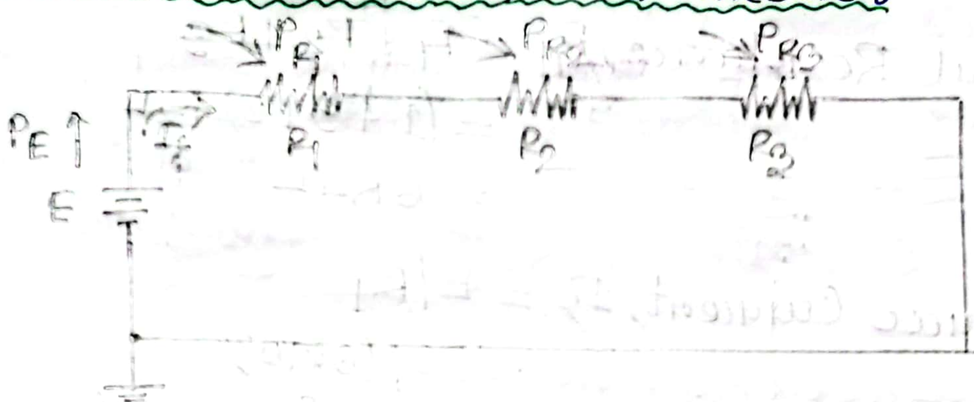
Again,

$E = I_T R_T$

$\Rightarrow E = (6 \times 10^{-3}) \times (12 \times 10^3)$

$\therefore E = 72V$

Power Distribution in a Series Circuit:

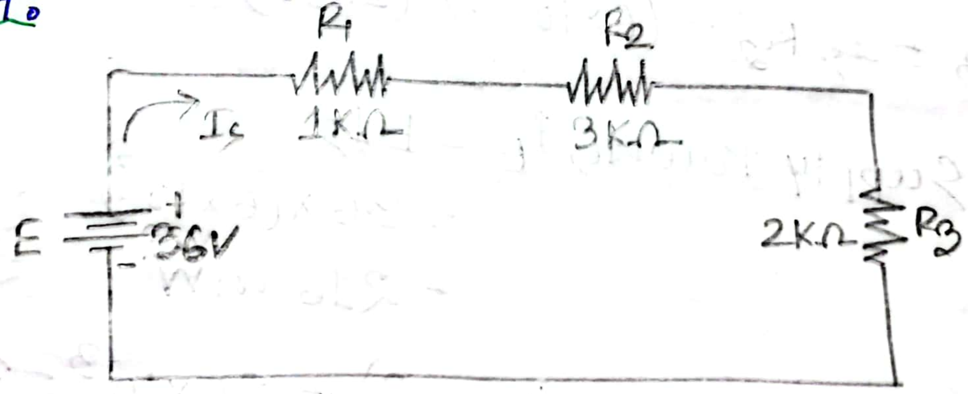


→ The power applied by the dc supply must equal that dissipated by the resistive elements.

Equation, $\boxed{P_E = P_{R_1} + P_{R_2} + P_{R_3}}$ $\boxed{P_E = I_s E}$

For resistor R_1 only, $P_{R_1} = V_1 I_1 = I_1^2 R_1 = V_1^2 / R_1$

Example-5.7:



(a) Determine the total resistance
(b) Calculate the current I_s
(c) Determine the voltage across each resistor.
(d) Find the power supplied by the battery.
(e) Determine the power dissipated by each resistor.
(f) showed that the total power dissipated is equal the supplied power.

Sol:

(a) Total Resistance, $R_T = R_1 + R_2 + R_3$

$= (1 + 3 + 2)\ K\Omega$

$= 6\ K\Omega$

(b) Source Current, $I_S = E / R_T$

$= 36 / (6 \times 10^3)$

$= 6 \times 10^{-3} A = 6 mA$

(c) $I_S = I_1 = I_2 = I_3 = 6 mA$

$V_1 = I_S R_1 = (6 \times 10^{-3}) \times (1 \times 10^3) = 6V$

$V_2 = I_S R_2 = (6 \times 10^{-3}) \times (3 \times 10^3) = 18V$

$V_3 = I_S R_3 = (6 \times 10^{-3}) \times (2 \times 10^3) = 12V$

(d) Supply Power, $P_E = E I_S$

$= 36 \times (6 \times 10^{-3})$

$= 216\ mW$

(e) $P_{R_1} = V_1 I_1 = 6 \times (6 \times 10^{-3}) = 36 \times 10^{-3} = 36 mW$

$P_{R_2} = V_2 I_2 = 18 \times (6 \times 10^{-3}) = 108 \times 10^{-3} = 108 mW$

$P_{R_3} = V_3 I_3 = 12 \times (6 \times 10^{-3}) = 72 \times 10^{-3} = 72 mW$

(f) Total power $= P_{R_1} + P_{R_2} + P_{R_3}$

$= (36 + 108 + 72) = 216 mW$

$\therefore$ Total Power = Supply Power

KIRCHHOFF'S Voltage law:

The law specifies that the algebraic sum of the potential rises and drops around a closed path (or closed loop) is zero.

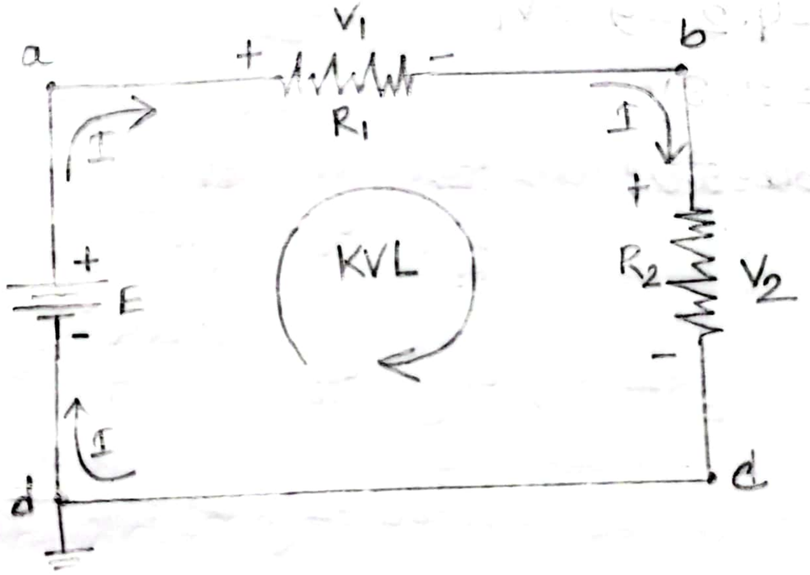
In symbolic form it can be written as

$$\Sigma V = 0$$

Kirchhoff's voltage law can also be written in the following form:

$$\Sigma V_{rises} = \Sigma V_{drops}$$

The sum of the voltage rises around a closed path will always equal the sum of the voltage drops.

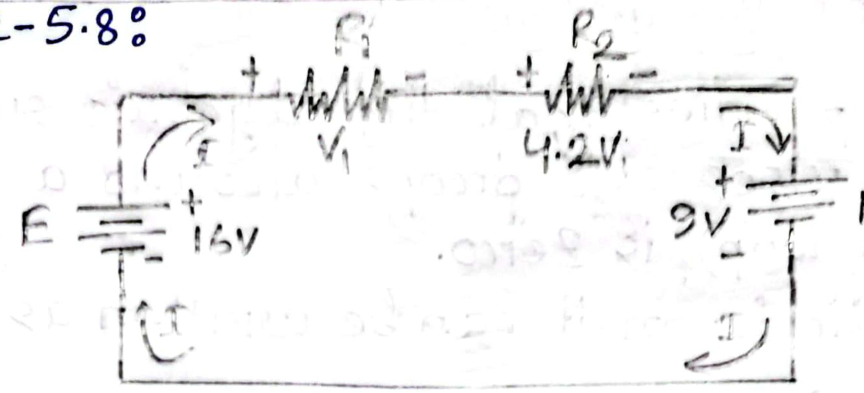


from abcda loop,

$$E - V_1 - V_2 = 0$$

$$\therefore E = V_1 + V_2$$

Example-5.8:



Use KVL to determine the unknown voltage from the circuit.

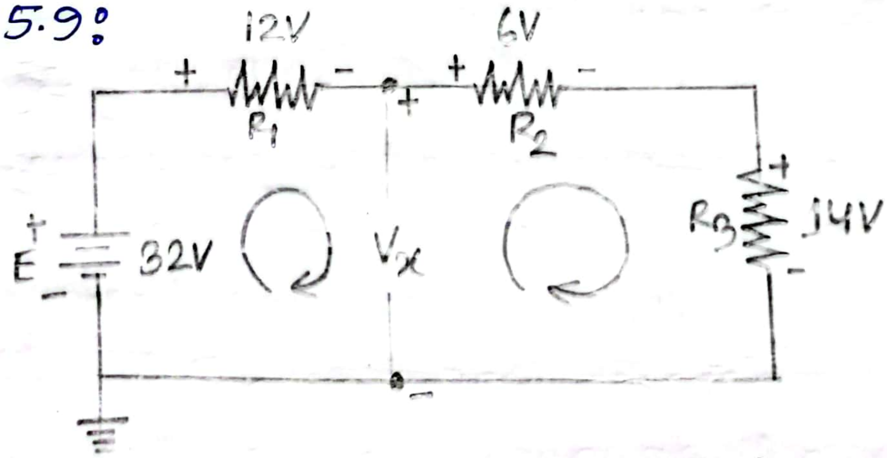
Sol: Application of Kirchhoff's voltage law from the circuit,

$$E_1 - V_1 - 4.2 - E_2 = 0$$

$$\Rightarrow 16 - 4.2 - 9 = V_1$$

$$\therefore V_1 = 2.8V$$

Example-5.9:



Determine the unknown voltage from the circuit.

Sol: Application of KVL from the circuit,

$$E - 12V - V_x = 0$$

$$\Rightarrow 32V - 12V = V_x$$

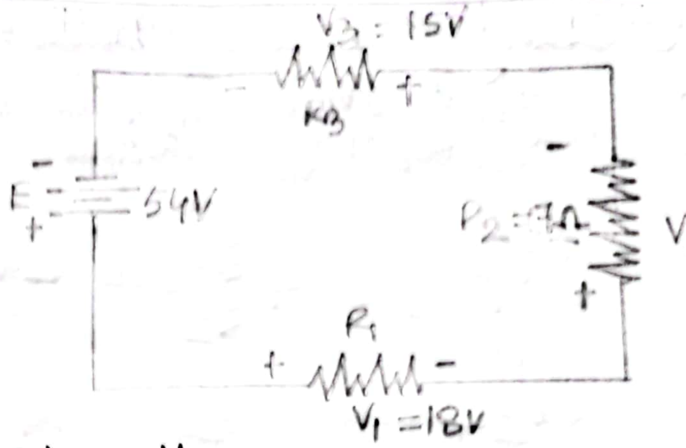
$$\therefore V_x = 20V$$

$$-6V - 14V + V_x = 0$$

$$\Rightarrow -20V + V_x = 0$$

$$\therefore V_x = 20V$$

Example - 5.13 :



For the series circuit,

(a) Determine V_2 using KVL

(b) Determine current I_2

(c) Find R_1 and R_3

Sol:

(a) Applying KVL,

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

$$\Rightarrow -18 - V_2 - 15 + 54 = 0$$

$$\Rightarrow 21 - V_2 = 0$$

$$\therefore V_2 = 21V$$

(b) Here, $V_2 = 21V$

$R_2 = 7\Omega$

$$\therefore I_2 = V_2/R_2$$

$$= 21/7$$

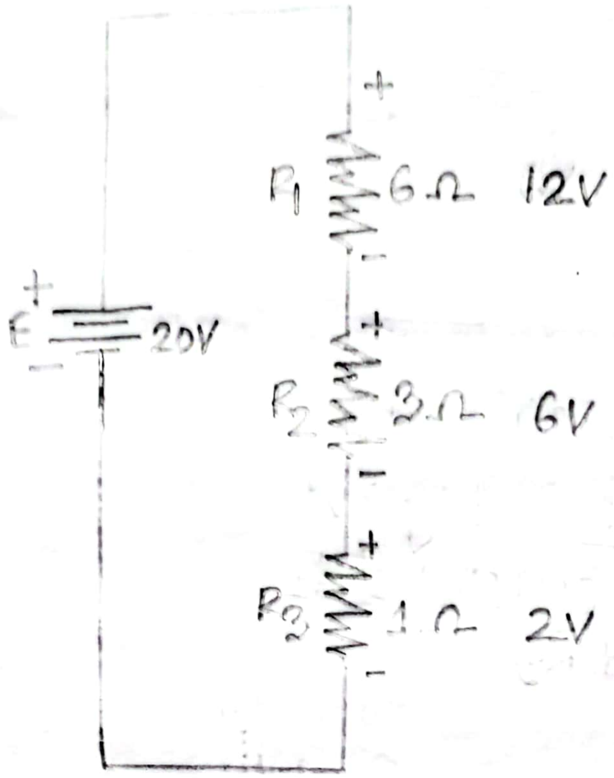
$$= 3A$$

(c) $I_2 = I_1 = I_3 = 3A$

$$\therefore R_1 = V_1/I_1 = 18/3 = 6\Omega$$

$$R_3 = V_3/I_3 = 15/3 = 5\Omega$$

Voltage Division in a Series Circuit:



→ The voltage across series resistive elements will devide as the magnitude of the resistance level.

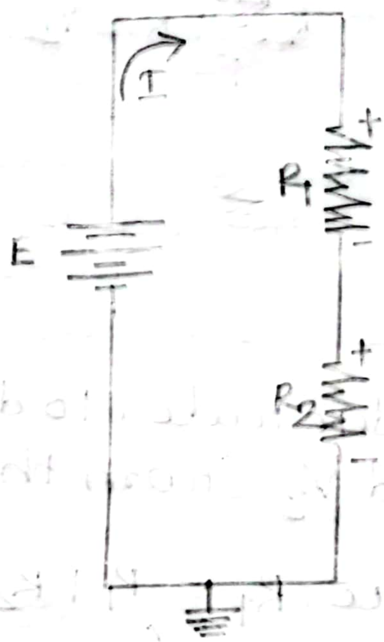
→ In a series resistive circuit, the larger the resistance, the more of the applied voltage it will capture.

→ The ratio of the voltages across series resistors will be the same as the ratio of their resistance levels.

Voltage Devider Rule:

The voltage devider rule permits the determination of the voltage across a series resistor without first having to determine the current of the circuit.

The voltage across a resistor in a series circuit is equal to the value ~~that~~ of the resistor times the total applied voltage devided by the total resistance of the series configuration.



From the circuit,

Total Resistance, $R_T = R_1 + R_2$

Then, $I_S = E/R_T$ (Total current)

$\therefore I_S = I_1 = I_2$

Apply ohm's law to each resistor,

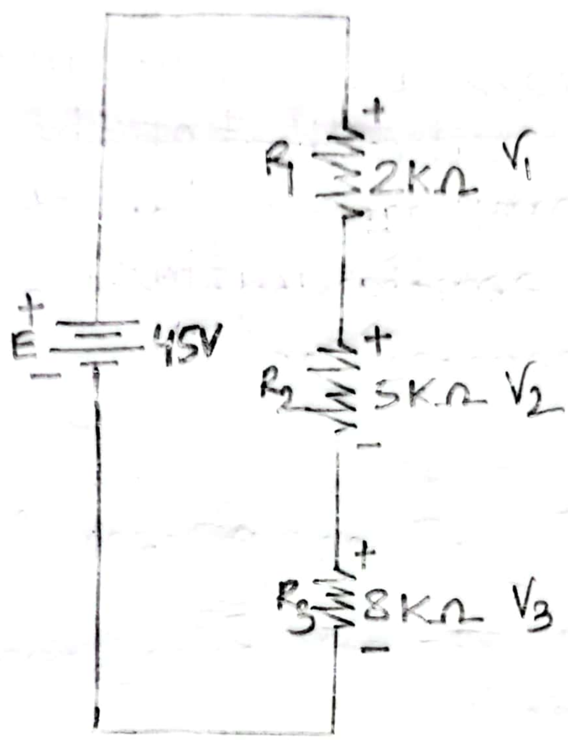
$$V_1 = I_1 R_1 = (E/R_T) R_1$$

$$V_2 = I_2 R_2 = (E/R_T) R_2$$

The resulting format for V_1 and V_2 is

$$V_x = R_x \frac{E}{R_T} \text{ (voltage devider rule)}$$

Example- 5.16:



(a) Using voltage devider rule, to determine the voltage V_1 and V_3 from the circuit.

Sol:

Total Resistance, $R_T = R_1 + R_2 + R_3$

$= (2+5+8) K\Omega$

$= 15 K\Omega$

$\therefore V_1 = R_1 \frac{E}{R_T} = 2K\Omega \times \frac{45V}{15K\Omega} = 6V$

$V_3 = R_3 \frac{E}{R_T} = 8K\Omega \times \frac{45V}{15K\Omega} = 24V$

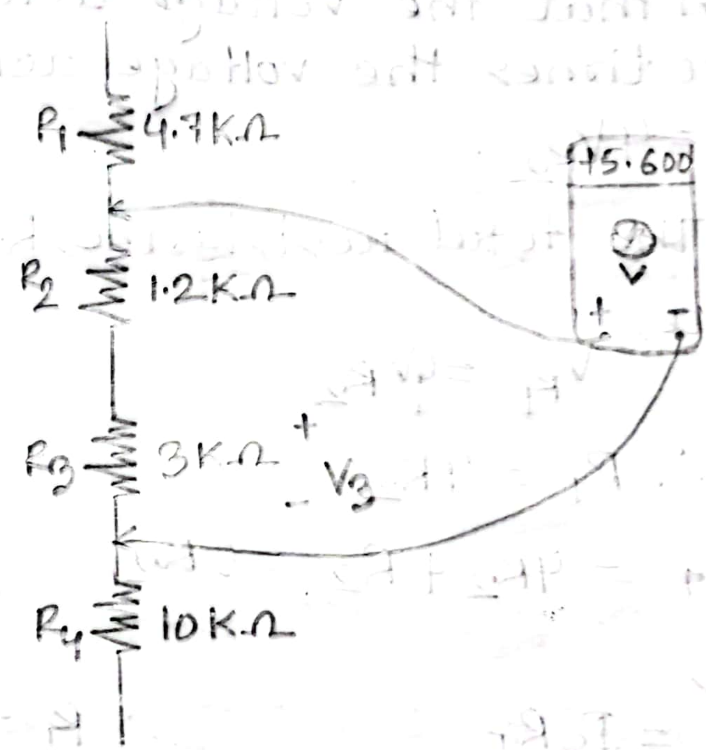
(b) Determine the voltage (devoted v') across the series combination of resistors R_1 and R_2 in Figgure.

Sol: Total Resistance, $R_T = 15K\Omega$

$$R' = R_1 + R_2 = (2+5)K\Omega = 7K\Omega$$

$$\therefore V' = R' \frac{E}{R_T} = 7K\Omega \frac{45V}{15K\Omega} = 21V$$

Example-5.18 :



Find Voltage V_3

Sol: $R_T = R_2 + R_3 = (1.2+3)K\Omega = 4.2K\Omega$

$$\therefore V_3 = R_3 \frac{5.6V}{R_T}$$

$$= 3K\Omega \frac{5.6V}{4.2K\Omega}$$

$$= 4V$$

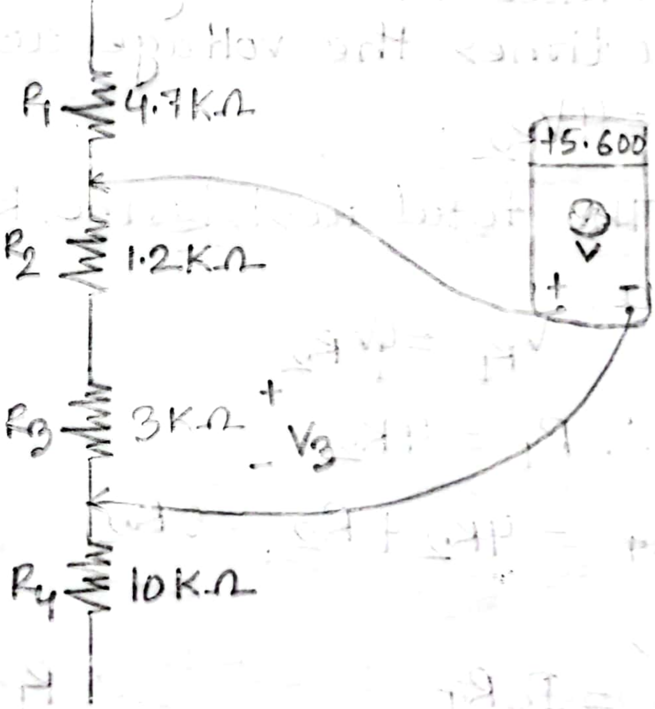
(b) Determine the voltage (devoted V') across the series combination of resistors R_1 and R_2 in Figure.

Sol: Total Resistance, $R_T = 15K\Omega$

$$R' = R_1 + R_2 = (2+5)K\Omega = 7K\Omega$$

$$\therefore V' = R' \frac{E}{R_T} = 7K\Omega \frac{45V}{15K\Omega} = 21V$$

Example-5.18:



Find Voltage V_3

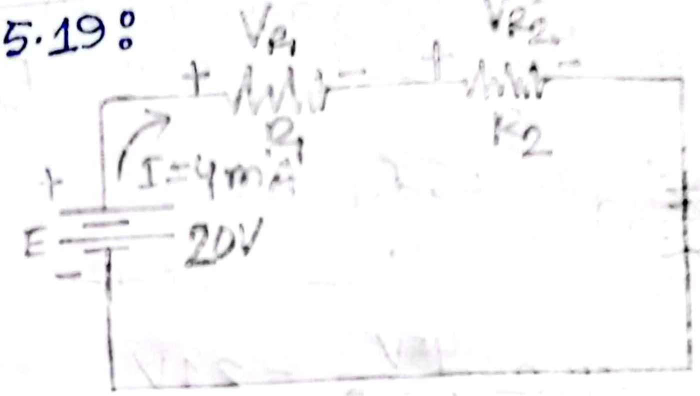
Sol: $R_T = R_2 + R_3 = (1.2+3)K\Omega = 4.2K\Omega$

$$\therefore V_3 = R_3 \frac{5.6V}{R_T}$$

$$= 3K\Omega \frac{5.6V}{4.2K\Omega}$$

$$= 4V$$

Example-5.19:



Design the voltage devidert circuit in figure such that the voltage across R_1 will be four times the voltage across R_2, that is $V_{R_1} = 4V_{R_2}$.

Sol: The total resistance, $R_T = R_1 + R_2$

Here,

$$V_{R_1} = 4V_{R_2}$$

$$\therefore R_1 = 4R_2$$

$$\therefore R_T = 4R_2 + R_2 = 5R_2$$

Now,

$$E = I_S R_T$$

$$\Rightarrow R_T = E/I_S$$

$$\Rightarrow R_T = \frac{20V}{4mA}$$

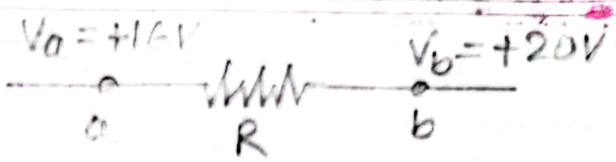
$$\Rightarrow R_T = 5K\Omega$$

$$\Rightarrow 5R_2 = 5K\Omega$$

$$\therefore R_2 = 1K\Omega$$

$$\therefore R_1 = 4R_2 = (4\times 1)K\Omega = 4K\Omega$$

Example-5.21:



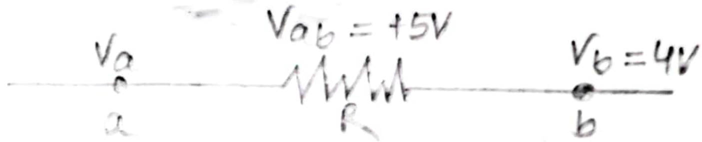
Find the voltage Vab

Sol: $V_{ab} = V_a - V_b$

$= 16 - 20$

$= -4V$

Example-5.22:



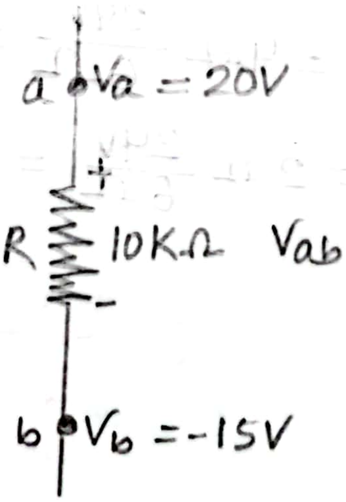
Find the voltage Va

Sol: $V_{ab} = V_a - V_b$

$\Rightarrow 5V = V_a - 4V$

$\therefore V_a = 9V$

Example-5.23:



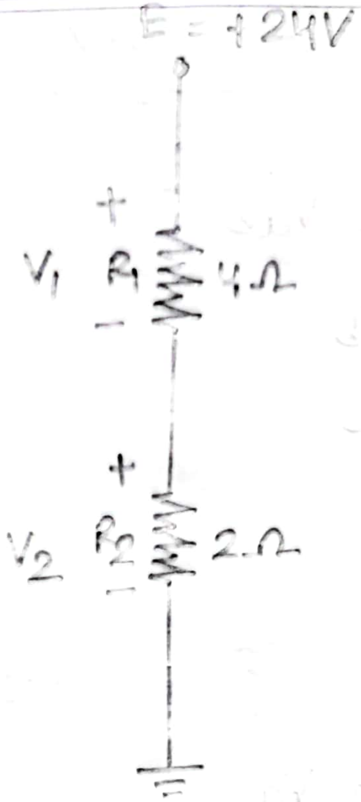
Find the voltage Vab.

Sol: $V_{ab} = V_a - V_b$

$= 20V - (-15V)$

$= 20V + 15V = 35V$

Example-5.26:



Using voltage devider rule to determine the voltage V_1 and V_2.

Sol: Total Resistance, $R_T = R_1 + R_2$

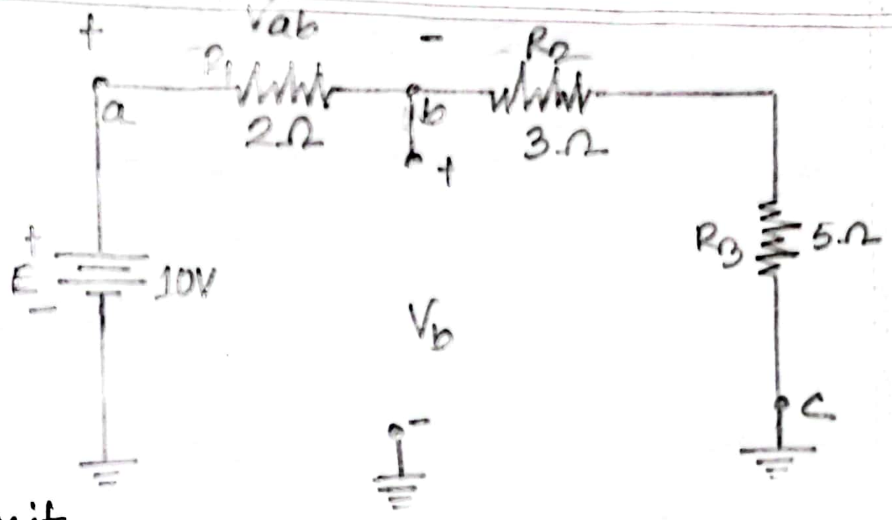
$$= (4+2)\,\Omega$$

$$= 6\,\Omega$$

$$\therefore V_1 = R_1 \frac{E}{R_T} = 4\Omega \frac{24V}{6\Omega} = 16V$$

$$V_2 = R_2 \frac{E}{R_T} = 2\Omega \frac{24V}{6\Omega} = 8V$$

Example-5.27:



From the circuit,

(a) Calculate V_{ab}

(b) Determine V_b

(c) Calculate V_c

Sol:

(a) Total Resistance, $R_T = (2+3+5) = 10\,\Omega$

$$V_{ab} = R_1 \frac{E}{R_T} = 2\Omega \frac{10V}{10\Omega} = +2V$$

(b) $V_{ab} = V_a - V_b$

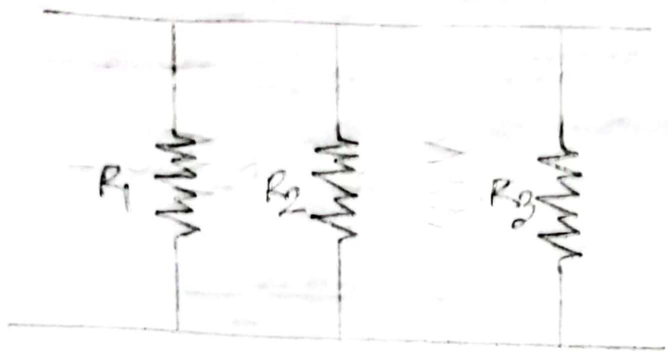
$\Rightarrow +2V = E - V_b$

$\Rightarrow +2V = 10V - V_b$

$\therefore V_b = 8V$

(c) V_c = ground potential = 0V

Chapter-03: Parallel dc Circuits



Parallel Resistors: In general two elements, branches or circuits are in parallel if they have two points in common.

For resistor in parallel, as shown in figure, the total resistance is determined from the following equation:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$

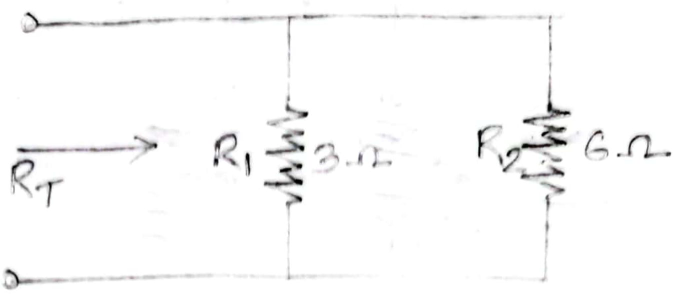
since, $G = \frac{1}{R}$, the equation can also be written in terms of conductance levels as follows:

$$G_T = G_1 + G_2 + G_3 + \cdots + G_N$$

$$\therefore R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}}$$

→ The total resistance of parallel resistor is always less than the value of the smallest resistor.

Example-6.1:



(a) Find the total conductance of the parallel network.
(b) Find the total resistance from the network.

Sol:

(a) Here,

$R_1 = 3\Omega$

$R_2 = 6\Omega$

$G_1 = \frac{1}{R_1} = \frac{1}{3} S$

$G_2 = \frac{1}{R_2} = \frac{1}{6} S$

$\therefore G_T = G_1 + G_2$

$= \frac{1}{3} + \frac{1}{6}$

$= \frac{2+1}{6}$

$= \frac{3}{6}$

$= \frac{1}{2}$

$= 0.5 S$

(b) total resistance,

$1/R_T = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{3} + \frac{1}{6}$

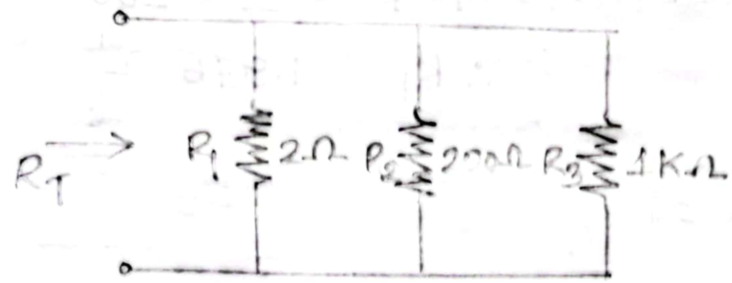
$= \frac{2+1}{6}$

$= \frac{3}{6}$

$= \frac{1}{2}$

$\therefore R_T = 2\Omega$

Example-6.2:



(a) By inseption, which parallel element in figure has the least conductance? Determine the total conductance of the network and note weather your conclution was ~~veref~~ verified.

(b) Determine the total resistance.

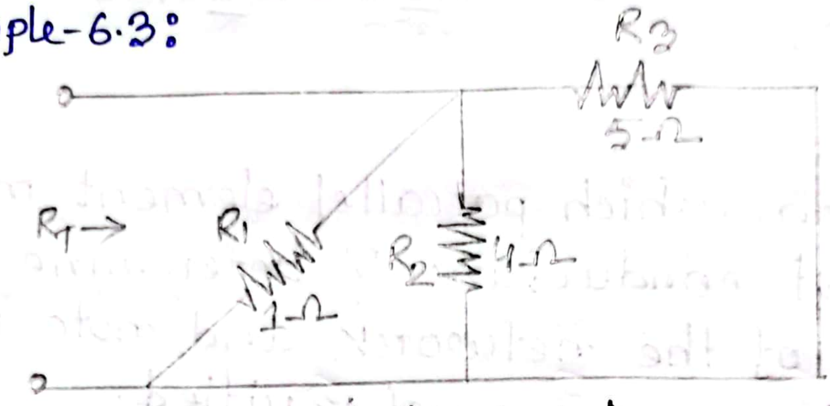
Sol:

(a)

(b) Total Resistance, $1/R_T = \frac{1}{2} + \frac{1}{200} + \frac{1}{1000}$

$\therefore R_T = 1.976\,\Omega$

Example-6.3:



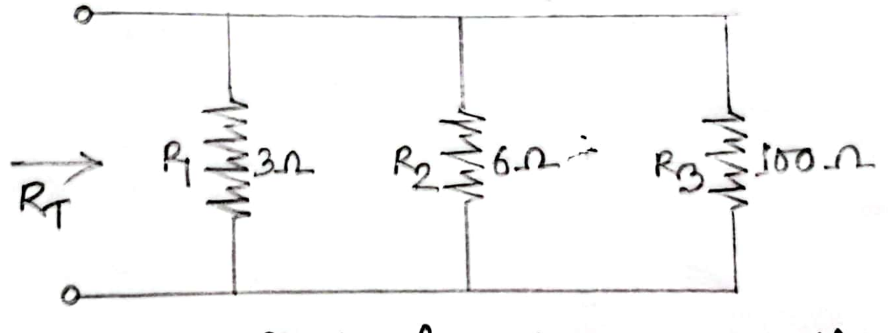
Determine the total resistance.

Sol: Total Resistance, $R_T = \dfrac{1}{\frac{1}{1} + \frac{1}{4} + \frac{1}{5}}$

$= \dfrac{1}{1 + \frac{1}{4} + \frac{1}{5}}$

$= 0.69\,\Omega$

Example-6.4:



(a) What is the effect of adding another resistor of $100\,\Omega$ in parallel with the parallel resistors of example 6.1 as shown in fig.

(b) What is the effect of adding a parallel $1\,\Omega$ resistor to the configuration in fig.

Sol:

(a) Total Resistance, $R_T = \dfrac{1}{1/R_1 + 1/R_2 + 1/R_3}$

$$= \frac{1}{\frac{1}{3} + \frac{1}{6} + \frac{1}{100}}$$

$$= 1.96\Omega$$

The effect of adding a resistor in parallel of 100Ω had little effect on the total resistance because its resistance level is significantly higher than the other two resistor.

(b) Total Resistance, $R_T = \dfrac{1}{1/R_1 + 1/R_2 + 1/R_3 + 1/R_4}$

$$= \frac{1}{1/3 + 1/6 + 1/100 + 1/1}$$

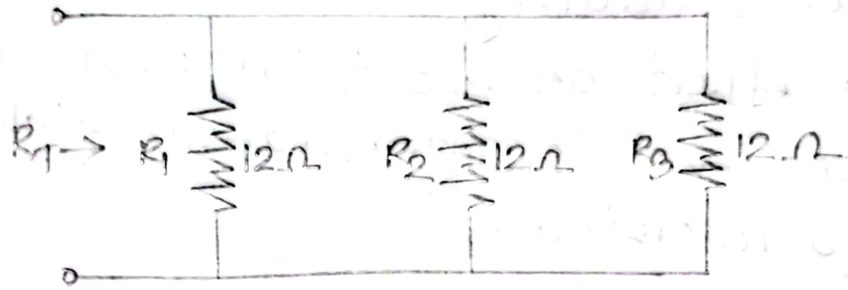
$$= 0.66\Omega$$

→ The total resistance of parallel resistors will always drop as new resistors (the added resistor has a resistance level less than the other parallel elements) are added in parallel, irrespective of their value.

→ The total resistance of N parallel resistors of equal value is the resistance of one resistor devided by the number (N) of parallel resistors

$$\boxed{R_T = R/N}$$

Example-6.5:



Find the total resistance of parallel resistor.

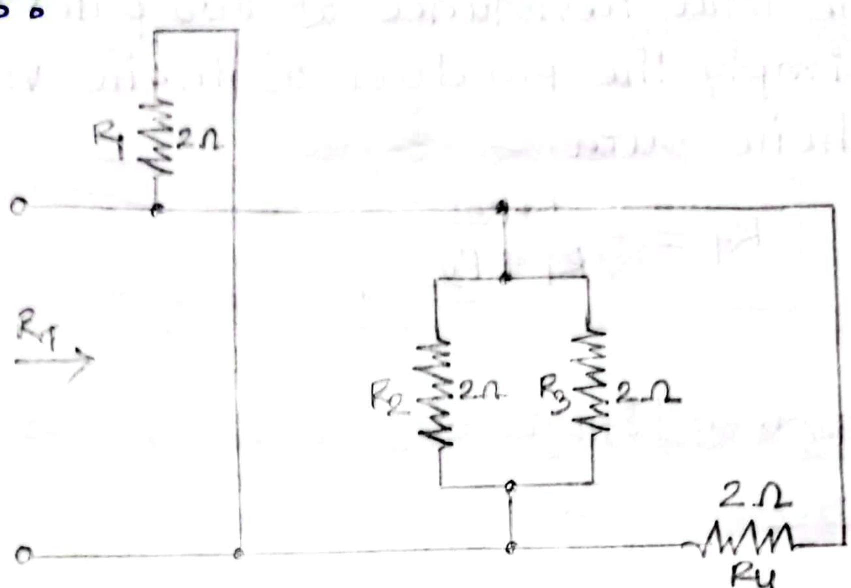
Sol: Applying Formula,

Total Resistance, $R_T = R/N$

$= 12\Omega/3$

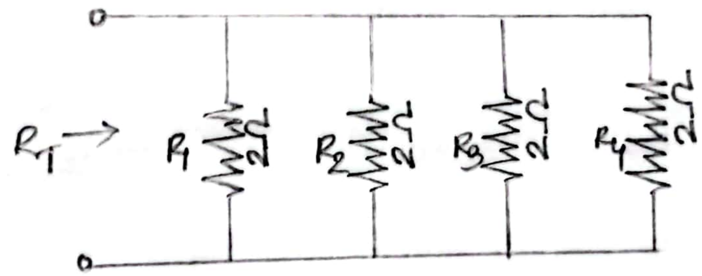
$= 4\Omega$

Example-6.6:



Find the total resistance from the configuration.

Sol: Equivalent circuit,



Applying Formula,

$$R_T = R/N$$

$$= \frac{2\Omega}{4}$$

$$= 0.5\Omega$$

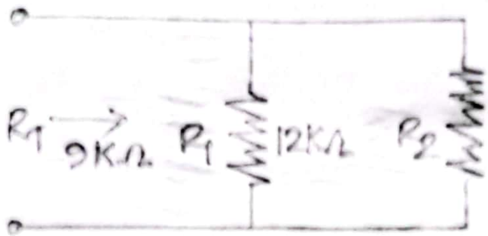
→ The total resistance of two parallel resistors is simply the product of their values divided by their sum.

$$\boxed{R_T = \frac{R_1 R_2}{R_1 + R_2}}$$

Example-6.7, 6.8, 6.9

Same

Example-6.10:



Determine the value of R_2.

Sol:

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

$$\Rightarrow R_T(R_1 + R_2) = R_1 R_2$$

$$\Rightarrow R_T R_1 + R_T R_2 = R_1 R_2$$

$$\Rightarrow R_T R_1 = R_1 R_2 - R_T R_2$$

$$\Rightarrow R_T R_1 = R_2 (R_1 - R_T)$$

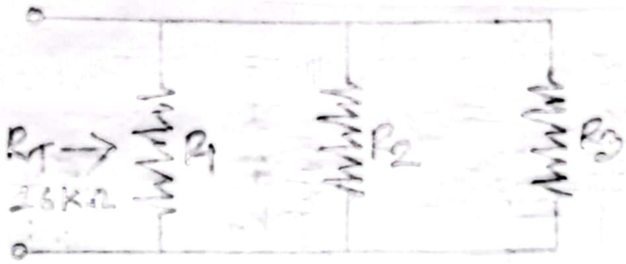
$$\Rightarrow R_2 = \frac{R_T R_1}{R_1 - R_T}$$

$$\Rightarrow R_2 = \frac{9K\Omega \cdot 12K\Omega}{12K\Omega - 9K\Omega}$$

$$\Rightarrow R_2 = \frac{108K\Omega}{3K\Omega}$$

$$\therefore R_2 = 36K\Omega$$

Example-6.11:



Determine the values of R_1, R_2 and R_3 in fig.
If $R_2 = 2R_1$, $R_3 = 2R_2$ and the total resistance is 16KΩ

Sol:
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$R_2 = 2R_1$ and $R_3 = 2R_2 = 2(2R_1) = 4R_1$

Now,
$$\frac{1}{R_T} = \frac{1}{R_1} + \cancel{\frac{1}{2R_1}} + \frac{1}{2R_1} + \frac{1}{4R_1}$$

$$= \frac{1}{R_1}\left(1 + \frac{1}{2} + \frac{1}{4}\right)$$

$$= 1.75\left(\frac{1}{R_1}\right)$$

$\Rightarrow R_T = \frac{R_1}{1.75}$

$\Rightarrow (16K\Omega)\cdot(1.75) = R_1$

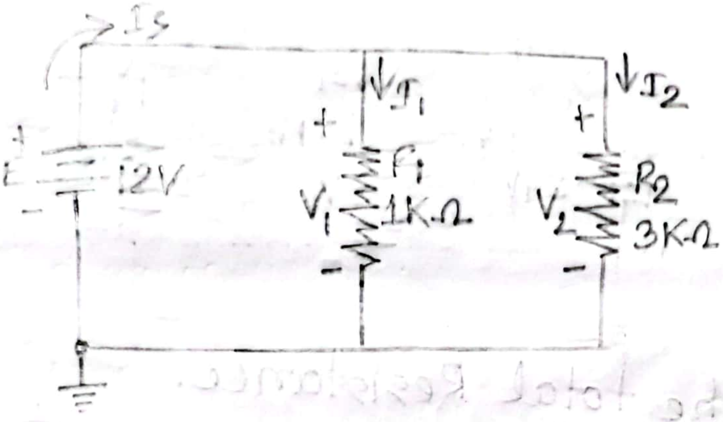
$\therefore R_1 = 28K\Omega$

$\therefore R_2 = (2 \times 28) = 56K\Omega$

$\therefore R_3 = (4 \times 28) = 112K\Omega$

A parallel circuit comprises branches so that current the divided and only part of it flows through any branch.

Parallel Circuit :



→ A parallel circuit can now be established by connecting a supply across a set of parallel resistors as shown in fig.

→ In general, the voltage is always the same across parallel elements.

$$\boxed{\therefore V_1 = V_2 = E}$$

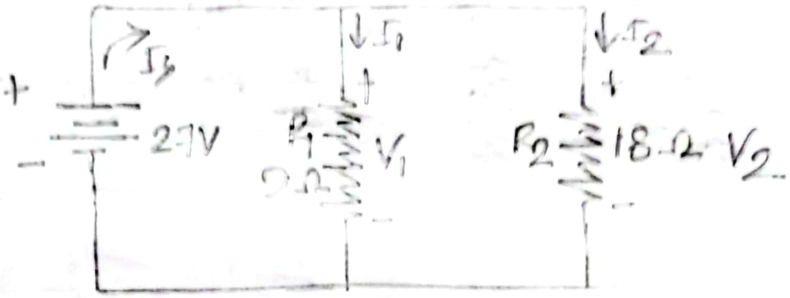
→ The source current can be determined as,

$$I_S = E/R_T, \quad I_1 = V_1/R_1 = E/R_1, \quad I_2 = V_2/R_2 = E/R_2$$

→ Source Current, $I_S = I_1 + I_2$

For single-source parallel networks, the source current (I_S) is always equal to the sum of the individual branch currents.

Example- 6.12:



ⓐ Find the total Resistance.

ⓑ Calculate the source Current.

ⓒ Determine the current through each parallel branch.

ⓓ show that, $I_s = I_1 + I_2$

Sol:

(a) Total Resistance, $R_T = \frac{R_1 R_2}{R_1 + R_2}$

$$= \frac{(9 \times 18)}{(18+9)}$$

$$= 6\Omega$$

(b) Source Current, $I_s = \frac{E}{R_T} = \frac{27V}{6\Omega} = 4.5A$

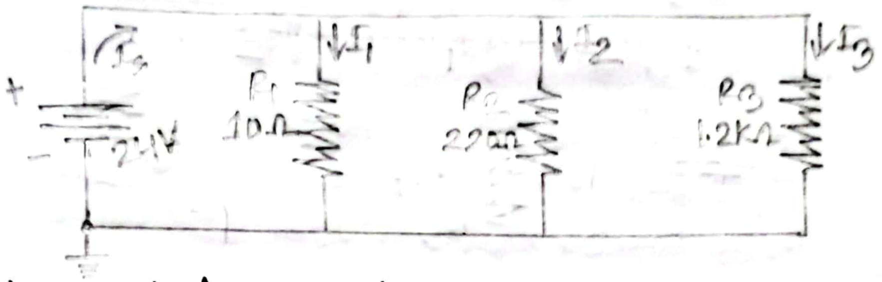
(c) $I_1 = \frac{E}{R_1} = \frac{27V}{9\Omega} = 3A$, $I_2 = \frac{E}{R_2} = \frac{27V}{18\Omega} = 1.5A$

(d) Source Current, $I_s = I_1 + I_2$

$$= (3 + 1.5)A$$

$$= 4.5A$$

Example-6.13:



(a) Find the total resistance.
(b) Calculate the source current.
(c) Determine the current through each branch.

Sol:

(a) Total Resistance, $R_T = \dfrac{1}{1/10 + 1/220 + 1/(1\times10^3)}$

$= 9.47\Omega$

(b) Source Current, $I_s = \dfrac{24V}{9.47\Omega}$

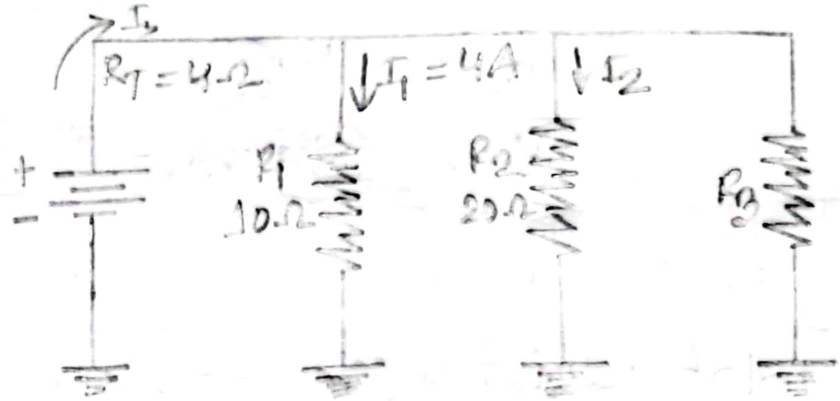
$= 2.53A$

(c) $I_1 = \dfrac{E}{R_1} = \dfrac{24V}{10\Omega} = 2.4A$

$I_2 = \dfrac{E}{R_2} = \dfrac{24V}{220\Omega} = 0.109A$

$I_3 = \dfrac{E}{R_3} = \dfrac{24V}{1.2\times10^3} = 0.02A$

Example-6.14:



(a) Determine R_3

(b) Find the applied voltage E

(c) Find the source current I_s

(d) Find I_2

Sol:

(a) $$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\Rightarrow \frac{1}{R_T} = \frac{1}{10} + \frac{1}{20} + \frac{1}{R_3}$$

$$\Rightarrow \frac{1}{R_3} = \frac{1}{4} - \frac{1}{10} - \frac{1}{20}$$

$$\Rightarrow \frac{1}{R_3} = 0.1$$

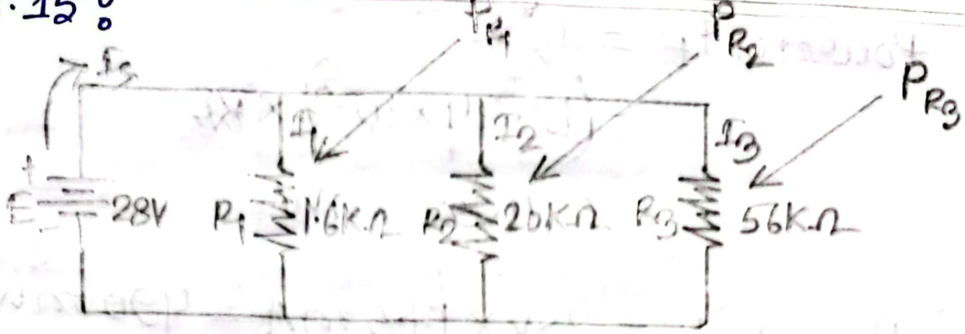
$\therefore R_3 = 10\,\Omega$

(b) $E = V_1 = I_1 R_1 = (4 \times 10) = 40V$

(c) Source Current, $I_s = E/R_T = 40/4 = 10A$

(d) $I_2 = E/R_2 = \frac{40V}{20\Omega} = 2A$

Example-6.15:



(a) Determine the total Resistance, R_T

(b) Find the source current and the current through each resistor.

(c) calculate the power delivered by the source.

(d) Determines the power absorbed by each parallel resistor.

(e) show that, $P_E = P_{R_1} + P_{R_2} + P_{R_3}$

Sol:

(a) Total Resistance, $R_T = \dfrac{1}{1/1.6 + 1/20 + 1/56}$

$= 1.44 K\Omega$

(b) Source current, $I_s = E/R_T$

$= 28V / 1.44 K\Omega$

$= 19.44 mA$

$I_1 = E/R_1 = 28V/1.6 = 17.5 mA$

$I_2 = E/R_2 = 28V/20 = 1.4 mA$

$I_3 = E/R_3 = 28V/56 = \cancel{2mA}\ 0.5 mA$

(c) Power, $P_E = I_S E$

$$= (19.44 \times 10^{-3}) \times 28$$

$$= 544.32 \text{ mW}$$

(d) $P_{R_1} = V_1 I_1 = 28V \times 17.5 \text{ mA} = 490 \text{ mW}$

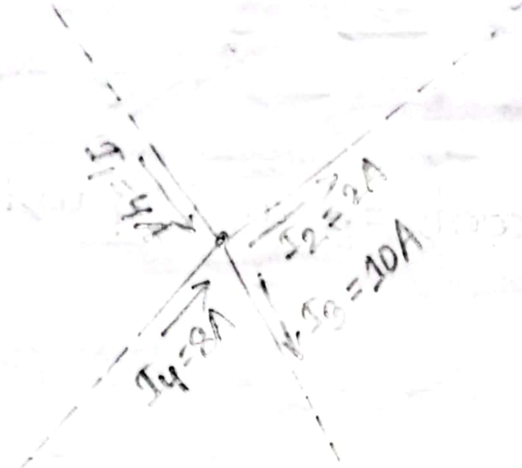
$P_{R_2} = V_2 I_2 = 28V \times 1.4 \text{ mA} = 39.2 \text{ mW}$

$P_{R_3} = V_3 I_3 = 28V \times 0.5 \text{ mA} = 14 \text{ mW}$

(e) $P_{R_1} + P_{R_2} + P_{R_3} = (490 + 39.2 + 14) \text{ mW}$

$$= 543.2 \text{ mW}$$

Kirchhoff's Current Law (KCL) :



→ The algebric sum of the currents entering and leaving a junction ~~(resis~~ (or region) of a network is zero.

→ The sum of the currents entering a junction (or region) of a network must equal the sum of the currents leaving the same junction (or region)

$$\therefore \sum I_i = \sum I_o$$

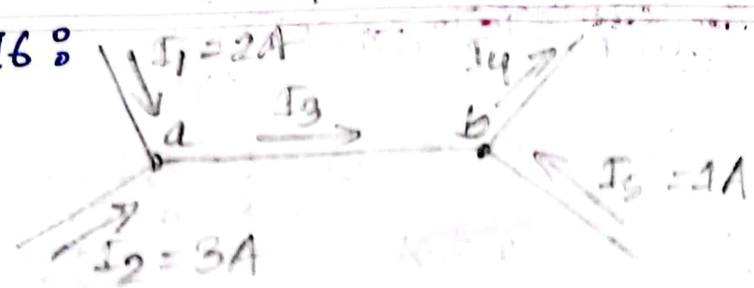
Here,

$$\sum I_i = \sum I_o$$

$$\Rightarrow 4+8 = 2+10$$

$$\therefore 12A = 12A$$

Example-6.16 :



Determine currents I_3 and I_4 using KCL

Sol:

At Node a,

$$\sum I_i = \sum I_o$$

$$\Rightarrow I_1 + I_2 = I_3$$

$$\Rightarrow 2A + 3A = I_3$$

$$\therefore I_3 = 5A$$

At Node b,

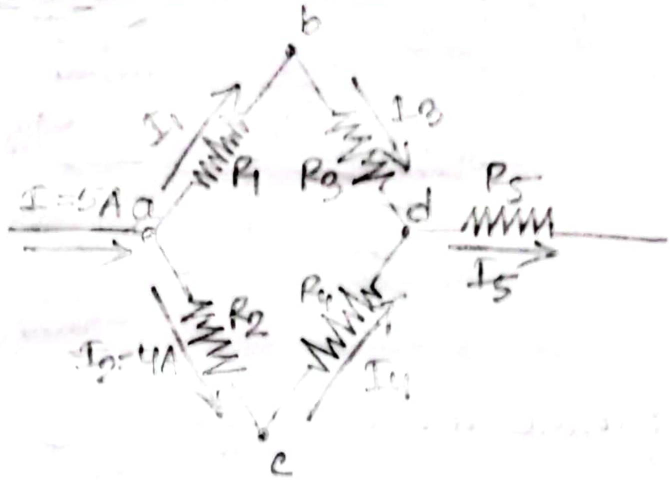
$$\sum I_i = I_o$$

$$\Rightarrow I_3 + I_5 = I_4$$

$$\Rightarrow 5A + 1A = I_4$$

$$\therefore I_4 = 6A$$

Example-6.17:



Determine currents I_1, I_3, I_4 and I_5 from the network.

Sol:

At node a,

$$I = I_1 + I_2$$

$$\Rightarrow 5A = I_1 + 4A$$

$$\Rightarrow I_1 = 5A - 4A$$

$$\therefore I_1 = 1A$$

At node b,

$$I_1 = I_3 \quad \therefore I_3 = 1A$$

At node c,

$$I_2 = I_4$$

$$\therefore I_4 = 4A$$

At node d,

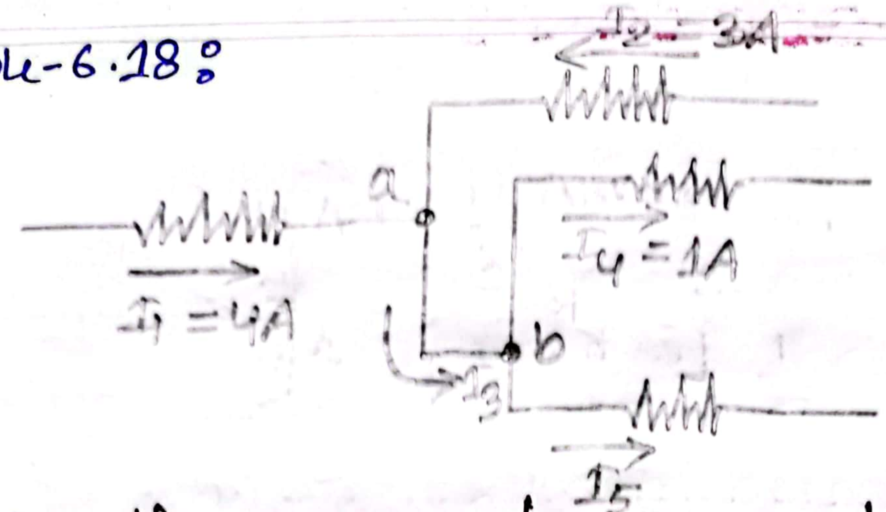
$$I_5 = I_3 + I_4$$

$$\Rightarrow I_5 = I_1 + I_2$$

$$\Rightarrow I_5 = 1A + 4A$$

$$\therefore I_5 = 5A$$

Example-6.18 :



Determine the currents I_3 and I_5.

Sol: At Node a,

$$I_1 + I_2 = I_3$$

$$\Rightarrow 4A + 3A = I_3$$

$$\therefore I_3 = 7A$$

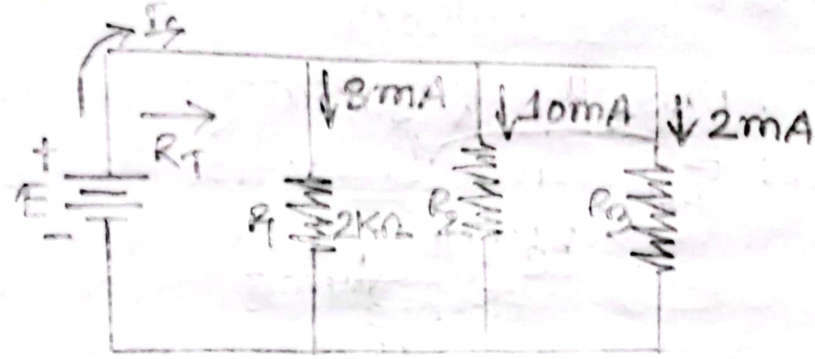
At Node b,

$$I_3 = I_4 + I_5$$

$$\Rightarrow 7A - 1A = I_5$$

$$\therefore I_5 = 6A$$

Example-6.19:



From the parallel network,

(a) Determine the source current, I_s

(b) Find the source voltage E.

(c) Determine R_3

(d) calculate R_T

Sol:

(a) from KCL,

$$I_s = I_1 + I_2 + I_3$$
$$= 8mA + 10mA + 2mA$$
$$= 20mA$$

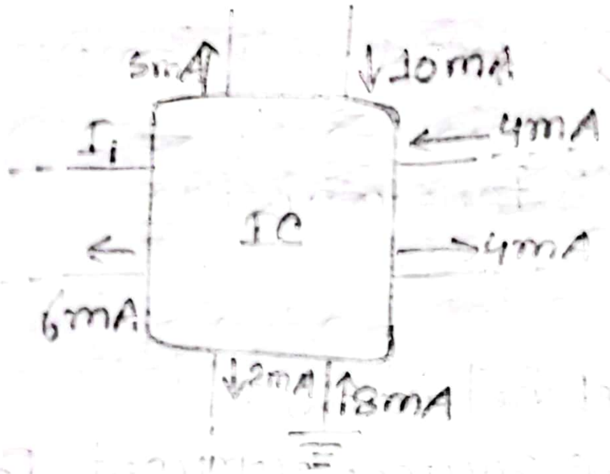
(b) $\cancel{E = (I_1 V_1}$

$$E = V_1 = I_1 R_1 = 8mA \times 2K\Omega$$
$$= 16V$$

(c) $$R_3 = \frac{V_3}{I_3} = \frac{E}{I_3} = \frac{16V}{2mA}$$
$$= 8K\Omega$$

(d) Total Resistance, $$R_T = \frac{E}{I_s} = \frac{16V}{20mA}$$
$$= 0.8K\Omega$$

Example - 6.20 :



Determine the current I_1.

Sol:

$$10mA + 4mA + 8mA + I_1 = 5mA + 4mA + 2mA + 6mA$$

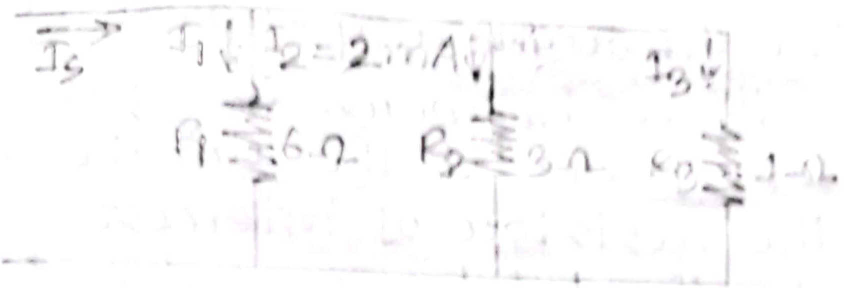
$$\Rightarrow 22mA + I_1 = 17mA$$

$$\Rightarrow I_1 = 17mA - 22mA$$

$$\therefore I_1 = -5mA$$

$\therefore$ We find that the direction for I_1 is leaving the IC.

Example-6.21:



1. Determine the currents I_1 and I_3 from the network.
2. Find the source current I_s

Sol:

1. Since, R_1 is twice R_2, the current I_1 must be one half I_2 and,

$$I_1 = \frac{I_2}{2} = \frac{2mA}{2} = 1mA$$

Since, R_2 is three times R_3, the current I_3 must be three times I_2 and

$$I_3 = 3 \times I_2$$
$$= 3 \times (2mA) = 6mA$$

2. From KCL,

$$I_s = I_1 + I_2 + I_3$$
$$= 1mA + 2mA + 6mA$$
$$= 9mA$$

Currrent Devider Rule:

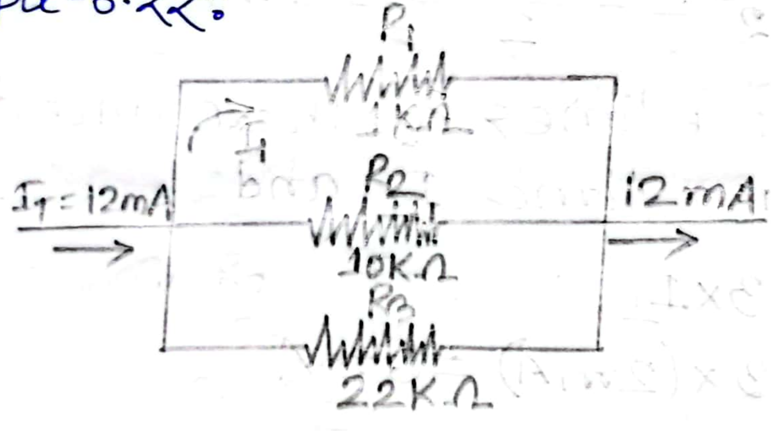
The currrent thrrough any brranch of a parrallel rresistive networrk is equal to the total rresistance of the parrallel networrk devided by the rresistorr of interrest and multiplied by the total currrent enterrring the parrallel configurration.

Total Resistance, $R_T = \frac{V}{I_T}$

$\therefore I_T = V/R_T$

From the rule, $I_x = \frac{R_T}{R_x} I_T$

Example-6.22:



Deterrmine the currrent, I_1 frrom the parrallel networrk.

Sol:

Total Resistance, $R_T = \frac{1}{1/R_1 + 1/R_2 + 1/R_3}$

$= \frac{1}{1/1K\Omega + 1/10K\Omega + 1/22K\Omega}$

$= 873.01\ \Omega$

From the current devider rule,

$$I_1 = \frac{R_T}{R_1} \times I_T$$

$$= \frac{873.01\,\Omega}{1\,K\Omega} \times (12\times10^{-3})A$$

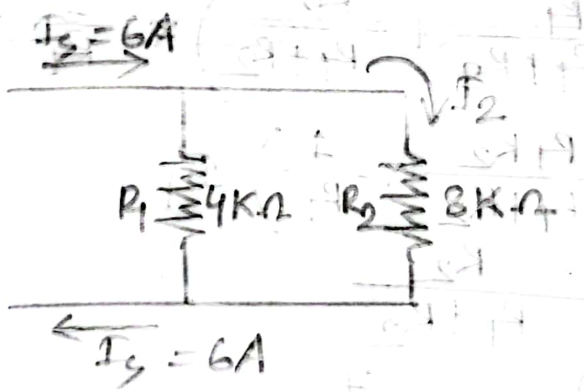
$$= 10.48\,mA$$

→ Current devider rule for two ~~special~~ parallel resistor,

$$I_1 = \left(\frac{R_2}{R_1+R_2}\right) I_T$$

$$I_2 = \left(\frac{R_1}{R_1+R_2}\right) I_T$$

Example-6.23:



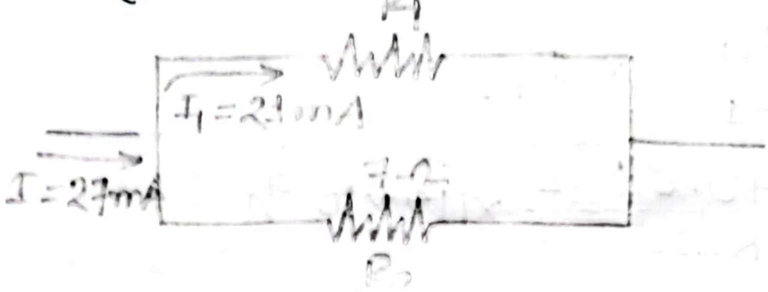
Determine the current I_2 from the network using current devider rule.

Sol: From Current devider rule,

$$I_2 = \frac{R_T}{R_2} I_T \qquad R_T = \frac{1}{1/4K\Omega + 1/8K\Omega}$$

$$= \_\_\_\_\_\_ \qquad =$$

Example-6.24:



Determine the resistor R_1 from the network to implement the devision of current shown.

Sol: From current devider rule,

$$I_1 = \frac{R_T}{R_1} I_T$$

$$\Rightarrow \cancel{21mA}\ I_1 = \frac{\dfrac{R_1 R_2}{R_1+R_2}}{R_1} I_T$$

$$\cancel{\Rightarrow I_1 = \left(\frac{R_1}{R_1+R_2} + \frac{R_2}{R_1+R_2}\right) \times \frac{1}{R_1} \times I_T}$$

$$\Rightarrow I_1 = \left(\frac{R_1 R_2}{R_1+R_2} \times \frac{1}{R_1}\right) I_T$$

$$\Rightarrow \frac{I_1}{I_T} = \frac{R_2}{R_1+R_2}$$

$$\Rightarrow \frac{(21\times10^{-3})}{(27\times10^{-3})} = \frac{7}{R_1+7}$$

$$\Rightarrow \frac{7}{9} = \frac{7}{R_1+7}$$

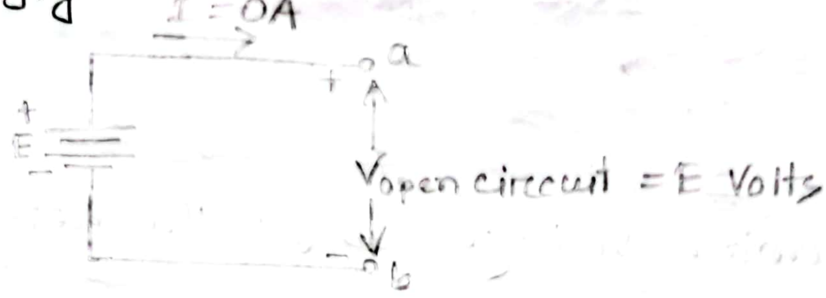
$$\Rightarrow 7(R_1+7) = 63$$

$$\Rightarrow R_1+7 = \frac{63}{7}$$

$$\Rightarrow R_1+7 = 9$$

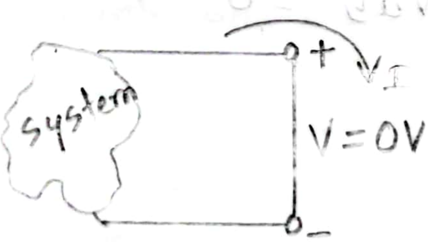
$$\Rightarrow R_1 = (9-7) \quad \therefore R_1 = 2\Omega$$

Open circuit: An open circuit is two isolated terminals not connected by an element of any kind as shown in fig.



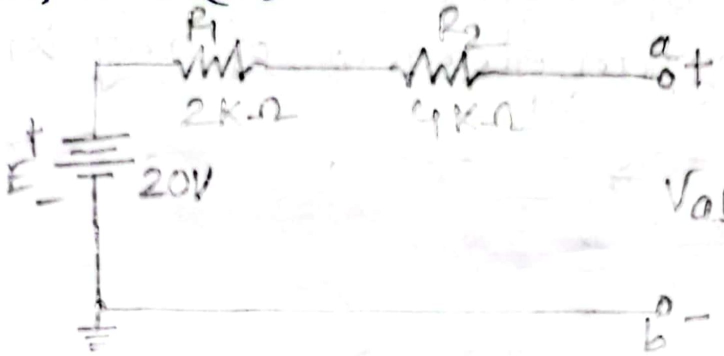
→ An open circuit can have a potential difference (voltage) across its terminals, but the current is always zero amperes.

Short circuit: A short circuit is a very low resistance, direct connection between two terminals of a network, as shown in fig.



A short circuit can carry a current of a level determined by the external circuit, but the potential difference (voltage) across its terminals is always zero volts.

Example-6.25:



Determine Voltage Vab for the network in fig.

Sol: Here,

The open circuit reequires that I be zero amperes. The voltage drop across both resistors is therefore zero volts since,

$V = IR = (0)R = 0$ Volts.

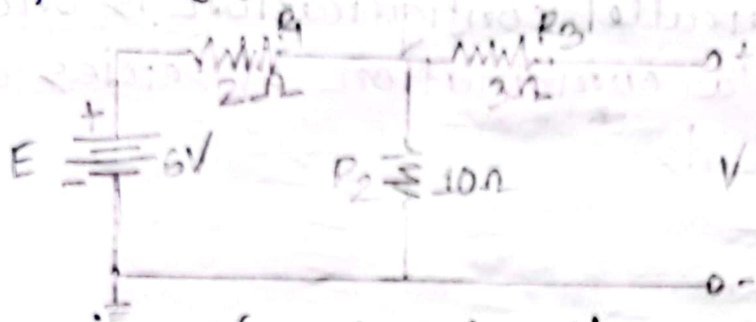
Applying Kirchhoff's voltage law,

$$E - V_1 - V_2 - V_{ab} = 0$$

$$\Rightarrow E = V_{ab}$$

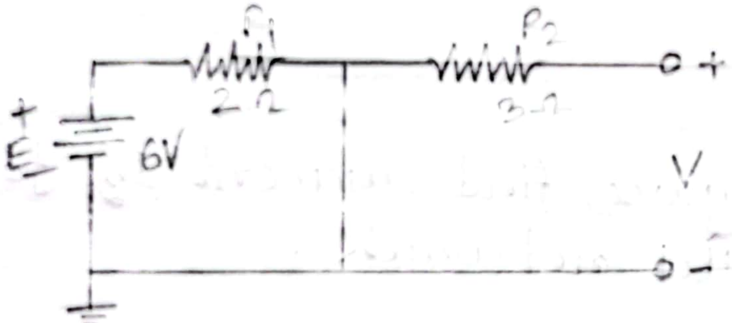
$$\therefore V_{ab} = 20V$$

Example-6.28:



Determine V and I for the network in fig if resistor R_2 is shorted out.

Sol: If the resistor R_2 is shorted,



The current through the R_2 (3Ω) resistor is zero due to the open circuit.

$$\therefore V_{(3\Omega)} = IR$$
$$= (0)R = 0 \text{ Volt}$$

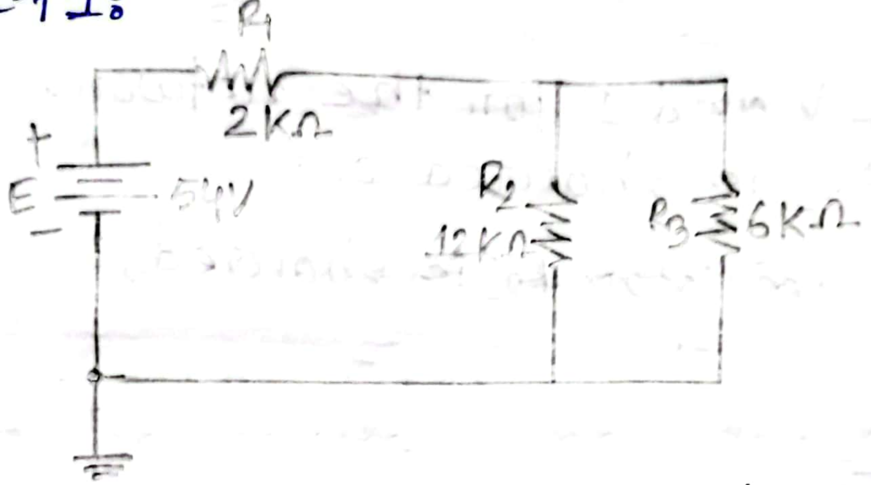
Now,

$$I = \frac{E}{R_1}$$
$$= \frac{6V}{2\Omega}$$
$$= 3A$$

Chapter: 07 (Series Parallel Circuit)

→ A series-parallel configuration is one that is formed by a combination of series and parallel elements.

Example-7.1:



From this figure, find current I_3 for the series-parallel network.

Sol: Here,

$$\frac{1}{R_P} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{12} + \frac{1}{6}$$

$$= \frac{1+2}{12}$$

$$= \frac{3}{12}$$

$\therefore R_P = 12/3 = 4K\Omega$

$\therefore$ Total Resistance, $R_T = R_S = R_1 + R_P$

$$= 2K\Omega + 4K\Omega$$

$$= 6K\Omega$$

Now,

the source current, $I_S = \frac{E}{R_T}$

$= \frac{54V}{6K\Omega}$

$= 9mA$

Here, the R_2 and R_3 resistors are parallaly conected. So, the voltage ~~dp~~ drop is same due to these two resistors.

$\therefore V = I_S R_P$

$= 9mA \times 4K\Omega$

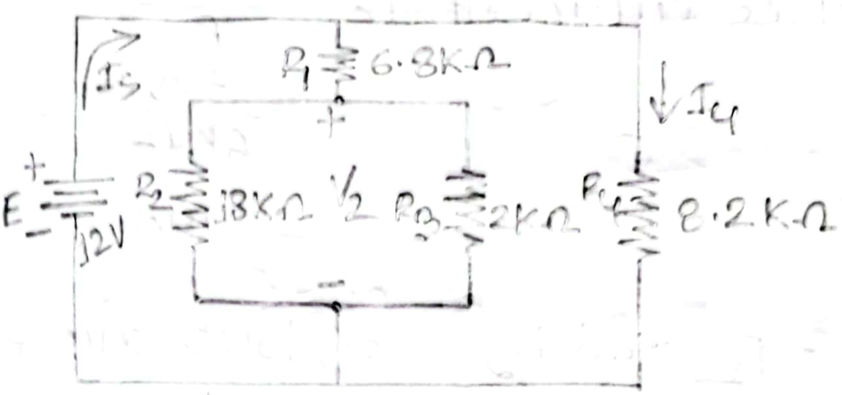
$= 36V$

$\therefore$ Current, $I_3 = \frac{V}{R_3}$

$= \frac{36V}{6K\Omega}$

$= 6mA$

Example-7.2:



(a) Determine current I_4 and I_s and Voltage V_2.

(b) Insert the meters to measure current I_4 and Voltage V_2

Sol:

(a) Here, the two resistor R_2 and R_3 are parallaly conected.

$\therefore$ The resistance, $R_p = \frac{1}{1/R_2 + 1/R_3}$

$$= \frac{1}{(1/18K\Omega) + (1/2K\Omega)}$$

$$= 1.8K\Omega$$

Now,

Series Resistance, $R_s = R_p + R_1$

$$= 1.8K\Omega + 6.8K\Omega$$

$$= 8.6K\Omega$$

$\therefore$ Total Resistance, $1/R_T = \frac{1}{R_s} + \frac{1}{R_4}$

$$= \frac{1}{8.6} + \frac{1}{8.2}$$

$$\therefore R_T = 4.2K\Omega$$

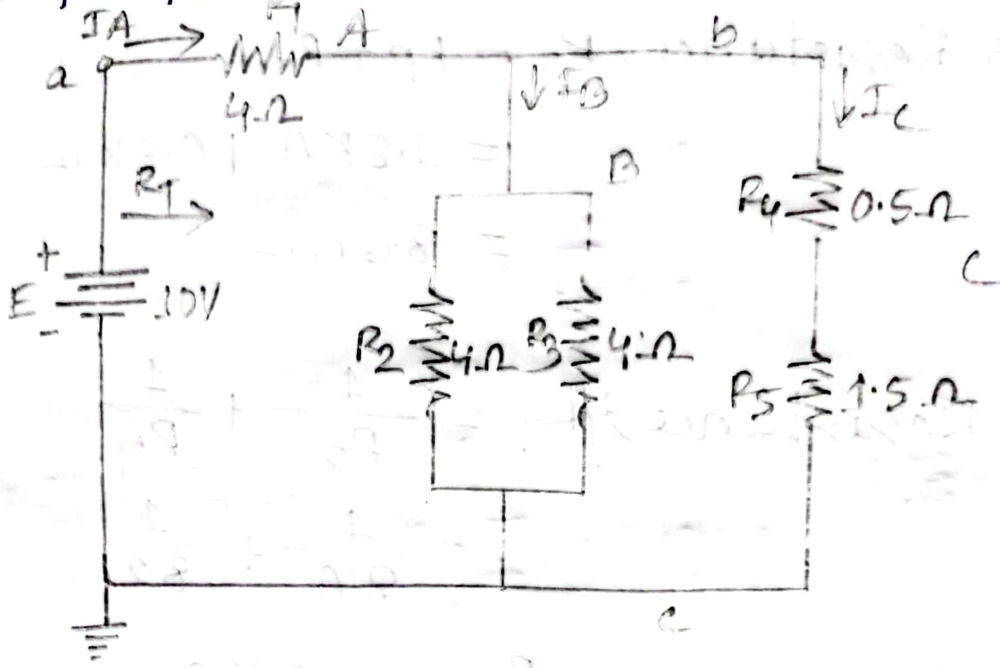
$\therefore$ Source Current, $I_s = \frac{E}{R_T} = \frac{12V}{4.2K\Omega} = 2.86mA$

$\therefore$ Current Through the resistor (R_4),

$$\underline{I_4} = \frac{V_4}{R_4} = \frac{E}{R_4} = \frac{12V}{8.2K\Omega}$$

$$= 1.46\,mA$$

Example-73:



Determine all the currents and voltages of the network from this fig.

Sol: Here,

$$R_A = R_1 = 4\Omega$$

$$R_B = R_2 \parallel R_3$$

$$R_C = (R_4 + R_5) = (0.5 + 1.5) = 2\Omega$$

Now,

$$R_B = \frac{1}{1/R_2 + 1/R_3}$$

$$= \frac{1}{1/4 + 1/4}$$

$$= 2\Omega$$

R_B and R_C are parallally connected.

$$\therefore R_{BC} = \frac{1}{1/R_B + 1/R_C}$$

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

$$= 1\,\Omega$$

$\therefore$ Total Resistance, $R_T = R_A + R_{BC}$

$$= 4\,\Omega + 1\,\Omega$$
$$= 5\,\Omega$$

$\therefore$ Source Current, $I_S = \frac{V}{R_T} = \frac{10V}{5\,\Omega} = 2A$

Now,

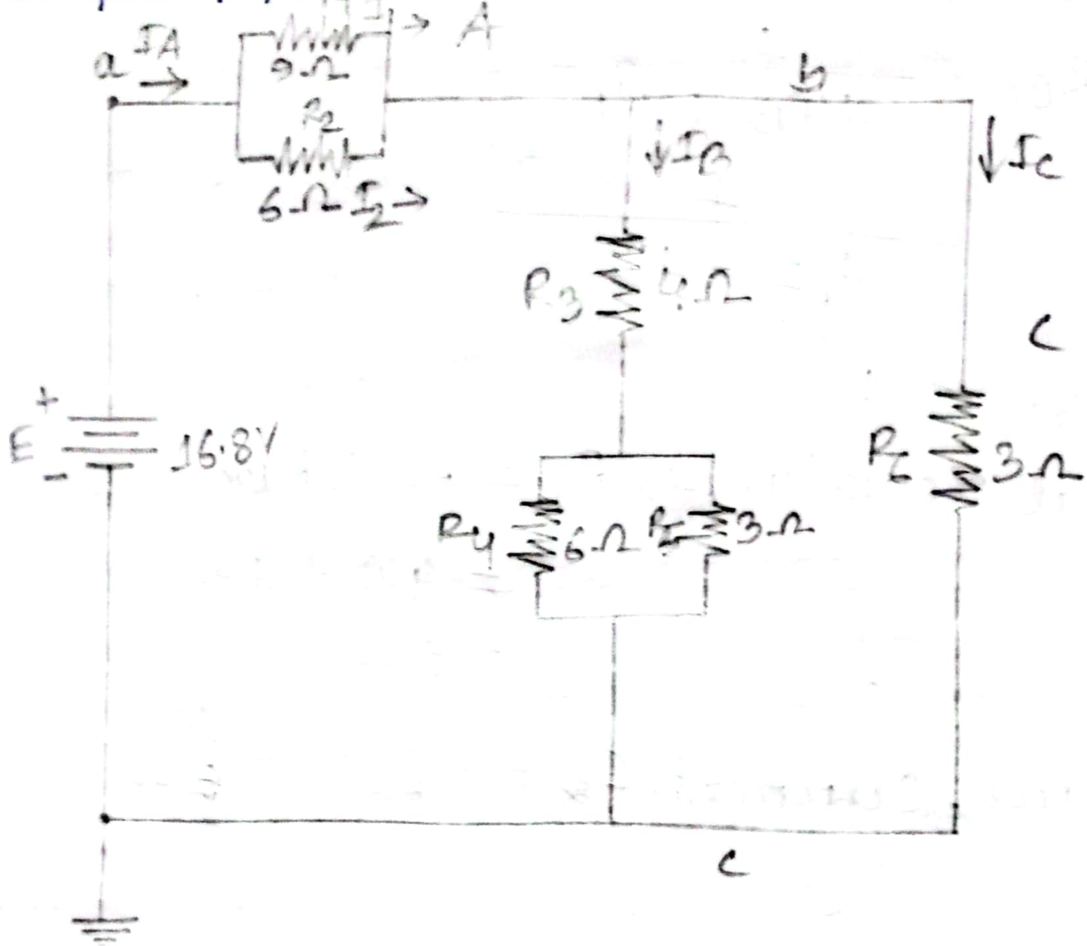
$$I_S = I_A = 2A$$

$$I_B = I_C = \frac{I_A}{2} = \frac{2A}{2} = 1A$$

Again,

$$V_A = I_A R_A = (2A \times 4\,\Omega) = 8\text{ Volt}$$
$$V_B = I_B R_B = (1A \times 2\,\Omega) = 2\text{ Volt}$$
$$V_C = V_B = I_C R_C = (1A \times 2\,\Omega) = 2\text{ Volt}$$

Example-7.4:



From this figure determine all the currents and voltages.

Sol: Here,

$$R_{P_1} = \frac{1}{1/R_1 + 1/R_2}$$

$$= \frac{1}{1/9 + 1/6}$$

$$= 3.6\,\Omega$$

$$\therefore R_A = R_{P_1} = 3.6\,\Omega$$

Again,

$$R_{P_2} = \frac{1}{1/R_4 + 1/R_5}$$

$$= \frac{1}{(1/6 + 1/3)}$$

$$= 2\Omega$$

$\therefore R_B = (R_3 + R_{P_2}) = (4\Omega + 2\Omega) = 6\Omega$

$\therefore R_C = R_6 = 3\Omega$

$$\therefore R_{BC} = \frac{1}{1/6 + 1/3} = 2\Omega$$

$\therefore$ Total Resistance, $R_T = R_A + R_{BC}$

$$= 3.6\Omega + 2\Omega$$

$$= 5.6\Omega$$

$\therefore$ Source current, $I_S = \frac{E}{R_T}$

$$= \frac{16.8V}{5.6\Omega}$$

$$= 3A$$

Now, $I_A = I_S = 3A$

From current devider rule,

$$I_B = \frac{R_{BC}}{R_B} I_T$$

$$= \frac{2\Omega}{6\Omega} \times 3$$

$$= 1A$$

From Kirchhoff's current law,

$$I_A - I_B - I_C = 0$$

$$\Rightarrow I_C = I_A - I_B$$

$$\Rightarrow I_C = 3A - 1A$$

$$\therefore I_C = 2A$$

By Ohm's law,

$$V_A = I_A R_A = (3A \times 3.6\Omega) = 10.8V$$

$$V_B = I_B R_B = (1A \times 6\Omega) = 6\Omega$$

$$V_C = I_C R_C = (3\Omega \times 2A) = 6\Omega$$

From current devider rule,

$$I_1 = \frac{R_{P_1}}{R_1} \times I_A$$

$$= \frac{3.6}{9} \times 3$$

$$= 1.2A$$

From Kirchof's current law,

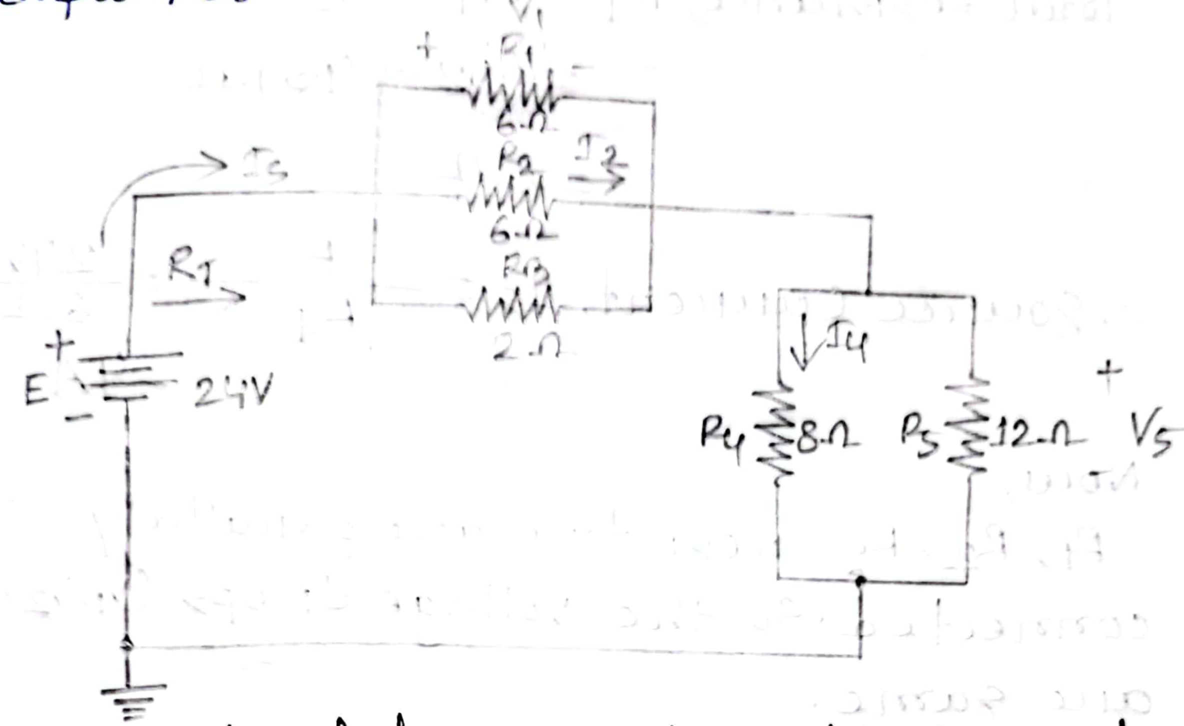
$$I_A - I_1 - I_2 = 0$$

$$\Rightarrow I_2 = I_A - I_1$$

$$\Rightarrow I_2 = 3A - 1.2A$$

$$\therefore I_2 = \cancel{2.5A}\ 1.8A$$

Example- 7.6:



Find the indicated currents and voltages for the network.

Sol: Here,

$$R_{P_1} = \frac{1}{1/R_1 + 1/R_2 + 1/R_3}$$

$$= \frac{1}{1/6 + 1/6 + 1/2}$$

$$= 1.2\ \Omega$$

$$R_{P_2} = \frac{1}{1/R_4 + 1/R_5}$$

$$= \frac{1}{1/8 + 1/12}$$

$$= 4.8\ \Omega$$

Total Resistance, $R_T = R_{P_1} + R_{P_2}$

$$= (1.2 + 4.8)\,\Omega$$

$$= 6\,\Omega$$

$\therefore$ Source Current, $I_S = \frac{E}{R_T} = \frac{24V}{6\,\Omega}$

$$= 4A$$

Now,

R_1, R_2, R_3 resistors are parallaly connected. So the voltage drops (V_1, V_2, V_3) are same.

$$\therefore V_1 = V_2 = V_3 = (I_S \times R_{P_1}) = (4A \times 1.2\,\Omega)$$

$$= 4.8V$$

Again,

R_4 and R_5 resistors are parallely connected. So the voltage drops (V_4, V_5) are same.

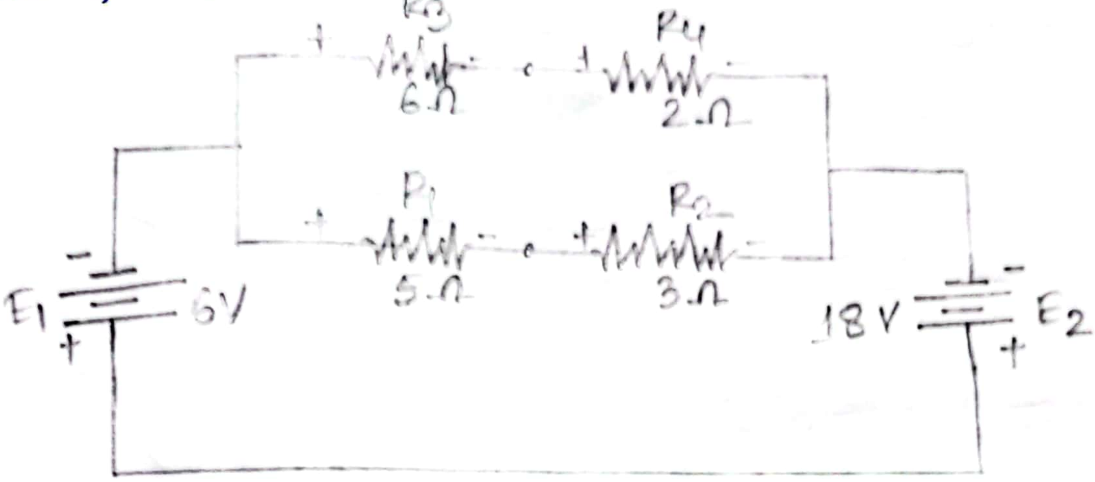
$$\therefore V_4 = V_5 = (I_S \times R_{P_2}) = (4A \times 4.8\,\Omega) = 19.2V$$

Here,

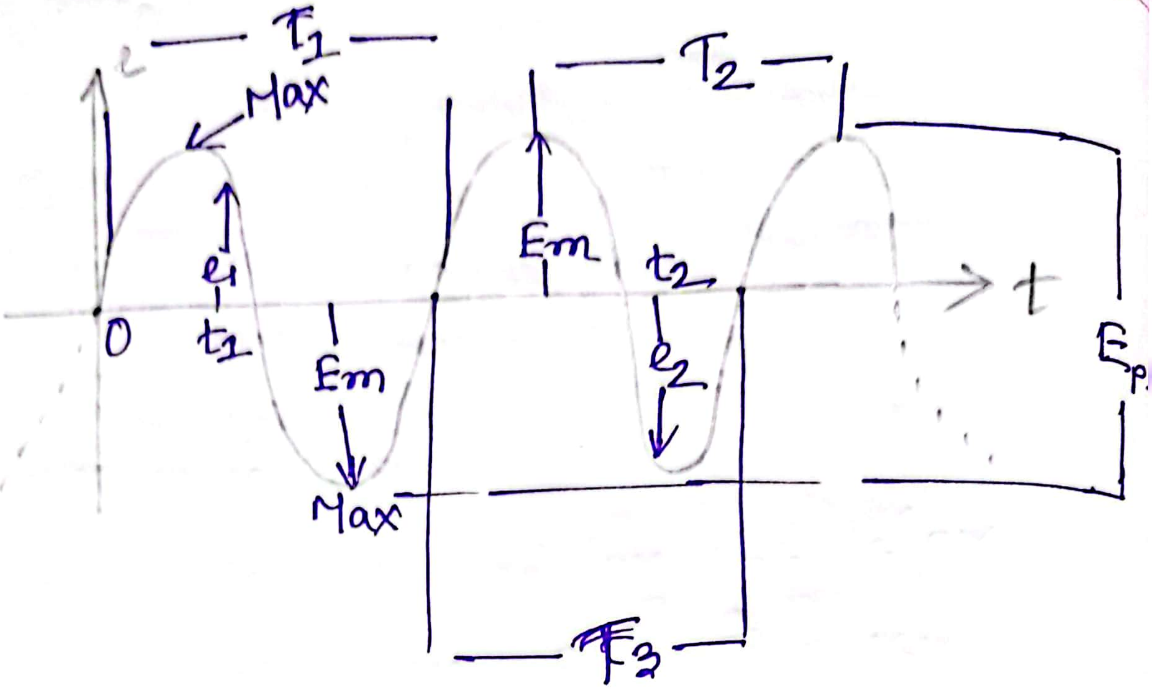
$$I_2 = \frac{V_2}{R_2} = \frac{4.8V}{6\,\Omega} = 0.8A$$

$$I_4 = \frac{V_4}{R_4} = \frac{19.2V}{8\,\Omega} = 2.4A$$

Example- 7.7:



Chapter-13 (Sinusoidal Alternating Waveforms)



Importence Parameters for a sinusoidal voltage :—

Waveform: The path traced by a quantity such as voltage, plotted as a function of some variable such as time (as above), position, degrees, radians, temperature and so on

Instantaneous Value: The magnitude of a wave-form at any instant of time; denoted by lowercase letters (e_1, e_2)

Peak amplitude: The maximum value of a waveform as measured from its average or mean value denoted by uppercase letter such as Em. In this figure, the average value is zero volt.

Peak value: The maximum instantaneous value of a function as measured from the zero volt level. In this figure, the peak value and peak amplitude are same because the average value of the function is zero volt.

Peak to Peak value: Denoted by E_{p-p} or V_{p-p}; the full voltage between the positive and negative peaks of the waveform. That is the sum of the magnitude of the positive and negative peaks.

Periodic Waveform: A waveform is continuosly repeats itself after the same time interval.

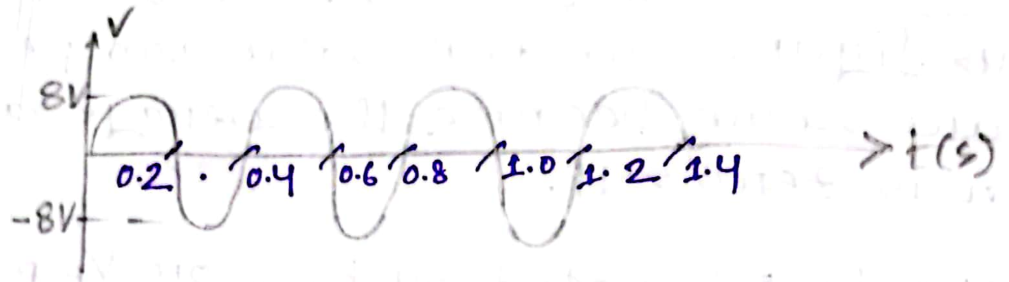
Period: The time of a periodic waveform. (T)

Cycle: The portion of waveform contained in one period of time.

Frequency: The number of cycles that occur in 1 second.

1 hertz (Hz) = 1 cycle per second (cps)

Ex-13.1!



(a) Peak value = 8V

(b) For 0.3s it's −8V and for 0.6s its 0V

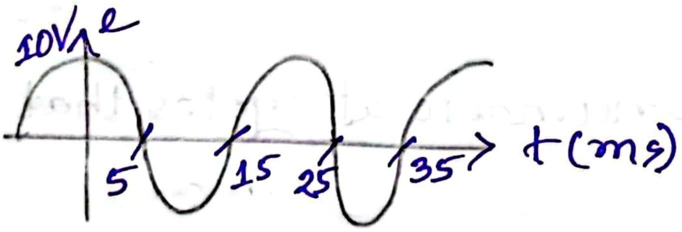
(c) Peak to peak value = 8V−(−8V) = 16V

(d) Period of the waveform = 0.4sec

(e) 3.5 cycles

(f) Frequency, $f = \frac{1}{0.4} = 2.5\text{Hz}$

Ex-13.3



From this figure, $T = (35-15)\,\text{ms} = 20\,\text{ms}$

$\therefore$ frequency, $f = \frac{1}{T} = \frac{1}{20\times10^{-3}\text{s}} = 50\text{Hz}$

Eien

Sinusoidal Waveform: The sinusoidal waveform is the only alternating waveform whoose shape is unaffected by the response of characteristics of R, L and C elements.

→ The quantity of π is the circumference of a circle to its diameter.

$$\text{Radians} = \left(\frac{\pi}{180^\circ}\right) \times (\text{Degree's})$$

$$\text{Degrees} = \left(\frac{180^\circ}{\pi}\right) \times (\text{radians})$$

→ **Angular Velocity:** The velocity with which the ~~radians~~ radius vector rotates about the ~~circle~~ centre called the angular velocity.

$$\text{Angular velocity} = \frac{\text{distance (degrees or radians)}}{\text{time (seconds)}}$$

$$\omega = \frac{\alpha}{t}$$

$$\therefore \alpha = \omega t$$

$$\omega = \frac{2\pi}{T}$$

$$\omega = 2\pi f$$

Ex-13.4

Angular velocity, $\omega = 2\pi f = 2\pi \times 60\,Hz$
$= 376.992 \; rad/s$

Ex-13.5

Here,
$\omega = 500 \; rad/s$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{500 \; rad/s} = 0.01256 \; sec$$
$$= 12.56 \; ms$$

$$\text{frequency}, f = \frac{1}{12.56\,ms} = 79.61 \; Hz$$

Ex-13.6

Here, $\omega = 200 \; rad/s$
$\alpha = 90^\circ$

$$\cancel{\omega = \alpha t}$$
$$\cancel{\Rightarrow t = \frac{\omega}{\alpha}}$$
$$\cancel{= \frac{\omega}{\frac{\pi}{180} \times 90^\circ \; rad}}$$
$$\cancel{= \frac{200 \; rad/s}{\pi/2}}$$
$$\cancel{= \frac{400}{\pi}}$$

$$\alpha = \omega t$$
$$\Rightarrow t = \frac{\alpha}{\omega}$$
$$= \frac{\frac{\pi}{180} \times 90^\circ}{200}$$
$$= \frac{\pi/2}{200}$$
$$= \frac{\pi}{400}$$
$$\therefore t = 7.85 \; ms$$

Ex-13.7

Here, $f = 60\,Hz$

$t = 5\,ms$

$\therefore \alpha = \omega t$

$= 2\pi f t$

$= 2\pi \times 60 \times (5 \times 10^{-3})$

$= 1.885$ rad

$\therefore \alpha = \frac{180^\circ}{\pi\ \cancel{rad}} \times 1.885\ \cancel{rad}$

$= 108^\circ$

General format of sinusoidal waveform:

$A_m \sin\alpha = A_m \sin\omega t$

$i = I_m \sin\omega t = I_m \sin\alpha$

$e = E_m \sin\omega t = E_m \sin\alpha$

Ex-13.8:

$e = 5\sin\alpha$

$\therefore e = 5\sin 40^\circ = 3.21V$

$\alpha = 0.8\pi = \frac{180^\circ}{\pi} \times 0.8\pi = 144^\circ$

$\therefore e = 5\sin 144^\circ = 2.94V$

Ex-13.11:

Given that,

$$i = 6\times10^{-3}\sin 1000t$$

$$\alpha = \omega t$$

$$= 1000t$$

$$= (1000\,rad/s)\times(2\times10^{-3})$$

$$= 2\,rad$$

$$= \frac{180^\circ}{\pi\,\cancel{rad}}\times 2\,\cancel{rad}$$

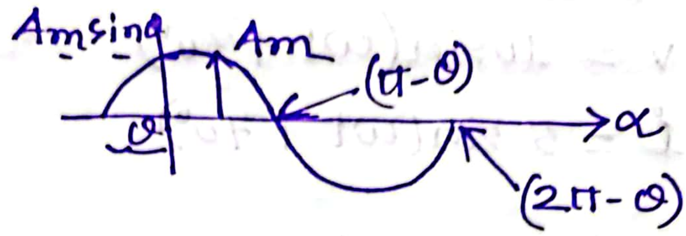
$$= 114.59^\circ$$

$$\therefore i = 6\times10^{-3}\sin 114.59^\circ$$

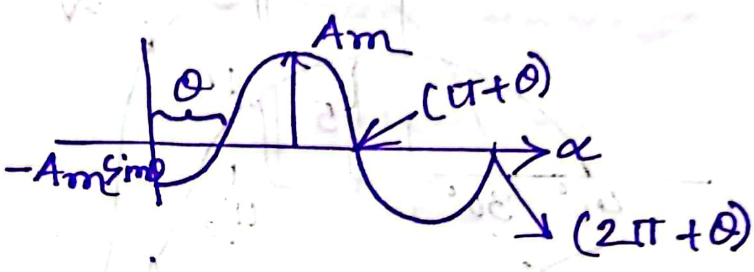
$$= 5.46\,mA$$

Phase Relationship: $A_m \sin(\omega t \pm \theta)$

→ $A_m \sin(\omega t + \theta)$



→ $A_m \sin(\omega t - \theta)$



→ $\sin(\omega t + 90^\circ) = \sin(\omega t + \frac{\pi}{2}) = \cos\omega t$

$\cancel{\sin(\omega t - 90^\circ)}$

$\sin\omega t = \cos(\omega t - 90^\circ) = \cos(\omega t - \frac{\pi}{2})$

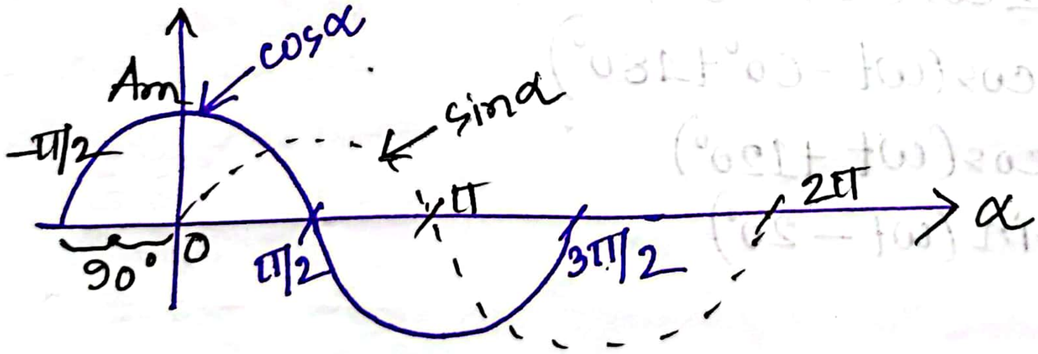
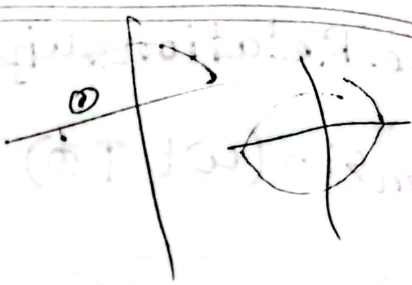


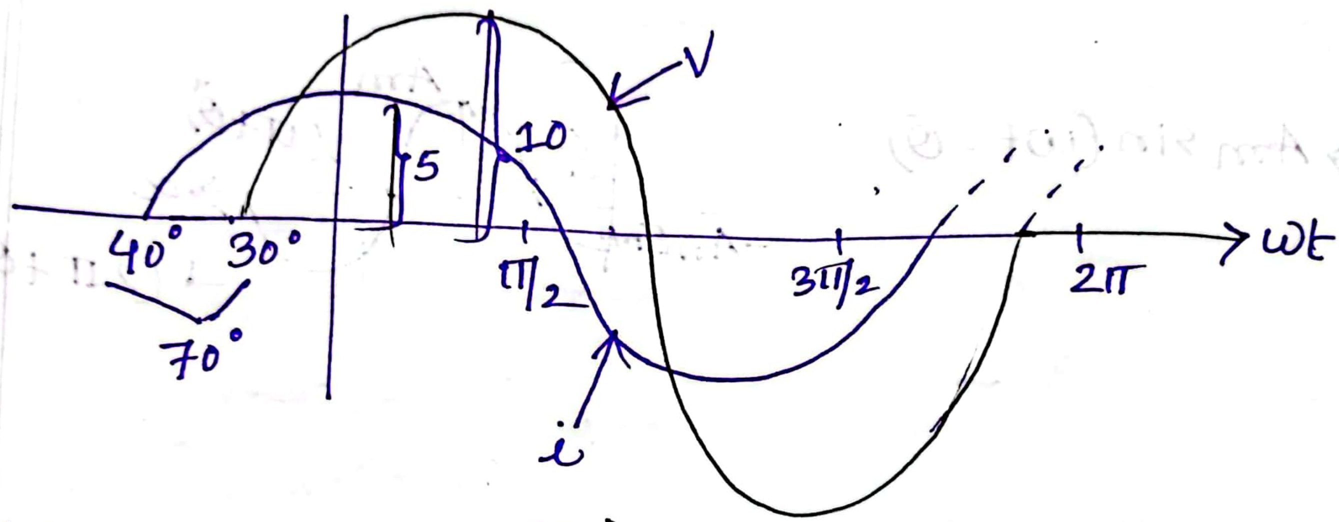
Figure : Phase relationship between a sin wave and cosine wave

Ex-13.12:

(a) $v = 10\sin(\omega t + 30^\circ)$

$i = 5\sin(\omega t + 70^\circ)$





(b) $i = 15\sin(\omega t + 60^\circ)$

$v = 10\sin(\omega t \cancel{+} -20^\circ)$

(c) $i = -2\cos(\omega t - 60^\circ)$

$= 2\cos(\omega t - 60^\circ + 180^\circ)$

$= 2\cos(\omega t + 120^\circ)$

$v = 10\sin(\omega t - 20^\circ)$

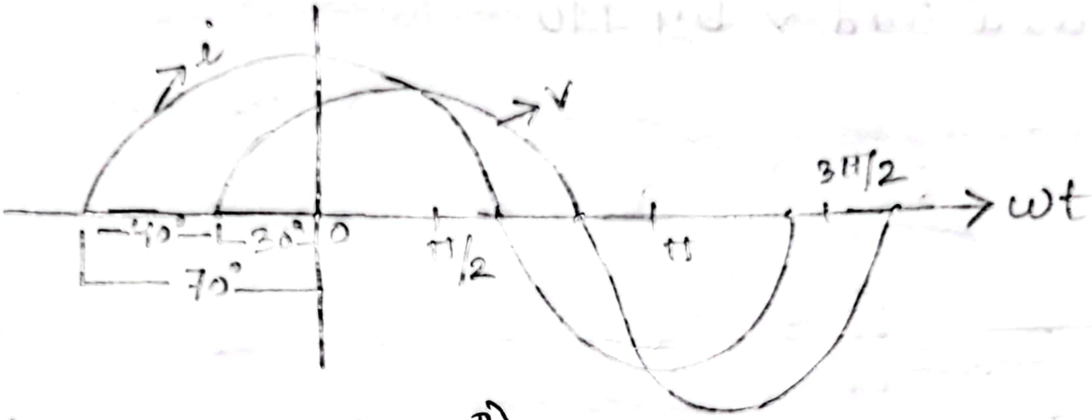
$=$

Ex-13.2

(a) $v = 10\sin(\omega t + 30^\circ)$

$i = 5\sin(\omega t + 70^\circ)$

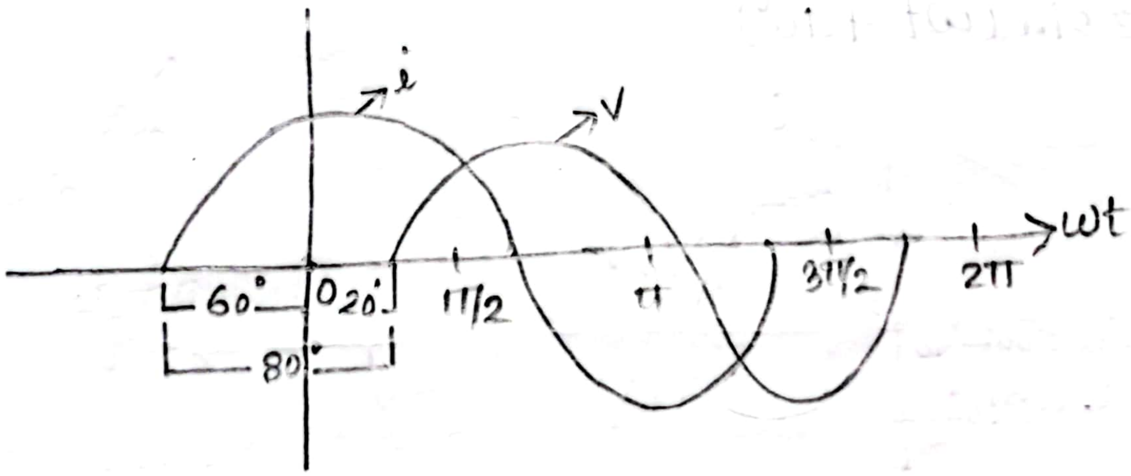
Here, i lead v by 40°



(b) $i = 15\sin(\omega t + 60^\circ)$

$v = 10\sin(\omega t - 20^\circ)$

Here, i lead v by 80°



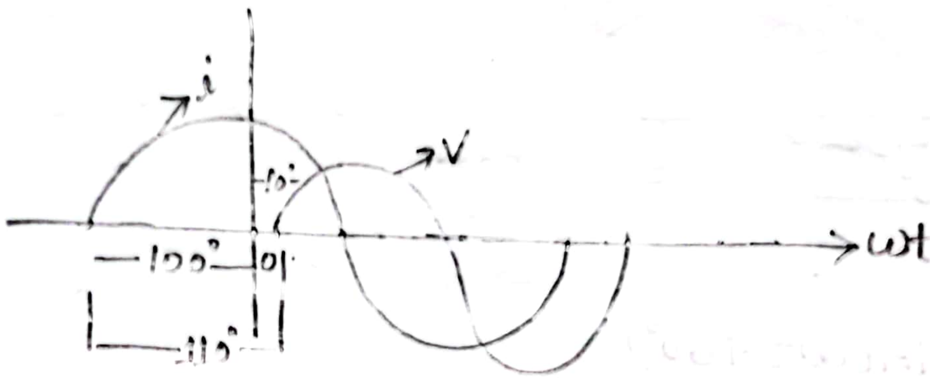
(c) $i = 2\cos(\omega t + 10^\circ)$

$= 2\sin(\omega t + 10^\circ + 90^\circ)$

$= 2\sin(\omega t + 100^\circ)$

$v = 3\sin(\omega t - 10^\circ)$

Here, i lead v by 110°

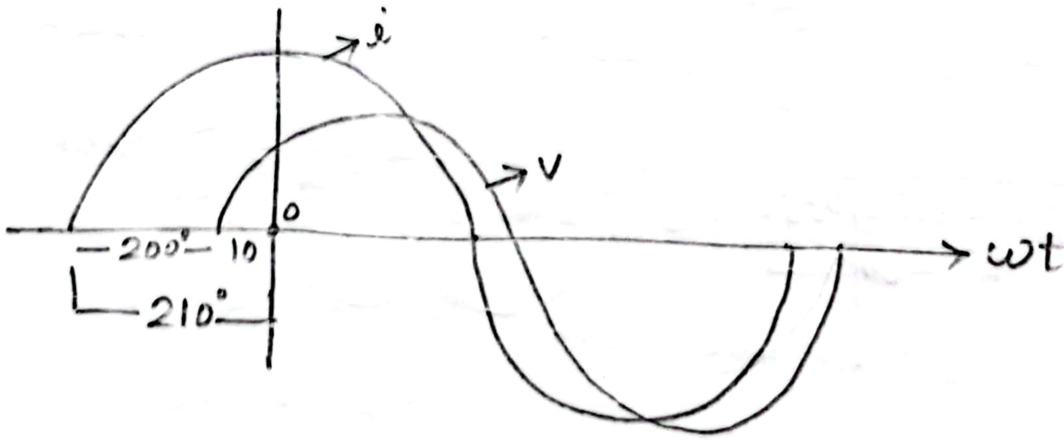


(d) $i = -\sin(\omega t + 30^\circ)$

$= \sin(\omega t + 30^\circ + 180^\circ)$

$= \sin(\omega t + 210^\circ)$ Here, i lead v by 200°

$v = 2\sin(\omega t + 10^\circ)$



Efective rms value:

The power delivered by ac pow supply,

$$P_{ac} = (i_{ac})^2 R$$

$$= (I_m \sin\omega t)^2 R$$

$$= (I_m^2 \sin^2\omega t) R$$

$$\sin^2\omega t = \frac{1}{2} \times 2\sin^2\omega t$$

$$= \frac{1}{2}(1 - \cos 2\omega t)$$

$$P_{ac} = I_m^2 \left\{ \frac{1}{2}(1 - \cos 2\omega t) \right\} R$$

$$= \frac{I_m^2}{2} R - \frac{I_m^2}{2} R\cos 2\omega t$$

$\left[\frac{I_m^2}{2} R\cos 2\omega t \text{ neglected}\right]$

Then, $P_{ac} = \dfrac{I_m^2 R}{2}$

Now,

$$P_{av(ac)} = P_{dc}$$

$$\Rightarrow \frac{I_m^2 R}{2} = I_{dc}^2 R$$

$$\Rightarrow \frac{I_m^2}{2} = I_{dc}^2$$

$$\Rightarrow I_{dc} = \frac{I_m}{\sqrt{2}}$$

$$\therefore I_{dc} = 0.707 I_m$$

The equivalent dc value of a sinusoidal current or voltage is $1/\sqrt{2}$ or 0.707 of its peak value.

The equivalent dc value is called the rms or effective value of the sinusoidal quantity.

$$\therefore I_{rms} = \sqrt{\frac{\int_0^T i^2(t)\,dt}{T}}$$

$$= \sqrt{\frac{\text{area}(i^2(t))}{T}}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707 I_m$$

$$E_{rms} = \frac{E_m}{\sqrt{2}} = 0.707 E_m$$

$$\therefore I_m = \sqrt{2}\, I_{rms} = 1.414 I_{rms}$$

$$E_m = \sqrt{2}\, E_{rms} = 1.414 E_{rms}$$

Ex-13.20!

(a) $I_m = 12\,mA$

$$I_{rms} = 0.707 \times 12 \times 10^{-3}$$

$$= 8.48\,mA$$

(b) $I_{rms} = 8.48\,mA$

(c) $V_{rms} = 169.7 \times 0.707 = 120V$

Ex-13.21:

$V_{dc} = 120V$

$P_{dc} = 3.6W$

$\because P_{dc} = V_{dc} \times I_{dc}$

$\therefore I_{dc} = \frac{P_{dc}}{V_{dc}} = \frac{3.6W}{120V} = 0.03A$

$\therefore I_{rms} = I_{dc}$

$I_m = 1.414\, I_{rms} = 1.414 \times 0.03$

$= 0.042$

$= 42mA$

$E_m = 1.414 \times 120 = \cancel{1.6}\ 169.68V$

Chapter-14: The basic elements and Phasors

→ The derivative of a sine wave has the same period and frequency as the original sinusoidal waveform.

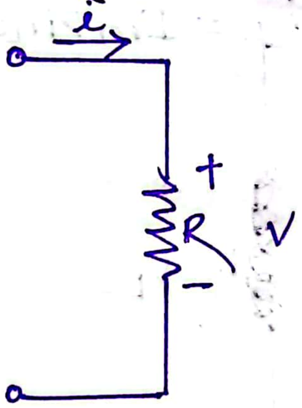
$$e(t) = E_m \sin(\omega t \pm \theta)$$

$$\Rightarrow \frac{d}{dt} e(t) = \frac{d}{dt}\{E_m \sin(\omega t \pm \theta)\}$$

$$\Rightarrow \frac{d}{dt} e(t) = \omega E_m \cos(\omega t \pm \theta)$$

$$\therefore \frac{d}{dt} e(t) = 2\pi f\, E_m \cos(\omega t \pm \theta)$$

Respone of Resistor (Sinusoidal current or voltage):



In figure, Resistor (R) is constant. From ohm's law,

$$i = \frac{v}{R}$$

$$= \frac{V_m \sin \omega t}{R}$$

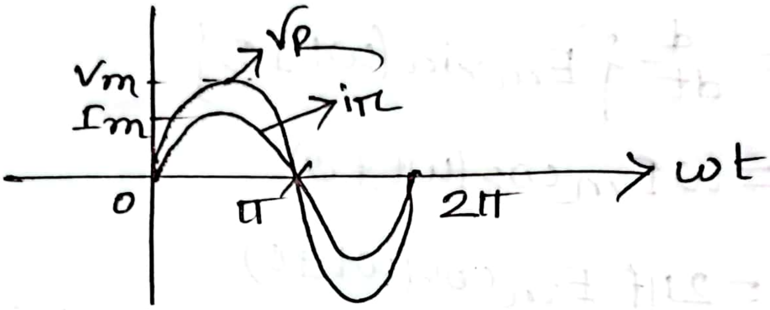
$$= \frac{V_m}{R} \sin \omega t$$

$$\therefore i = I_m \sin \omega t$$

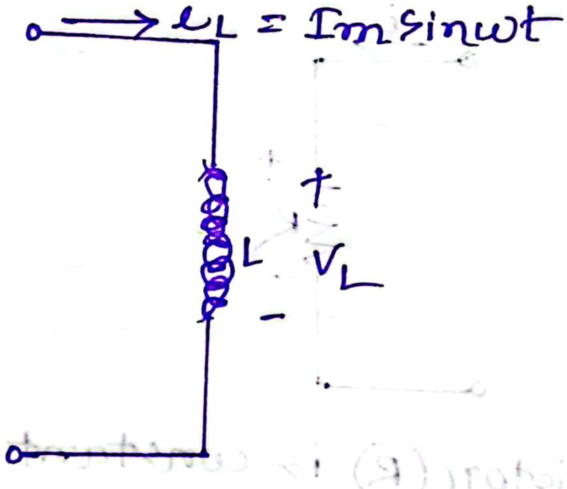
$\therefore v = iR$ $V_m = I_m R$

$\therefore v = I_m R \sin\omega t$ $I_m = \frac{V_m}{R}$

$\therefore V = V_m \sin\omega t$



Response of Inductor:



In figure,

For the Inductor, $V_L = L\frac{di_L}{dt}$

Applying differentiation,

$$\frac{di_L}{dt} = \frac{d}{dt}(I_m \sin\omega t)$$

$$= I_m \cdot \cos\omega t \cdot \omega$$

$$= \omega I_m \cos\omega t$$

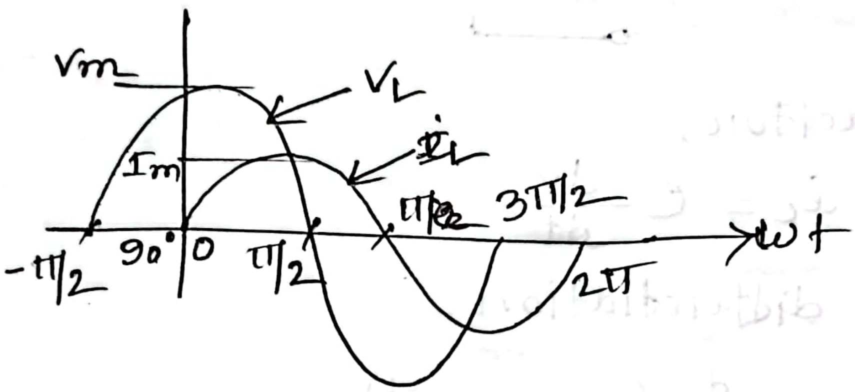
$$\therefore v_L = L\frac{di_L}{dt}$$

$$= L.\omega I_m \cos\omega t$$

$$v_L = V_m \sin(\omega t + 90^\circ)$$

Here, $V_m = \omega I_m L$

v_L leads I_L by 90° or I_L Lags v_L by 90°



Now,

$$i_L = I_m \sin(\omega t \pm \theta)$$

$$v_L = \omega L I_m \sin(\omega t \pm \theta + 90^\circ)$$

We know,

$$\text{Effect} = \frac{\text{cause}}{\text{oposition}}$$

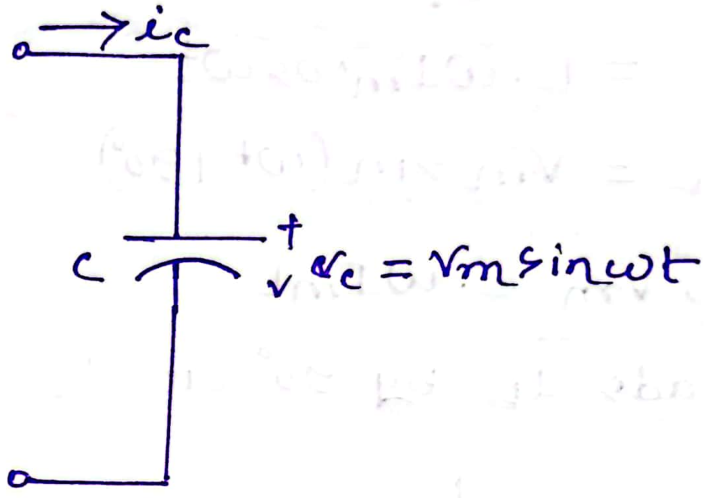
$$\text{opposition} = \frac{\text{cause}}{\text{effect}}$$

$$= \frac{V_m}{I_m} = \frac{\omega L I_m}{I_m} = \omega L$$

$$\therefore X_L = \omega L \ (\Omega)$$

$$\therefore X_L = \frac{V_m}{I_m} \ (\Omega)$$

Response of Capacitor:



For capacitor,

$$i_c = C\frac{dv_c}{dt}$$

Applying differtiation,

$$\frac{dv_c}{dt} = \frac{d}{dt}(V_m \sin\omega t)$$

$$= V_m \cos\omega t \cdot \omega$$

$$= \omega V_m \cos\omega t$$

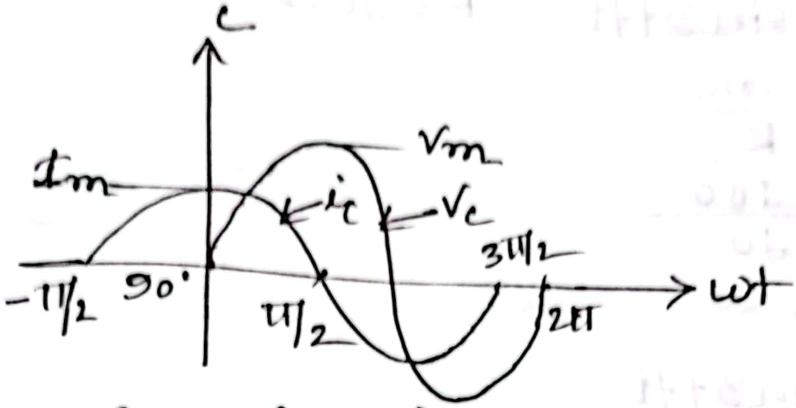
$$i_c = C\frac{dv_c}{dt}$$

$$= C\omega V_m \cos\omega t$$

$\therefore i_c = I_m \cos\omega t = I_m \sin(\omega t + 90^\circ)$

$\therefore I_m = C\omega V_m$

For capacitor, i_L lead v_L by $90°$ or V_L lags i_L by $90°$.



Now, $V_c = V_m \sin(\omega t \pm \theta)$

$i_c = I_m \sin(\omega t \pm \theta + 90°)$

Here, opposition $= \frac{\text{cause}}{\text{effect}}$

opposition $= \frac{V_m}{I_m}$

$= \frac{V_m}{\omega C V_m}$

$\therefore X_C = \frac{1}{\omega C} \; (\Omega)$

$X_C = \frac{V_m}{I_m} \; (\Omega)$

Ex-14.1

(a) $v = 100\sin 377t$ $R = 10\Omega$

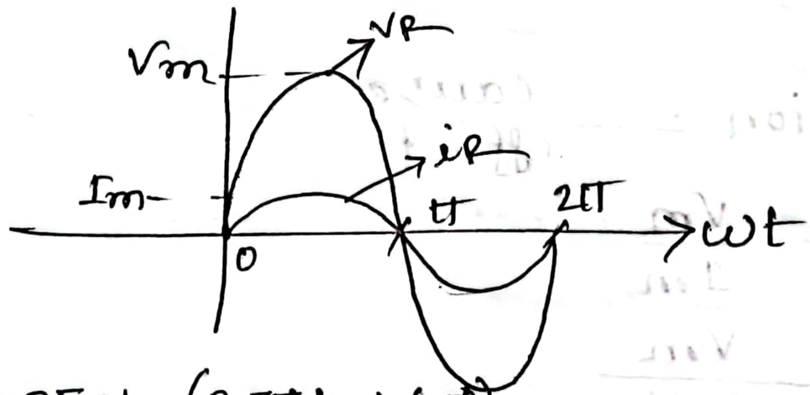
$$I_m = \frac{V_m}{R}$$

$$= \frac{100}{10}$$

$$= 10$$

$$i = I_m \sin 377t$$

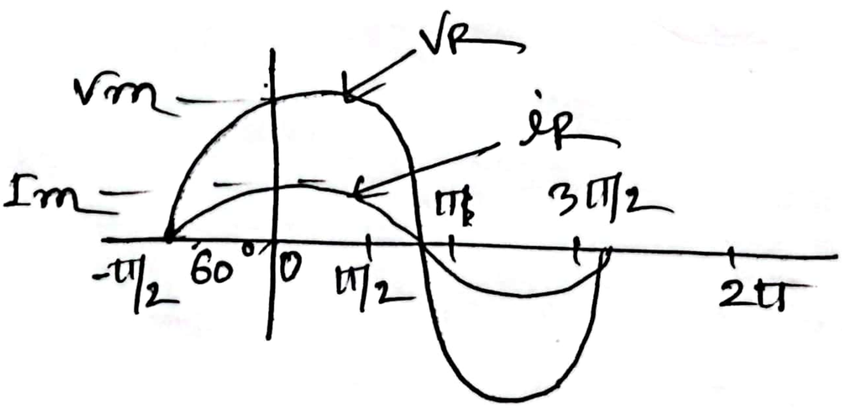
$$= 10\sin 377t$$



(b) $v = 25\sin(377t + 60°)$, $R = 10\Omega$

$$I_m = \frac{25}{10} = 2.5$$

$$\therefore i = 2.5\sin(377t + 60°)$$



Ex-14.2:

$i = 40\sin(377t + 30^\circ)$

$R = 5\cancel{0}\Omega$

$V_m = I_m R$

$= (40 \times 5\cancel{0})$

$= 200\cancel{0}V$

$\therefore v = 200\sin(377t + 30^\circ)$

Ex-14.4:

$L = 0.5H$

$v = 100\sin\cancel{\omega t}20t$

$X_L = \omega L$

$= (20\,rad/s) \times 0.5H$

$= 10\,\Omega$

$\cancel{I_m = \frac{X_L}{V_m}}$

$\cancel{= \frac{10\,\Omega}{100}}$

$X_L = \frac{V_m}{I_m}$

$\Rightarrow I_m = \frac{V_m}{X_L} = \frac{100}{10}$

$\therefore I_m = 10A$

i lags v by 90°

$\therefore i = I_m \sin(\omega t - 90^\circ)$

$\therefore i = 10\sin(\cancel{\omega}20t - 90^\circ)$

Ex-14.5:

$C = 1\mu F$

$V = \cancel{300}\ 30\sin 400t$

$X_c = \dfrac{V_m}{I_m}$

$\Rightarrow I_m = \dfrac{V_m}{X_c} = \dfrac{30}{2500}$

$\therefore I_m = 12mA$

$X_c = \dfrac{1}{\omega C}$

$= \dfrac{1}{400 \times 1\mu F}$

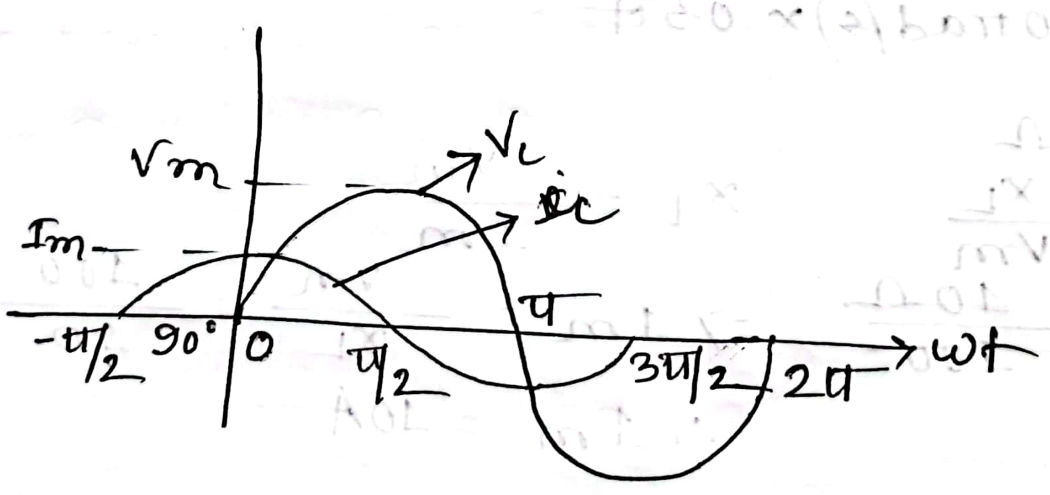
$= \dfrac{1}{400 \times 1 \times 10^{-6}}$

$= \dfrac{10^6}{400}$

$= 2500\Omega$

i lead v by 90°

$\therefore i = 12 \times 10^{-3} \sin(400t + 90^\circ)$



Ex-14.7:

(a) $v = 100\sin(\omega t + 40^\circ)$

$i = 20\sin(\omega t + 40^\circ)$

$V_m = 100$

$I_m = 20$

$R = \frac{V_m}{I_m} = \frac{100}{20} = 5\Omega$

$\cancel{X_C = \frac{V_m}{I_m} = \frac{100}{20} = 5\Omega}$

$\cancel{X_C = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega X_C} = \frac{1}{\quad}}$

Here v and i, both are in phase. element is R

(b) $v = 1000\sin(377t + 10^\circ)$

$i = 5\sin(377t - 80^\circ)$

Here,

i lag v by 90° / v lead i by 90°

element is Inductor.

$X_L = \frac{V_m}{I_m} = \frac{1000}{5} = 200\Omega$

$X_L = \omega L$

$\Rightarrow L = \frac{200}{377}$

$\therefore L = 0.53H$

(c) $v = 500\sin(157t + 30^\circ)$

$i = 1\sin(157t + 120^\circ)$

Here, i lead v by 90°. element is capacitor

$\therefore X_C = \frac{500}{1} = 500\Omega$

$X_C = \frac{1}{\omega C}$

$\Rightarrow C = \frac{1}{157 \times 500}$

$\therefore C = 12.74 \mu F$

(d) $v = 50 \cos(\omega t + 20^\circ)$

$i = 5 \sin(\omega t + 110^\circ)$

Now,

$v = 50 \cos(\omega t + 20^\circ)$

$= 50 \sin(\omega t + 90^\circ + 20^\circ)$

$= 50 \sin(\omega t + 110^\circ)$

v and i both are in phase.

element is Resistor.

$\therefore R = \frac{V_m}{I_m}$

$= \frac{50}{5}$

$= 10 \Omega$

Frequency Response:

Capacitor, $X_C = \frac{1}{2\pi f C}$

Inductor, $X_L = \cancel{\frac{1}{2}}\ 2\pi f L$

Ex-14.8.

$R = 5K\Omega$

$= 5000\ \Omega$

$L = 200mH$

$= 200 \times 10^{-3} H$

$R = X_L = 2\pi f L$

$\Rightarrow 5000 = 2 \times \pi \times (200 \times 10^{-3}) L$

$\therefore L = \cancel{3.98H}\ 3.98KHz$

Ex-14.9

$X_L = X_C$

$\Rightarrow 2\pi f L = \frac{1}{2\pi f C}$

$\Rightarrow f^2 = \frac{1}{4\pi^2 LC}$

$\Rightarrow f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(5\times10^{-3}) \times (0.1\times10^{-6})}}$

$\therefore f = 7.12KHz$

Average value:

$$P = \frac{V_m I_m}{2} \cos(\theta_v - \theta_i)$$

For resistor,

$(\theta_v - \theta_i) = \theta$, $\theta = 0°$; $\cos 0° = 1$

$$\therefore P = \frac{V_m I_m}{2}$$

$$= \frac{\sqrt{2} V_{rms} \times \sqrt{2} I_{rms}}{2}$$

$$\therefore P = V_{rms} I_{rms}$$

$$I_{rms} = \frac{P}{V_{rms}}$$

$$P = \frac{V_{rms}^2}{R} = I_{rms}^2 R$$

For capacitor, ~~[v lead i]~~ [i lead v]

$\theta_v - \theta_i = -90° = |-90°| = 90°$; $\cos 90° = 0$

$$P = \frac{V_m I_m}{2} \cos(90°)$$

$$= 0$$

For Inductor, [v lead i]

$\theta_v - \theta_i = -90° = |-90°| = \cos 90° = 0$

$= 90°$

$$P = \frac{V_m I_m}{2} \cos 0°$$

$$= 0$$

Power Factor:

$$\cancel{P = \frac{V_m I_m}{2} \cos\theta}$$

~~cosθ~~

Here $\cos\theta$ is called power factor (f_p)

$$\therefore f_p = \cos\theta = \frac{P}{V_{rms} I_{rms}}$$

Rectangular Form:

$$c = X + jY$$

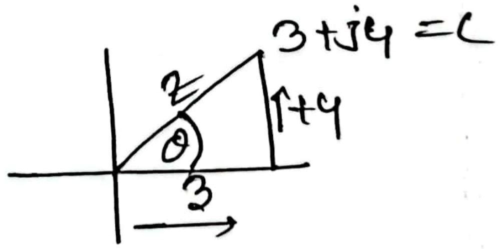
Polar Form:

$$c = Z\angle\theta$$

Rectangular to Polar:

$$Z = \sqrt{X^2 + Y^2}$$

$$\theta = \tan^{-1}\frac{Y}{X}$$



Ex – 14:15:

$$c = 3 + j4$$

where,

$$X = 3$$

$$Y = 4$$

$$Z = \sqrt{X^2 + Y^2} = \sqrt{3^2 + 4^2} = 5$$

$$\theta = \tan^{-1}\frac{4}{3} = 53.13^\circ$$

$$\therefore c = 5\angle 53.13^\circ$$

Polar to Rectangular:

$$x = z\cos\theta$$

$$Y = z\sin\theta$$

Ex-14.16:

$$C = 10\angle 45^\circ$$

where,

$$z = 10$$

$$\theta = 45^\circ$$

$$x = 10\cos 45^\circ = 7.07$$

$$Y = 10\sin 43^\circ = 7.07$$

$$C = 7.70 + j7.07$$

Chapter - 16

Resistor :

$$R = \frac{V_m}{I_m}$$

$\therefore$ Impedence, $Z_R = R\angle 0^\circ$

Ex 15.1:

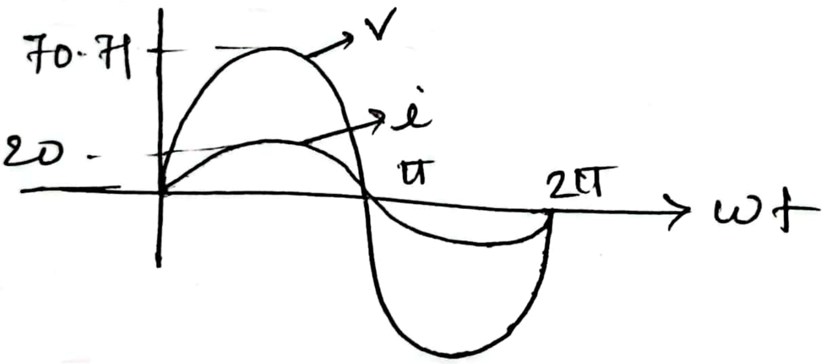
$$v = 100\sin\omega t$$

Phasor form,

$$V = 70.71\angle 0^\circ$$

$$\therefore I = \frac{V}{Z_R} = \frac{70.71\angle 0^\circ}{5\angle 0^\circ} = 14.142\angle 0^\circ$$

$$i = 20\sin\omega t$$



15.2:

$$i = 4\sin(\omega t + 30^\circ)$$

Phasor form,

$$I = 2.82\angle 30^\circ$$

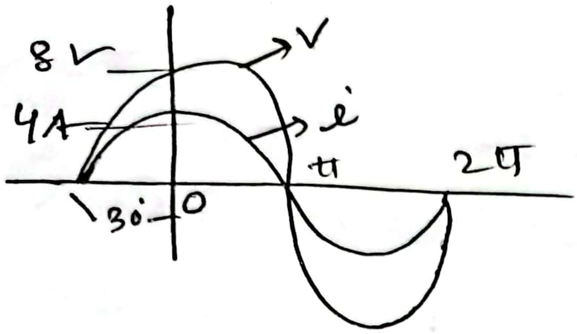
$$V = I\cancel{R}Z_R$$

$$= (I\angle\theta)\cancel{\times}(R\angle 0^\circ)$$

$$= (2.82\angle 30^\circ)(2\angle 0^\circ)$$

$$= 8.65\angle 30^\circ$$

$\therefore v = 8\sin 30^\circ(\omega t + 30^\circ)$



Inductor: $Z_L = X_L \angle 90^\circ$

15.3 $X_L = 3\,\Omega$

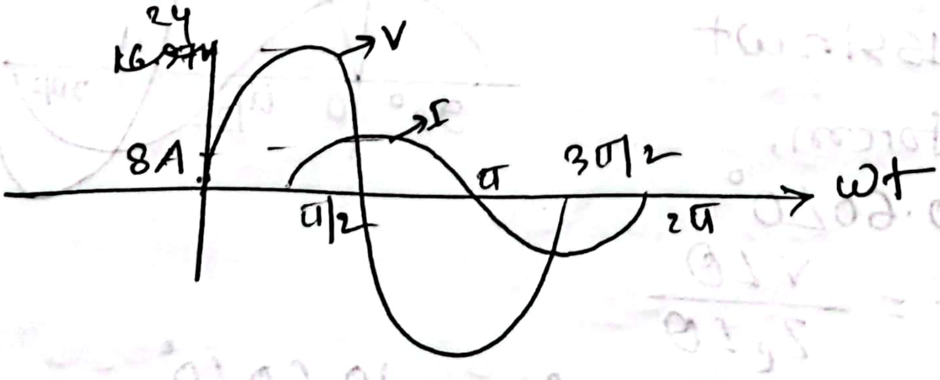
$v = 24\sin\omega t$

phasor form,

$v = 16.97\angle 0^\circ$

$I = \frac{v}{Z_L} = \frac{V\angle\theta}{\cancel{Z}_L\angle 90^\circ} = \frac{16.97\angle 0^\circ}{3\angle 90^\circ} = 5.67\angle -90^\circ$

$\therefore I = 8\sin(\omega t - 90^\circ)$



15.4: $i = 5\sin(\omega t + 30^\circ)$

Phasor form,

$$I = 3.53 \angle 30^\circ$$

$$V = I Z_L$$

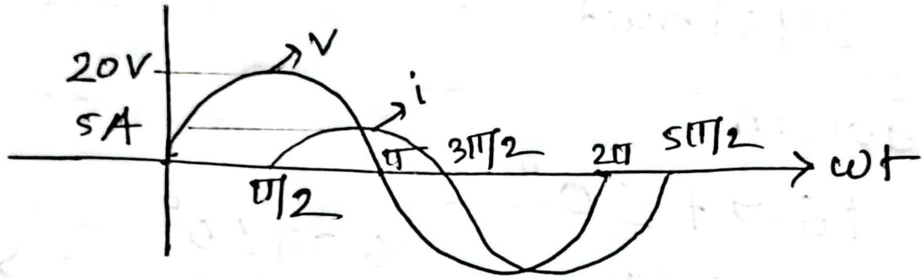
$$= (I\angle\theta)(X_L\angle\theta)$$

$$= (3.53\angle 30^\circ)(4\angle 90^\circ)$$

$$= 14.12 \angle 120^\circ$$

$$\therefore v = (\sqrt{2}\times 14.12)\sin(\omega t + 120^\circ)$$

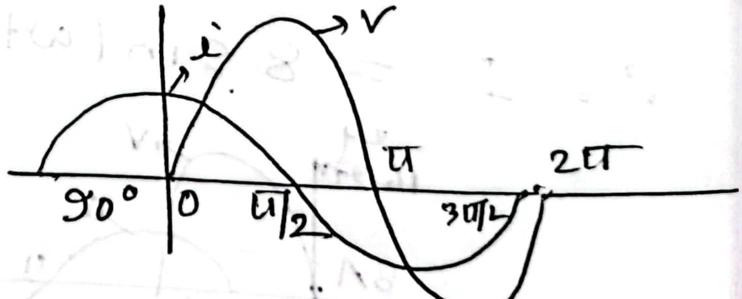
$$= 20\sin(\omega t + 120^\circ)$$



Capacitor:

$$Z_C = X_C\angle -90^\circ$$

15.5 $v = 15\sin\omega t$



Phasor form,

$$V = 10.60\angle 0^\circ$$

$$I = \frac{V}{Z_C} = \frac{V\angle\theta}{Z_C\angle\theta}$$

$$= \frac{10.60\angle 0^\circ}{X_C\angle -90^\circ} = \frac{10.60\angle 0^\circ}{2\angle -90^\circ} = 5.3\angle 90^\circ$$

$$\therefore i = (5.3\times\sqrt{2})\sin(\omega t + 90^\circ)$$

$$= 7.5\sin(\omega t + 90^\circ)$$

15.6 $i = 6\sin(\omega t - 60^\circ)$

Phasor form, $I = 4.24\angle -60^\circ$

$V = I Z_C$

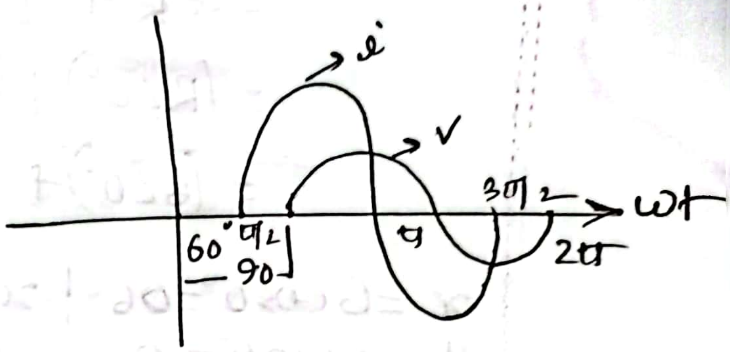
$= (I\angle\theta)(X_C\angle -90^\circ)$

$= (4.24\angle -60^\circ)(0.5\angle -90^\circ)$

$= 2.12\angle -150^\circ$

$\therefore v = (2.12\times\sqrt{2})\sin(\omega t - 150^\circ)$

$= 3\sin(\omega t - 150^\circ)$

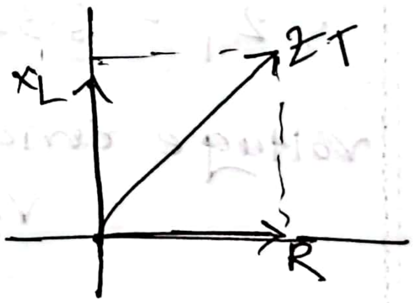


Series configuration:

$Z_T = Z_1 + Z_2 + Z_3 + \cdots + Z_n$

15.7 $R = 4\Omega$

$X_L = 8\Omega$



$Z_T = Z_R + Z_L$

$= R\angle 0^\circ + X_L\angle 90^\circ$

$= 4\angle 0^\circ + 8\angle 90^\circ$

$= \cancel{12\angle 90}$

$= 4\Omega + 8j\Omega$

$c = x + jy$

$x = Z\cos\theta = 4,0$

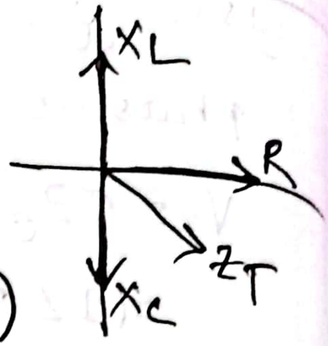
$y = Z\sin\theta = 0,8$

$Z = \sqrt{(4)^2 + (8)^2} = 8.94$

$\theta = \tan^{-1}\frac{8}{4} = 63.43$

$\therefore Z = 8.94\angle 63.43^\circ$

15.8 $Z_T = Z_1 + Z_2 + Z_3$



$$= Z_R + Z_L + Z_C$$
$$= (R\angle 0^\circ) + (X_L\angle 90^\circ) + (X_C\angle -90^\circ)$$
$$= (6\angle 0^\circ) + (10\angle 90^\circ) + (12\angle -90^\circ)$$

$x = 6\cos 0^\circ = 06$	$x = 10\cos 90^\circ = 0$	$x = 12\cos(-90^\circ) = 0$
$y = 6\sin 0^\circ = 0$	$y = 10\sin 90^\circ = 10$	$y = 12\sin(-90^\circ) = -12$

$$\therefore Z_T = 6 + 10j + (-12j)$$
$$= 6 - 2j$$

$$Z = \sqrt{(6)^2 + (2)^2} = \sqrt{36+4} = 6.32$$
$$\theta = \tan^{-1}\left(\frac{-2}{6}\right) = 180^\circ - \underline{18.43} = 161.56^\circ$$

$$\therefore Z_T = 6.32\angle -18.43^\circ$$

voltage devider rule:
$$V_x = \frac{Z_x E}{Z_T}$$

15.9
$$V_R = \frac{Z_R E}{Z_T}$$
$$= \frac{(R\angle 0^\circ)(100V\angle 0^\circ)}{Z_1 + Z_2}$$
$$= \frac{(3\angle 0^\circ)(100\angle 0^\circ)}{3\angle 0^\circ + 4\angle -90^\circ} = \frac{300\angle 0^\circ}{3 - 4j}$$
$$= \frac{300\angle 0^\circ}{5\angle -53.13^\circ}$$
$$= 60V\angle 53.13^\circ$$

$$v_C = \frac{Z_C E}{Z_T}$$

$$= \frac{(4\angle -90^\circ)(100V\angle 0^\circ)}{5\angle -53.13^\circ}$$

$$= \frac{400\angle -90^\circ}{5\angle -53.13^\circ}$$

$$= 80\angle -36.87^\circ$$

15.10

$$v_R = \frac{Z_R E}{Z_T}$$

$$= \frac{(6\angle 0^\circ)(50\angle 30^\circ)}{6\angle 0^\circ + 9\angle 90^\circ + 17\angle 90^\circ}$$

$$= \frac{300\angle 30^\circ}{6 + 9j - 17j}$$

$$= \frac{300\angle 30^\circ}{6 - 8j}$$

$$= \frac{300\angle 30^\circ}{10\angle -53.13^\circ}$$

$$= 30\angle 83.13^\circ$$

$$v_C = \frac{Z_C E}{Z_T} = \frac{(4\angle -90^\circ)(\overset{50}{\cancel{100}}\angle 30^\circ)}{10\angle -53.13^\circ}$$

$$= \frac{200\angle -60^\circ}{10\angle -53.13^\circ} = \overset{20}{\cancel{40}}\angle -36.87$$

$$V_C = \frac{Z_C E}{Z_T}$$

$$= \frac{(17\angle -90^\circ)(50\angle 30^\circ)}{10\angle -53.13^\circ}$$

$$= \frac{850\angle -60^\circ}{10\angle -53.130}$$

$$= 85\angle -6.87^\circ$$

$$V_L = \frac{Z_L E}{Z_T}$$

$$= \frac{(9\angle 90^\circ)(50\angle 30^\circ)}{10\angle -53.13^\circ}$$

$$= \frac{450\angle 120^\circ}{10\angle -53.13^\circ}$$

$$= 45\angle 173.13^\circ$$

$9j - 17j$

$-8j$

8

$$V_1 = \frac{(Z_L + Z_C)E}{Z_T}$$

$$= \frac{(9\angle 90^\circ + 17\angle -90^\circ)(50\angle 30^\circ)}{10\angle -53.13^\circ}$$

$=$

Current divider rule:

$$Z_T = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$= \frac{Z_2 + Z_1}{Z_1 Z_2}$$

$$I_x = \frac{Z_T}{Z_1} I_T$$

$$= \frac{(Z_2 + Z_1)}{Z_1 Z_2 \times Z_1} I_T$$

$$= \frac{\cancel{Z_1} Z_2 I_T}{(Z_1 + Z_2)\cancel{Z_1}}$$

$$\therefore I_1 = \frac{Z_2 I_T}{Z_1 + Z_2}, \quad I_2 = \frac{Z_1 I_T}{Z_1 + Z_2}$$

15.16

$$Z_T = \frac{Z_R \times Z_L}{Z_R + Z_L}$$

$$= \frac{(3\angle 0^\circ)(4\angle 90^\circ)}{3\angle 0^\circ + 4\angle 90^\circ}$$

$$= \frac{12\angle 90^\circ}{3 + 4j}$$

$$= \frac{12\angle 90^\circ}{5\angle 53.13^\circ}$$

$$= 2.4\angle 36.87^\circ$$

$$I_R = \frac{Z_L \times I}{Z_T}$$

$$= \frac{(4\angle 90^\circ)(20\angle 0^\circ)}{2.4\angle 36.87^\circ}$$

$$= \frac{80\angle 90^\circ}{2.4\angle 36.87^\circ}$$

$$= 33.33\angle 53.13^\circ$$

$$I_R = \frac{(2.4\angle 36.87^\circ)(20\angle 0^\circ)}{13\angle 0^\circ}$$

$$= \frac{48\angle 36.87^\circ}{3\angle 0^\circ}$$

$$= 16\angle 36.87^\circ$$

$$I_L = \frac{(2.4\angle 36.87^\circ)(20\angle 0^\circ)}{4\angle 90^\circ}$$

$$= \frac{48\angle 36.87}{4\angle 90^\circ}$$

$$= 12\angle -53.13^\circ$$

15.17

$$Z_S = Z_1 + Z_2$$

$$= (1\angle 0^\circ) + (8\angle 90^\circ)$$

$$= 1 + 8j$$

$$= 8.06\angle 82.87^\circ$$

$Z\cos 82.87^\circ = 1$

$Z\sin = 8$

$$Z_T = \frac{(8.06\angle 82.87^\circ)(2\angle -90^\circ)}{8.06\angle 82.87^\circ + 2\angle -90^\circ}$$

$$= \frac{16.12\angle -7.13^\circ}{1 + 8j - 2j} = \frac{16.12\angle -7.13}{1 + 6j}$$

$$= \frac{16.12\angle -7.13}{}$$

$$I_{Rt} = \frac{(2.65\angle -87.63^\circ)\times(5\angle 30^\circ)}{8.06\angle 82.87^\circ}$$

$$= \frac{13.25\angle -57.63^\circ}{8.06\angle 82.87}$$

$$= 1.64\angle -140.5^\circ$$

$$I_c = \frac{(2.65\angle -87.63^\circ)\times(5\angle 30^\circ)}{2\angle -90^\circ}$$

$$= \frac{13.25\angle -57.63^\circ}{2\angle -90^\circ}$$

$$= 6.625\angle 32.37^\circ$$