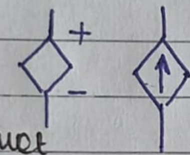
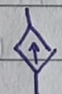
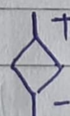
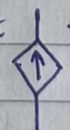
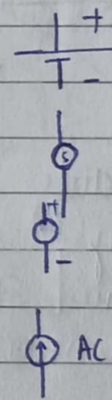
20/09/2022

Electrical Sources

- voltage Source
- current source
  - Dependent
  - Independent
    - Dependent 
      vol cur.
      - voltage dependent voltage source  $V = KI_1$
      - voltage dependent current source  $I = KV_1$
      - current dependent voltage source  $V = KI_1$
      - current dependent current source.  $I = KV_1$
    - voltage
    - current 

Parameters | Elements

1) Resistance : $(R) = \frac{\rho l}{A}$

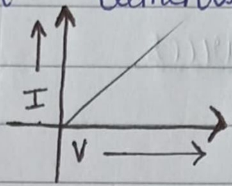
2) Inductance (L) : Inductor stores energy in the form of magnetic energy field

3) Capacitance (C) : Energy will be stored in the form of charge / electrical field.

* Properties

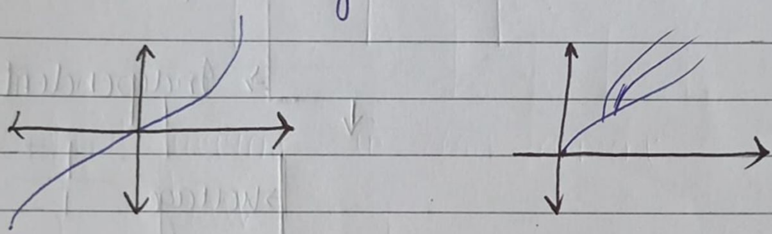
1) Linear → The elements who follow the Ohms law are known as linear elements.

V → voltage i/p
I → current o/p



VI characterstic Representing st. line then it is linear eg:- Resistance

2) Non-linear → The elements who don't follow the Ohm's law
* Elements having curvilinear characterstics of VI.



3) Active Elements : Those elements having their own electrical energy

Passive Elements: Elements that do not have their own energy & works on behalf of the source

Distributed Parameters
Those parameter which are distributed across length area
eg :- Rheostat

Lumped Parameters
Those parameters that are focused or concentrated on a specific point
Eg:- Resistance / Capacitance

- open circuit → there will be no current
  → voltage may be there

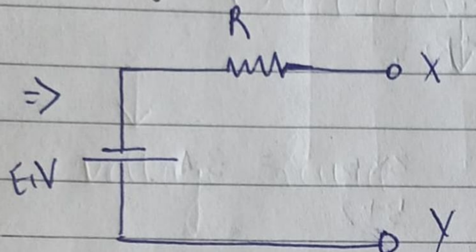
- Short circuit → voltage is 0
  → Infinite Current

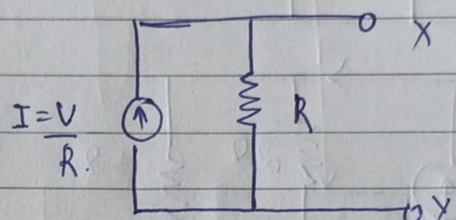
- Unilateral Elements
Elements that work in a specific direction eg. diode

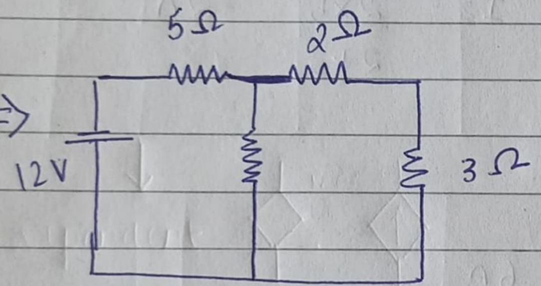
- Bilateral Elements - Elements that work in a both direction
eg. Resistance, inductor

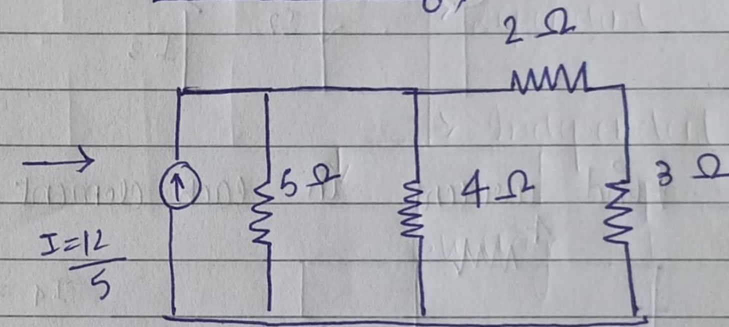
⟹ In a circuit (Active)

- Voltage Source to Current Source Conversion

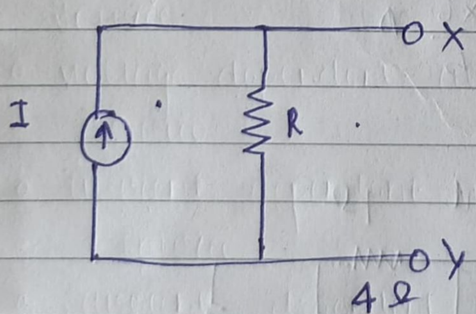


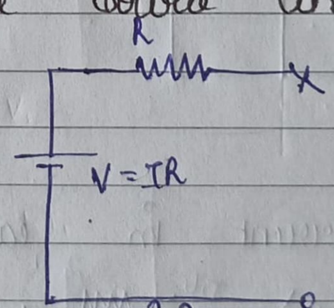


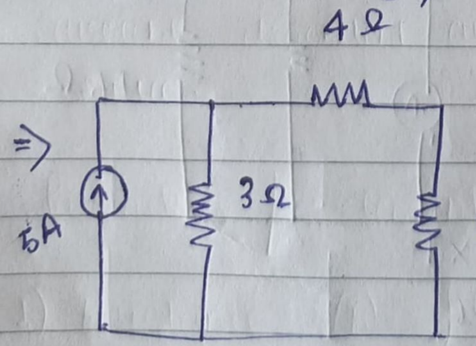


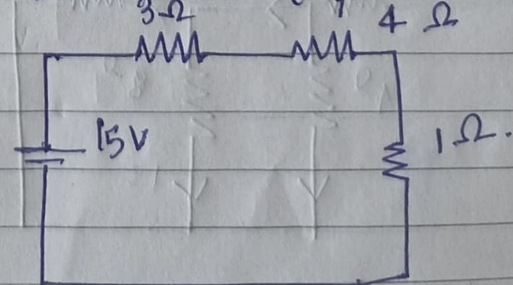


- Current Source to Voltage Source Conversion



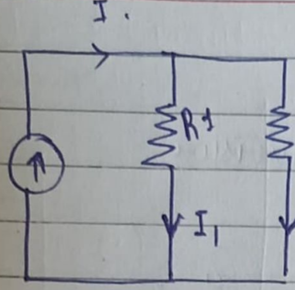






* Current division Rule :-

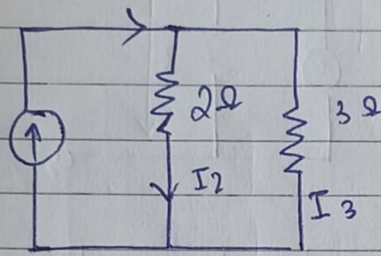
$I =$



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

$$I_2 = \frac{I R_1}{R_1 + R_2}.$$

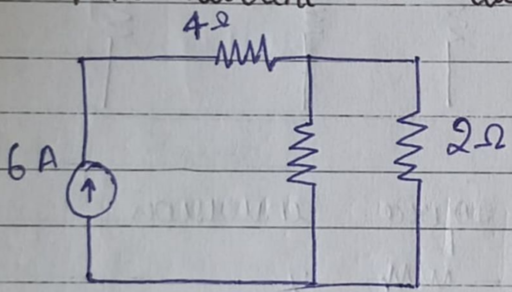
eg:- (i)



$$I_2 = \frac{3 \times 5}{3+2} = 3A$$

$$I_3 = \frac{2 \times 5}{2+3} = 2A$$

(ii) Find current in each element

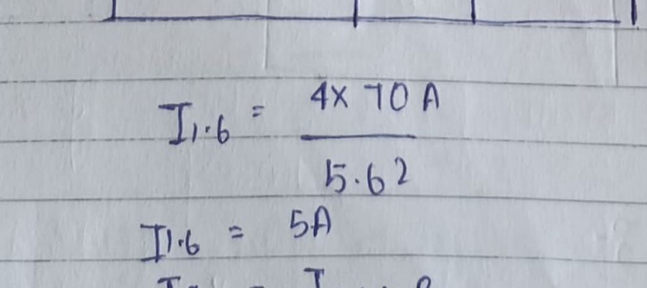


$$I_4 = 6A$$

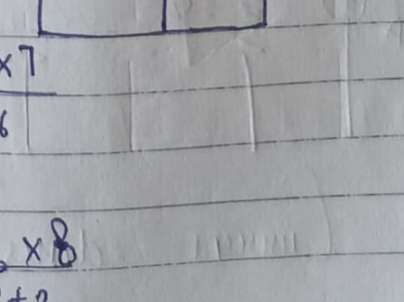
$$I_3 = \frac{2 \times 6}{5} A$$

$$I_2 = \frac{3 \times 6}{5} A$$

(iii) Find Current in each element



$I_1 = 4A$



$$I_{1.6} = \frac{4 \times 70 A}{5.62}$$

$$I_{1.6} = 5A$$

$$I_8 = \frac{I_{1.6} \times 2}{8+2}$$

$$I_8 \Rightarrow \frac{5 \times 2}{10} = 1A$$

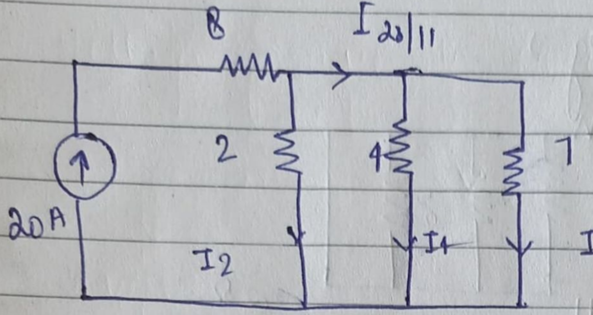
$$I_4 = \frac{1.6 \times 7}{5.6}$$

$$I_4 = 2A$$

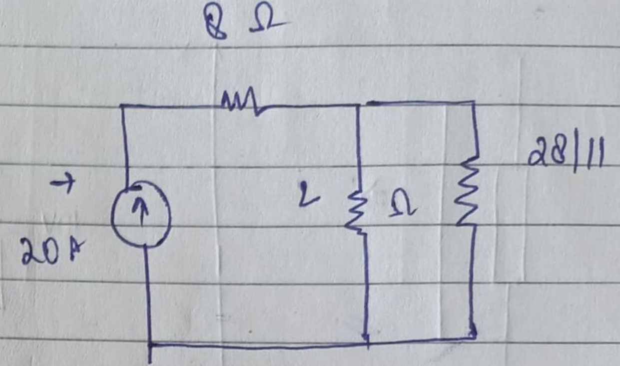
$$I_2 = \frac{I_{1.6} \times 8}{8+2}$$

$$= \frac{5 \times 8}{1.62} = 4A$$

Q) find current in each element.



→



$I_{28/11} = \frac{2 \times 20}{(22+28)/11}$

$I_0 = 20A$

$= \frac{40 \times 11}{50}$

$I_4 = \frac{I_{28/11} \times 7}{11} = \frac{4 \times 11 \times 7}{5 \times 11}$

$= \frac{28A}{5}$

$I_7 = \frac{I_{28/11} \times 4}{11}$

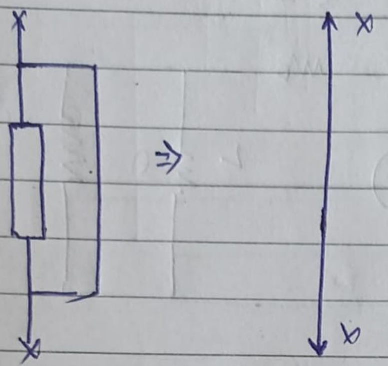
$\Rightarrow \frac{4 \times 11 \times 4}{5 \times 11}$

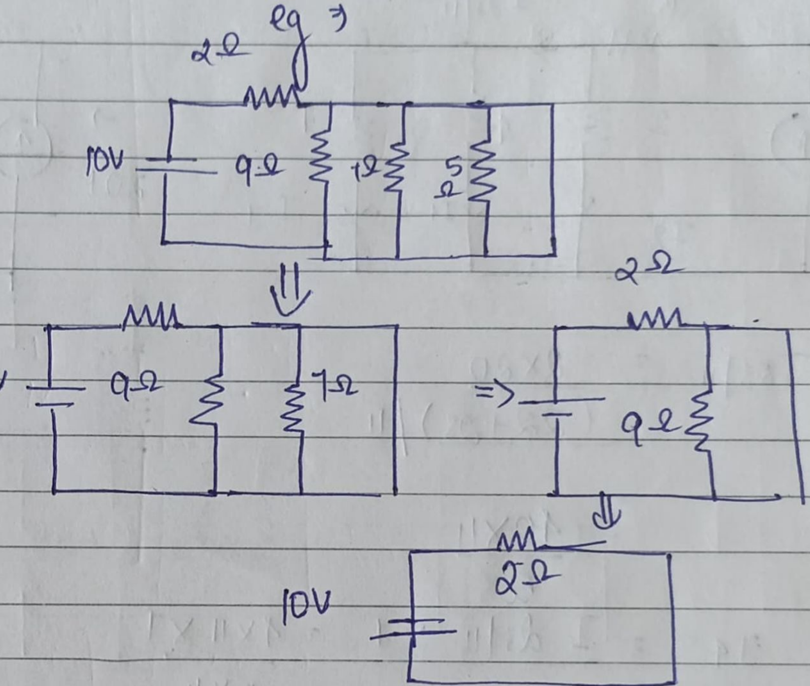
$\Rightarrow \frac{16}{5} A$

$I_2 = \frac{\frac{28 \times 20}{11}}{(22+28)/11}$

$\Rightarrow \frac{28 \times 20}{50} = I_2 \quad \frac{56}{5} A$

* Short Circuit Condition



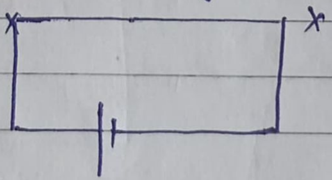


Ohm's Law :-

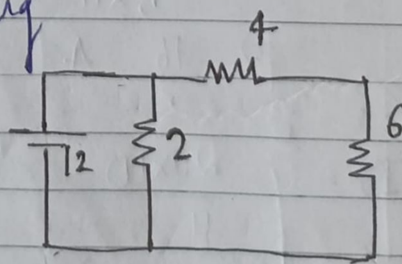
If any current carrying conductor has its physical condition constant then the current will be proportional to voltage
I

$I \propto V$

$V = IR$



Mesh :- No. of closed path having no other close path within it



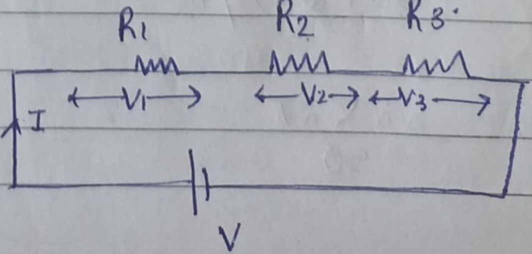
Loop Total No of closed path present

Kirchoff's Law
KVL

$V = V_1 + V_2 + V_3$

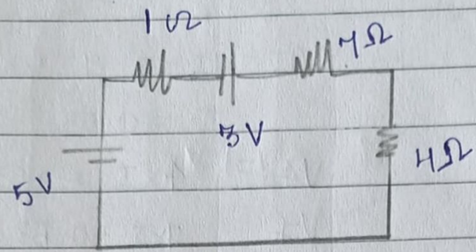
$V = V_1 + V_2 + V_3 = 0$

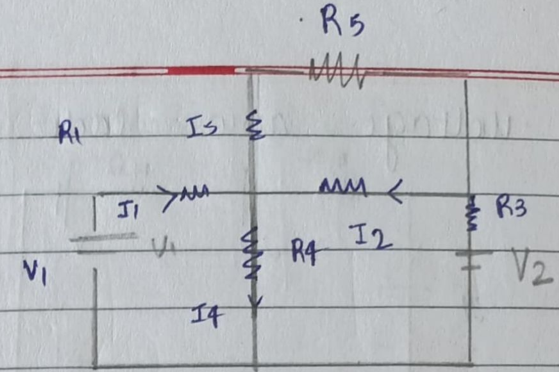
$\Sigma V = 0$



KCL

Node / Junction

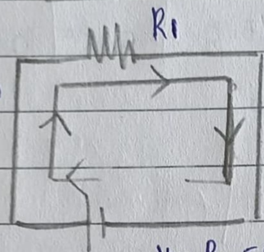


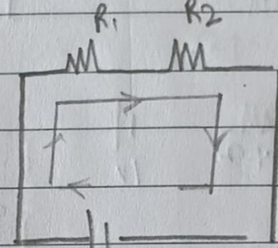


$I_1 + I_2 = I_5 + I_4$

$I_1 + I_2 - I_5 - I_4 = 0$

$\Sigma I = 0$





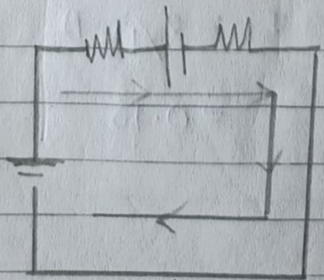
$V - R_1 = 0$

$V - IR_1 - IR_2 = 0$

- For battery conditions if we are moving from -ve terminal to the terminal it will be taken as + sign. If we are moving from +ve to -ve terminal it will be taken as -ve sign.

- In a closed path if we assume specific current direction & we are moving in the same direction voltage drops will be taken as -ve sign. If we are moving to the specified direction of the current it will be taken as +ve sign.

Find the voltage across each element.



$+4 - 2I - 2 - I \times 1 = 0$

$2 = 3I$

$I = .66$

$I = \frac{2}{3}$

$V_2 = 2 \times I$

$= 2 \times .66$

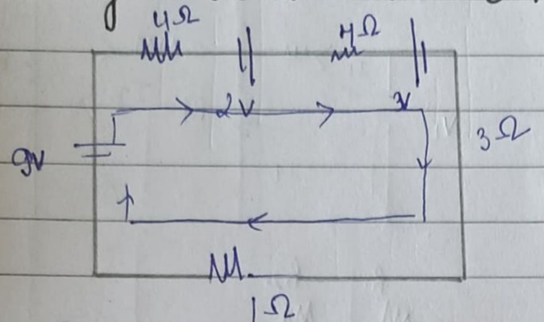
$\Rightarrow$

$V_2 = \frac{2}{3} \times 2 = \frac{4}{3} V = 1.33V$

$V_1 = \frac{2}{3} V = 0.66 V$

Find voltage across each element

(1)



$+9I - 4I + 2 - 4I - 3 - 3I - 1I = 0$

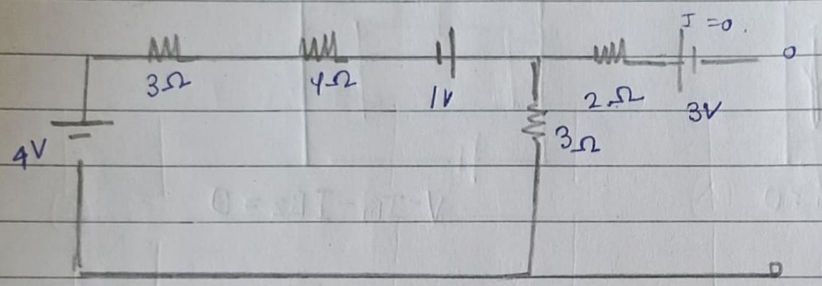
$I = 0.53$

$V4 = 4 \times I = 0.53 \times 4 =$

$V7 = 7 \times I = 0.53 \times 7 =$

$V5 = 5 \times I = 0.53 \times 5 =$

2)



$+4 - 3I_1 - 4I_1 + 1 - 3I = 0$

$I_1 = 0.5A$

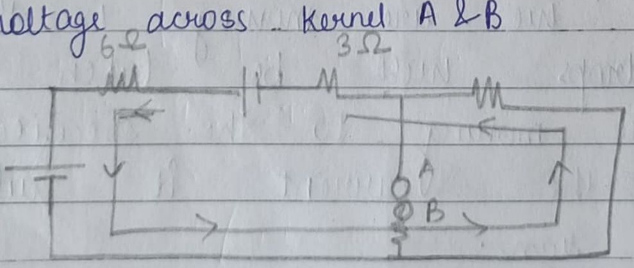
$V_A + 3 - 2 \times 0 - 3I_1 = V_B$

$V_A - V_B = -1.5$

$V_{AB} = -1.5$

3) Find voltage across kernel A & B

(b)



$\Rightarrow -6I_1 - 5 - 2I_1 - 3I_1 = 0$

$-11I_1 = 0$

$7 - 6I_1 - 5 - 2I_1 - 3I_1 = 0$

$\Rightarrow I_1 = .18$

$I_1 = 2/11\ A$

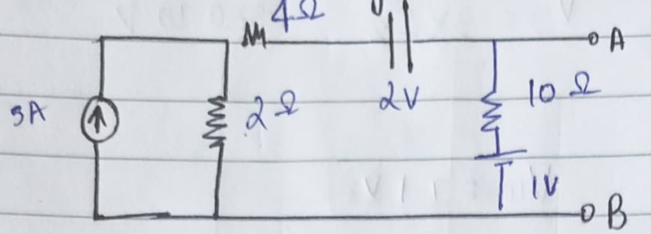
$= 0.18$

$V_A + 2I_1 - 3 \times 0 = V_B$

$V_A - V_B = -.36$

$V_{AB} = .36\ V$

find the Voltage across the terminal A & B



$$10 - 2I - 4I + 2 - 10I - 1 = 0$$

$$11 = 16I$$

$$I = \frac{11}{16} \text{ A} = 0.68 \text{ A}$$

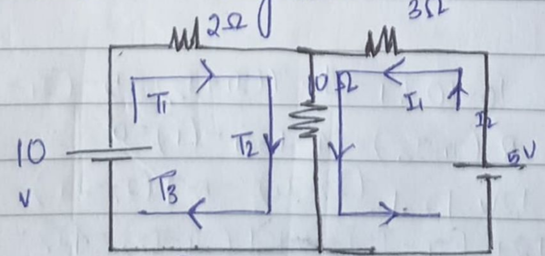
$$V_A = 10I + 1 = V_B$$

$$V_A - V_B = 1 + \frac{110}{16} = \frac{126}{16}$$

$$\boxed{V_{AB} = 7.8 \text{ V}}$$

When we are working with different circuits then there are more current when calculated value comes with -ve sign we will draw the circuit of same sign.

When a element is common to mesh in which mesh we are moving we will take its value higher.



$$10 - 2I_1 - 10(I_2 + I_2) = 0$$

$$5 - 3I_2 - 10(I_1 + I_2) = 0$$

$$5 - 3I_2 = 10 - 2I_1$$

$$2I_1 - 3I_2 = 5$$

$$2I_1 = 5 + 3I_2$$

$$2I_1 = 5 - 3(0.7)$$

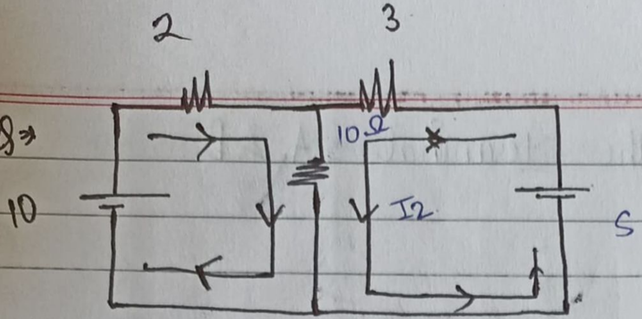
$$I_1 = 1.45 \text{V}$$

$$10\left(\frac{5 + 3I_2 + I_2}{2}\right) = 10 - (5 + 3I_2)$$

$$25 + 15I_2 + 10I_2 = 10 - 5 - 3I_2$$

$$28I_2 = -20 \Rightarrow I_2 = -20/28 = -0.714$$

Q ⇒



$V_2 = 2 \times I_1 \Rightarrow 2 \times 1.41\ V$

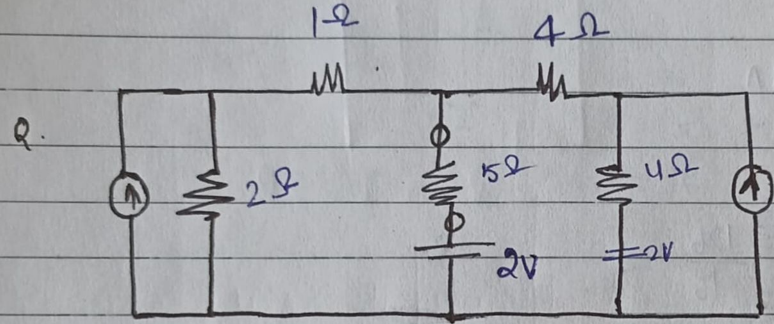
$V_3 = 3 \times I_2 \quad 3 \times 0.70\ V$

$V_{10} = 7.1\ V$

$1.41 \downarrow \quad \uparrow .70$

$V_2 \Rightarrow \quad 2 \times I_1 = 2 \times 1.41 V$

Q.



$6 - 2I_1 - 1I_1 - 5(I_1 + I_2)$

$-2 = 0$

$5(I_1 + I_2) = 4 - 3I_1$

$0 - 4I_2 - 5(I_1 + I_2) - 2 + 8$

$-4I_2 = 0$

$5(I_1 + I_2) = 6 - 8I_2$

$4 - 3I_1 = 6 - 8I_2$

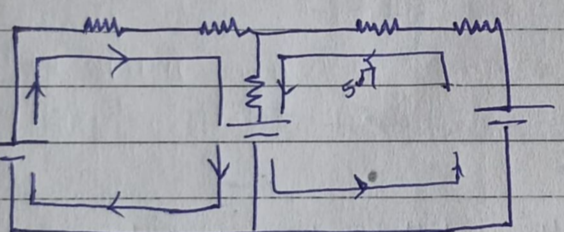
$8I_2 - 2 = 3I_1$

$8 \times 0.35 - 2 = 3I_1$

$2.8 - 2 = 3I_1$

$I_1 = 0.8/3$

0.27



$5\left[\frac{8I_2 - 2}{3} + I_2\right] = 4 - [8I_2 - 2]$

$5(8I_2 - 2 + 3I_2) = 12 - 24I_2 + 6$

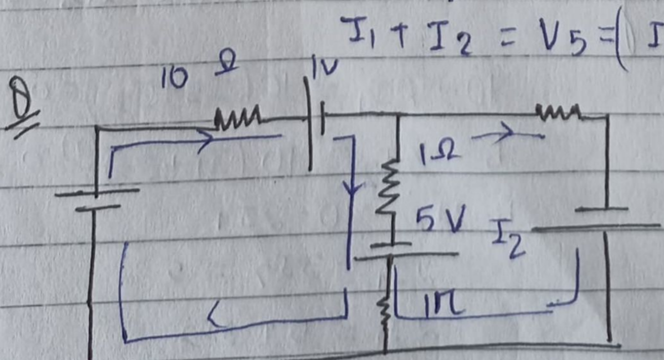
$55I_2 - 10 = 12 - 24I_2 + 6$

$79I_2 = 28$

$I_2 = 28/79 = 0.35$

$I_1 + I_2 = V_5 = (I_1 * I_2) \times 5.$

Q



$10 - 10I_1 - 1 - 7(I_1 + I_2) + 5 - (I_1 - I_2)$

$8(I_1 - I_2) = 14 - 10I_1 - (i) = 0$

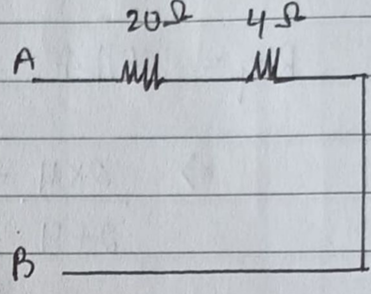
$12V \cdot 12 - 1 \quad (I_2 - I_1) - 5 - 7(I_2 - I_1) - 4I_2$

$12 + (I_1 - I_2) - 5 + 7(I_1 - I_2) - 4I_2 = 0$

$8(I_1 - I_2) = 4I_2 - 7$ —— (ii)

$\boxed{I_1 = 1.476\ A}$

Equivalent Resistance

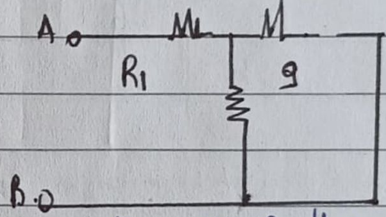


$R_{AB} = R_{eq}$

$R_{eq} = R_1 + R_2$

$= 20 + 4$

$= 24$



$R_2 = R_1 + R_2 \| R_3$.

$R_{eq} = 3 + 4 \| 9$

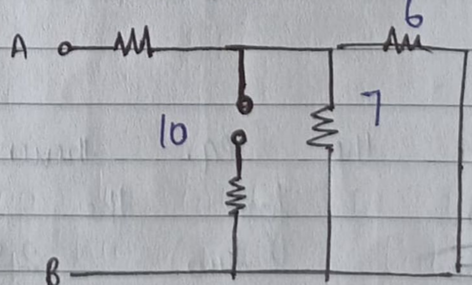
$= 3 + \frac{4 \times 9}{4+9}$

$\Rightarrow \frac{3}{1} + \frac{36}{13}$

$\Rightarrow \frac{39 + 36}{13}$

$= \frac{75}{13}$

$= 5.76$

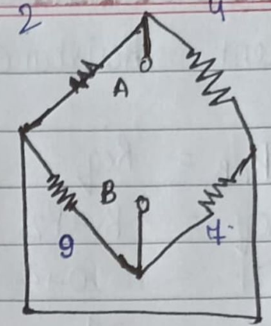


$R_{eq} = 2 + \frac{6 \times 7}{13} = 2 + \frac{42}{13}$

$\Rightarrow 2 + 3.23$

$= 5.23\ \Omega$

Q)



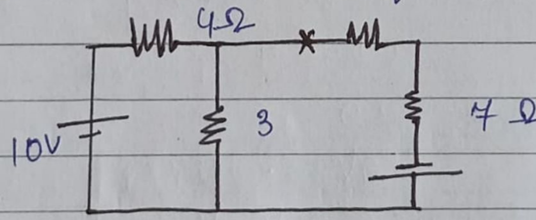
$$R_{eq} = 2 \| 4 + 9 \| 7$$

$$\Rightarrow \frac{2 \times 4}{2+4} + \frac{9 \times 7}{9+7}$$

$$\Rightarrow \frac{8}{6} + \frac{63}{16} \Rightarrow \frac{64 + 189}{48} \Rightarrow \frac{253}{48}$$

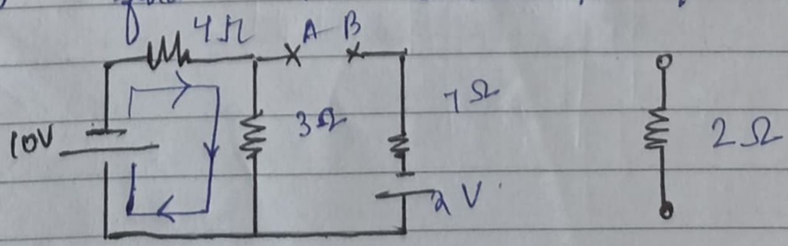
$$= 5.2.$$

⇒ Thevenin's theorem - A complex active linear bilateral ~~single~~ circuit can be represented by a single voltage source connected with equivalent series resistance & load.



Q) Find the eq. thevenin's circuit, thevenin's theorem for the calculation of current in (two) 2Ω resistance

step 1 Remove the element across which we have to find the current / eq. circuit.



step - 2
Calculate the voltage across the open terminals & this voltage ~~which~~ will called thevenins voltage

- $V_{AB} \Rightarrow 10 - 4I - 3I = 0$

$10 = 7I$

$I = 10/7 \simeq 1.4\ A$

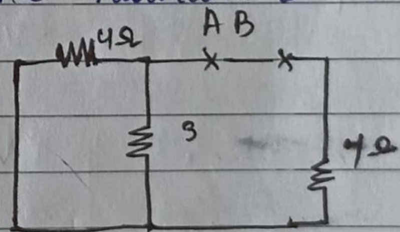
$V_{AB} \Rightarrow 6.2$

$V_{TH} = 6.2$

step . 3

1) Find the eq. resistance of the circuit obtained by step 1 & this eq. resistance will called thevenins eq. resistance are TH.

- short all the voltage circuit (If the internal resistance is given it will be exist.



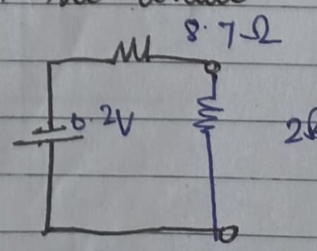
2) open all the current sources.

$R_{TH} = 3 \| 4 + 4$

$R_{TH} = \frac{3 \times 4}{3+4} + 7\ \Omega$

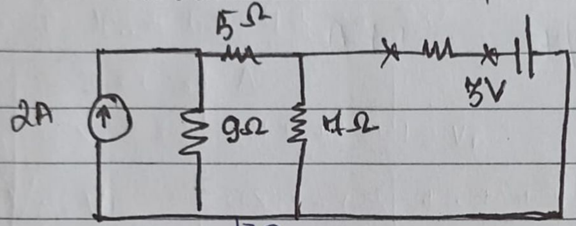
$\Rightarrow 8.7\ \Omega$

Draw the circuit containing V_{TH} & R_{TH} in the circuit. Attach the element in the circuit which was removed in the step this circuit will called Thevenins Eq. circuit

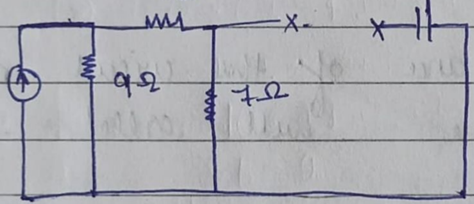


$I_{Th} = \left(\frac{6.2}{8.7+2}\right) A \Rightarrow$

Q) Find the current in 4Ω of resistor in themenins current 4Ω.



step 1 $\Rightarrow$

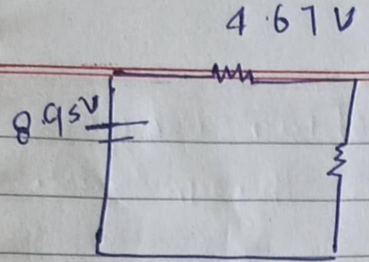


step 2 $\Rightarrow$

$$18 - 9I - 5I - 7I = 0$$
$$18 = 21 I$$
$$I = 0.85$$
$$V_A - 4I - 3 = V_B$$
$$V_A - V_B = 3 + 7I \doteq 3 + 7 \times 0 \times 0.85$$
$$\Rightarrow -3 + 5.95$$
$$\Rightarrow 8.95$$

step 3.

$$R_{TH} = (5+9) \parallel 7$$
$$\Rightarrow 14 \parallel 7$$
$$\Rightarrow \frac{14 \times 7}{14+7} \Rightarrow \frac{98}{21}$$
$$= 4.67$$

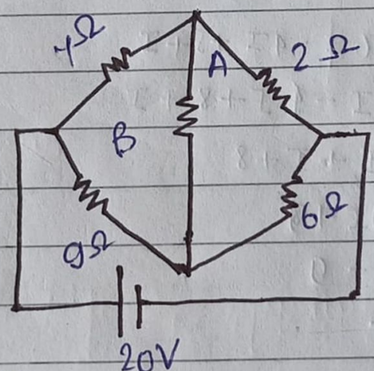


$\Rightarrow I_{TH} = \dfrac{8.95}{(4.67+4)}$

$\Rightarrow \dfrac{8.95}{8.67} =$

$I_{TH} = 1.03\ A$

Q.1) find the current in 1Ω resistor using thevenins theorem.



$V_A = 2I_1 + 6I_2 = V_B$

$V_A - V_B = 2I_1 - 6I_2$

$V_{TH} = 2\times2.2 - 6\times1.33$

$V_{TH} \Rightarrow 3.5\ V$

$I_1 = \dfrac{20}{7+2} = \dfrac{20}{9} = 2.2$

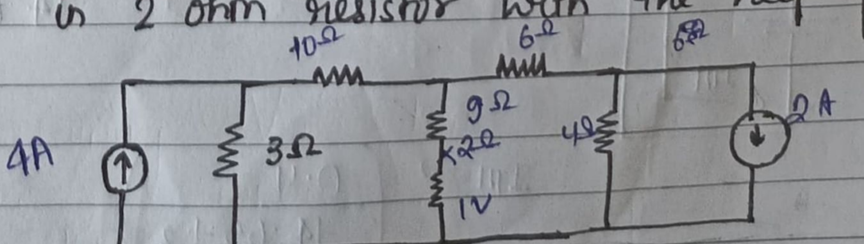
$R_{TH} = 1\|2 + 9\|6$

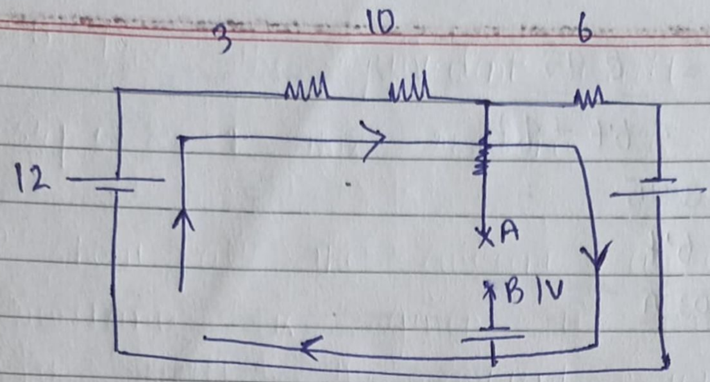
$= \dfrac{1\times2}{1+2} + \dfrac{9\times6}{9+6}$

$\Rightarrow 4.26\ \Omega$.

$I_2 = \dfrac{20}{9+6} = \dfrac{20}{15} \Rightarrow \dfrac{4}{3} = 1.33$

Q) find the current in 2 ohm resistor with the help of thevenim theorem





$12 - 3I - 10z - 6I - 4I - 8 = 0$

$I = 0.86\ A$

$V_A - 9 \times 0 - 6I - 4I + 8 + 1 = V_B$

$V_A - V_B = -9 \times 0 - 6I - 4I + 8 + I$

$\Rightarrow 0 - 6I - 4I + 8 + I$

$\Rightarrow -10I + I + 8$

$V_A - V_B \Rightarrow -10I + 9$

$\Rightarrow 8.6 - 9$

$V_A - V_B \Rightarrow 0.4$

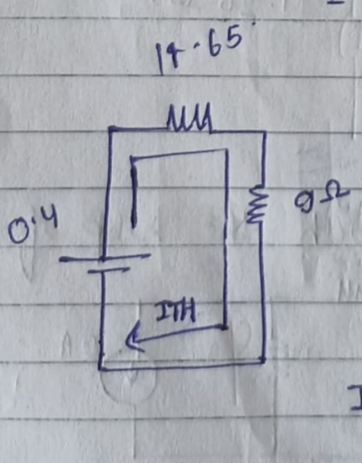
$V_{TH} = 4V$

$R_{TH} = 9 + 13 \| 10$

$= 9 + \frac{13 \times 10}{13 + 10} \Rightarrow \frac{9}{1} + \frac{130}{23}$

$\Rightarrow \frac{207 + 130}{23} \Rightarrow \frac{337}{23}$

$= 14.65$

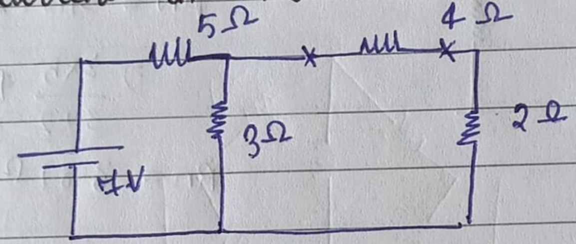


$I_{TH} \Rightarrow \left(\frac{0.4}{14.65 + 2}\right) \Rightarrow \frac{0.4}{16.65}$

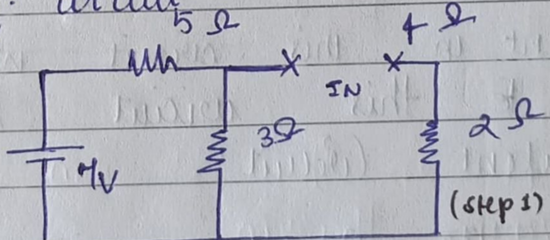
$\Rightarrow 0.02$

Norton's Theorem :- A complex active linear bilateral circuit can be represented by a single voltage source connected with equivalent series resistance & load.

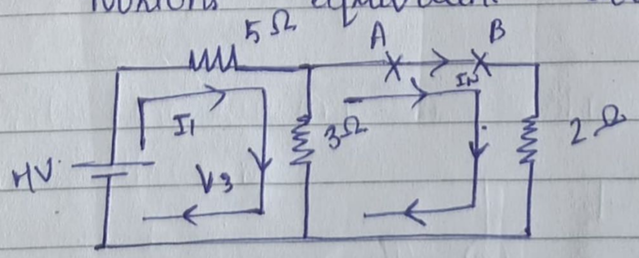
Find the current in 4 Ω resistor in circuit using Norton's theorem



Step 1
Remove the element across which we have to find the current across eq. circuit



Step 2
↓
Connect the / short the open terminals after step 1. & find the current in this branch it may called the Norton's equivalent current.



$+7 - 5I_1 - 3(I_1 - I_2) = 0$ —— ① $\Rightarrow 7 - 5I_1 - 3I_1 - 3I_2 = 0$

$-2I_2 - 3(I_2 - I_1) = 0$ —— ② $\Rightarrow 2I_2 - 3I_2 - 3I_1 = 0$

$7 - 5I_1 - 3I_1 - 3I_1$ $\qquad 2I_2 - 3I_2 - 3I_1 = 0$

$-I_2 - 3I_1 = 0$

$7 - 8I_1 - 3I_2 = 0$ $\qquad 3I_1 = I_2$

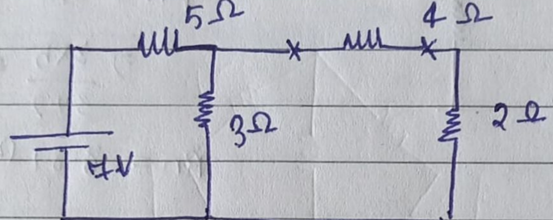
$7 - 8I_1 - 3 \times 3I_1 = 0$

$9I_1 = 0$

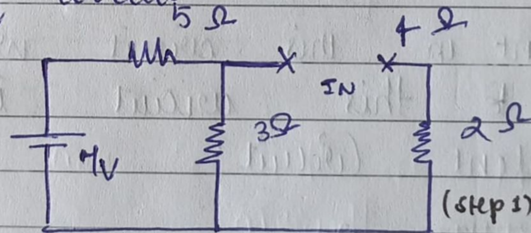
0674

Norton's Theorem :- A complex active linear bilateral circuit can be represented by a single voltage source connected with equivalent series resistance & load.

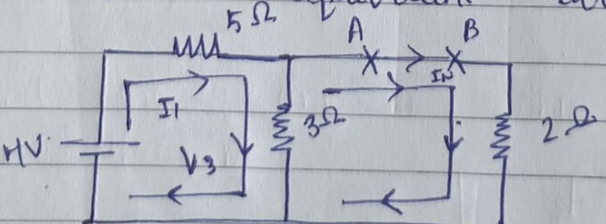
Find the current in $4\,\Omega$ resistor in circuit using Norton's theorem



Step 1
Remove the element across which we have to find the current acro eq. circuit



Step 2
↓
Connect the / short the open terminals after step 1. & find the current in this branch it may called the Norton's equivalent current.



$+4 - 5I_1 - 3(I_1 - I_2) = 0$ —— ① $\Rightarrow 4 - 5I_1 - 3I_1 - 3I_2 = 0$

$-2I_2 - 3(I_2 - I_1) = 0$ —— ② $\Rightarrow 2I_2 - 3I_2 - 3I_1 = 0$

$4 - 5I_1 - 3I_1 - 3I_1$

$2I_2 - 3I_2 - 3I_1 = 0$

$-I_2 - 3I_1 = 0$

$3I_1 = I_2$

$4 - 8I_1 - 3I_2 = 0$

$4 - 8I_1 - 3 \times 3I_1 = 0$

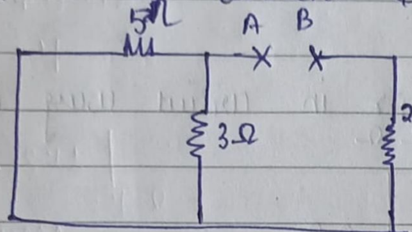
$4 - 8I_1 - 9I_1 = 0$

0674

Q) Find the equivalent circuit (resistance) obtained by step 1 & ~~E~~ this resistance is called Norton's theorem (R_n).

=) Short all the current circuit (If the internal resistance is given it will be exist.

Open all the current sources.



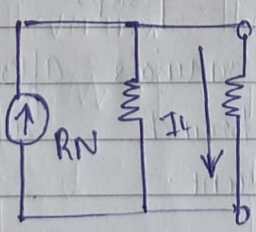
$R_N = 3 \| 5 + 2$

$\Rightarrow \frac{3 \times 5}{3+2} + \frac{2}{1} \Rightarrow \frac{15}{5} + \frac{2}{1}$

$R_n = 3.87 \Omega$

Q) Draw the current containing circuit I_N & R_N Parallel

Attach the element in this circuit which was removed in step 1, & this circuit is called Norton's Equivalent Circuit.



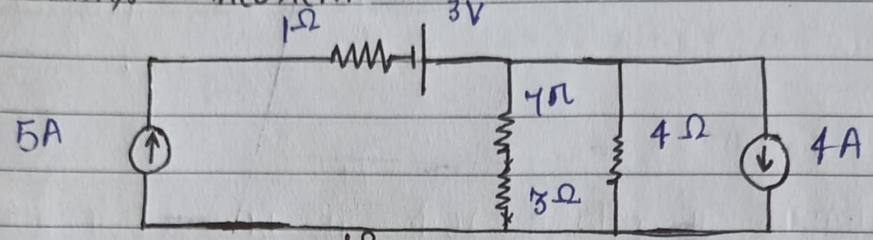
$\frac{I_N R_N}{R_N + R_L} = I_L$

$I_L \Rightarrow \frac{0.67 \times 3.87}{3.87 + 4}$

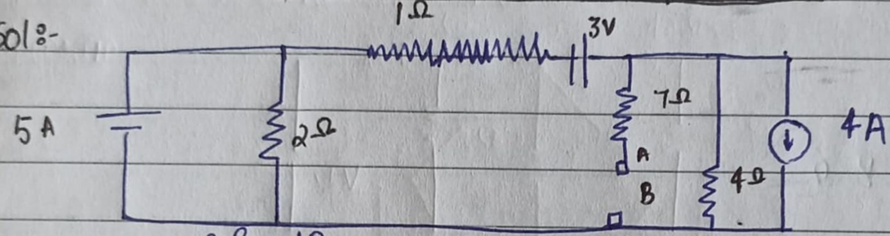
$\Rightarrow 0.32$.

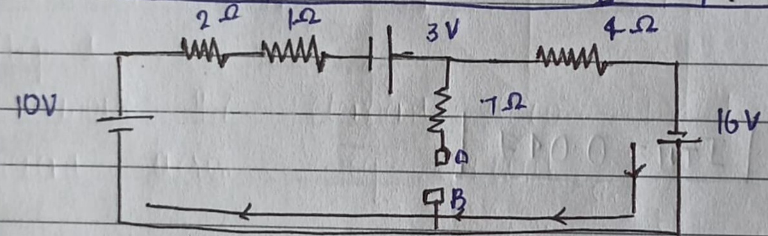
☆ Numericals

1) Find the current in 3Ω resister with the help of Thevenims Theorem



Sol:-





$16 - 4I + 10 - 2I - 1I + 3 = 0$

$29 - 7I = 0$

$I = \frac{29}{7}$

$I = 4.14$

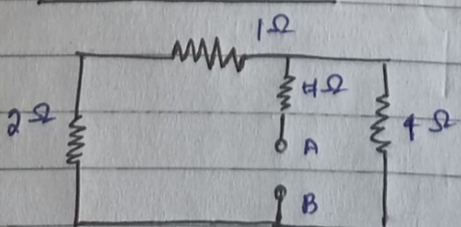
$V_A - 7\times 0 + 16 - 4I = V_B$

$V_A - V_B = -16 + 4I$

$V_A - V_B = -16 + 4\times 4.14$

$V_A - V_B = -0.56$

$\boxed{V_{TH} = 0.56}$

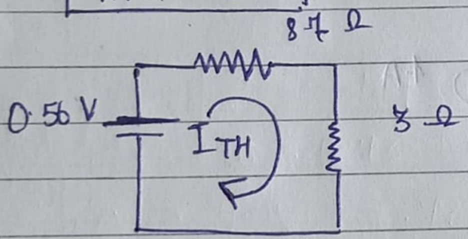


$R_{TH} = 7 + 3||4$

$R_{TH} = 7 + \frac{3 \times 4}{3+4}$

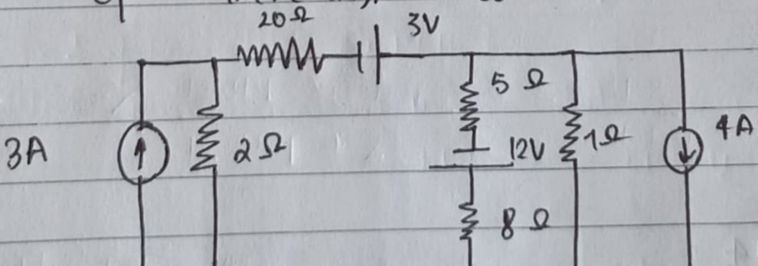
$R_{TH} = \frac{49+12}{7}$

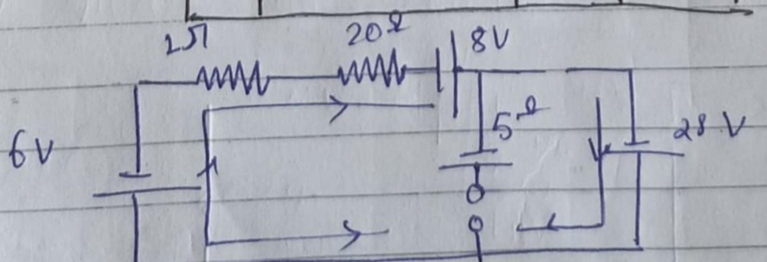
$\boxed{R_{TH} = 8.71}$



$I_{TH} = \left(\frac{0.56}{8.7+3}\right) = \boxed{I_{TH} = 0.047}$

2) Find the current in the 80 ohm resistor with the help of Thevenims theorem





$28 + 6 - 2I - 20I + 3 - 7I = 0$

$37 = 29I$

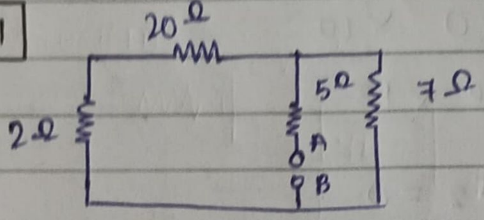
$I = \frac{37}{29} = 1.27$

$V_A + 12 - 7 \times I + 28 = V_B$

$V_A - V_B = -28 - 12 + 7 \times I$

$V_A - V_B = -40 + 7 \times 1.27$

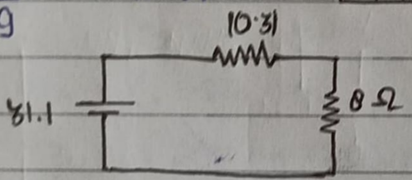
$\boxed{V_{TH} = 81.11}$



$= 5 + 22 \| 7$

$= 5 + \frac{22 \times 7}{22 + 7} \Rightarrow 5 + \frac{154}{29} \Rightarrow \frac{145 + 154}{29}$

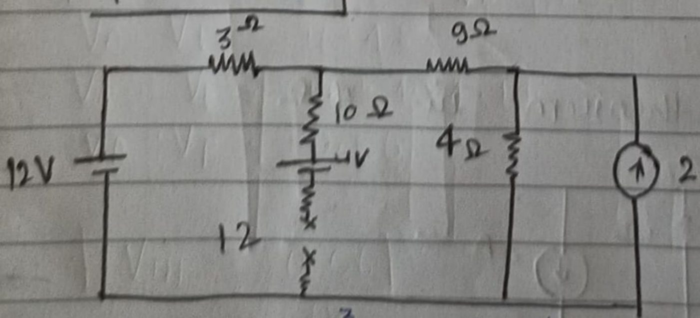
$= \frac{299}{29} = 10.31$ $\boxed{R_{TH} = 10.31}$



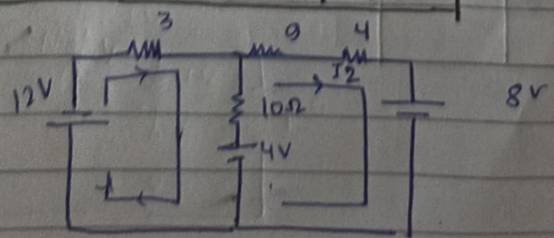
$I_{TH} = \frac{V_{TH}}{R_{TH} + R}$

$I_{TH} = \frac{31.1}{10.31 + 8}$

$\boxed{I_{TH} = 1.69}$



Find the current in 12 Ω resistor by Nortons theorem.



$12 - 3I_1 - 10(I_1 - I_2) - 4 = 0$ —— ①

$-9I_2 - 4I_2 - 8 + 4 - 10(I_2 - I_1) = 0$ — ②

$8 - 13I_1 + 10I_2 = 0 \quad \times 10$

$-4 + 10I_1 - 23I_2 = 10 \quad \times 13$

$-80 - 130I_1 + 100I_2 = 0$

$-52 + 130I_1 - 299I_2 = 0$

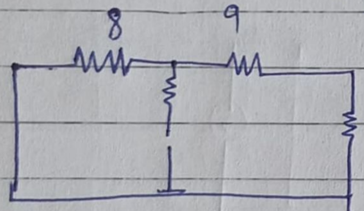
$28 - 199I_2 = 0$

$I_2 = \frac{28}{199} = 0.14$

$I_1 = 0.73$

$I_N = I_1 - I_2 = 0.73 - 0.14$

$= 0.59\,A$



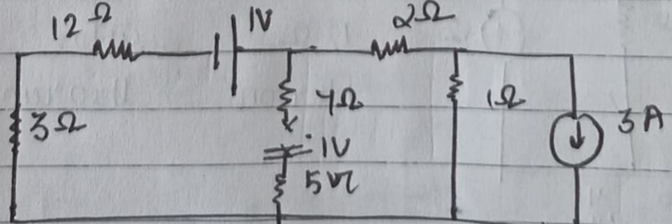
$= R_N = 10 + 13 \| 3$

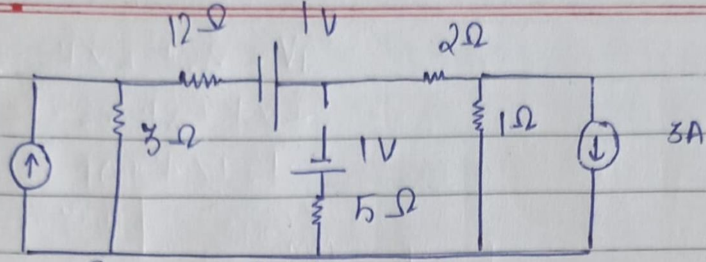
$\Rightarrow 10 + \frac{13 \times 3}{13 + 3} \Rightarrow 10 + \frac{39}{16}$

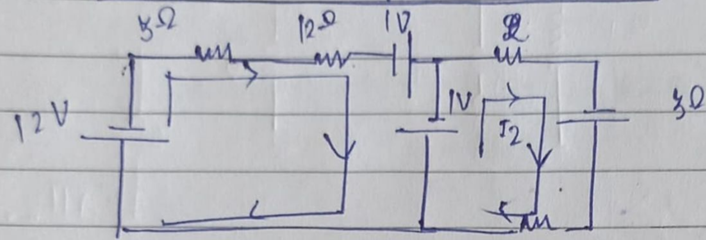
$\Rightarrow 12.4$

$I \Rightarrow \frac{12.44 \times 0.59}{12.44 + 2} = \frac{4.3}{14.4} \Rightarrow 0.3$

8) Find the Nortons theorem in 4Ω







$$12-3I_1-12I_1+1+1-5(I_1-I_2)=0$$

$$-1-2I_2+3-I_2-5(I_2-I_1)=0 \quad \text{—— (2)}$$

$$14-20I_1+5I_2=0$$

$$2-8I_2+5I_1=0$$

$$2+5I_1-8I_2=0$$

$$14-20I_1+5I_2=0$$

$$8+20I_1-32I_2=0$$

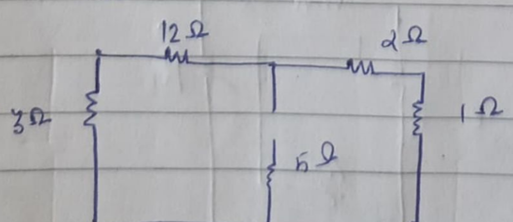
$$20-27I_2=0$$

$$I_2=\frac{20}{27}=0.74 \qquad I_1=0.76$$

$$I_N=I_1-I_2$$

$$=0.76-0.72$$

$$I_N=0.04$$



$$R_N=5+3\|15$$

$$\Rightarrow 5+\frac{3\times15}{3+15}$$

$$R_N=5+\frac{45}{18}$$

$$\Rightarrow \frac{90+45}{18}=\frac{135}{18}$$

$$\Rightarrow 7.5$$

$I_2 \Rightarrow \dfrac{0.04 \times 7.5}{7.5+7}$

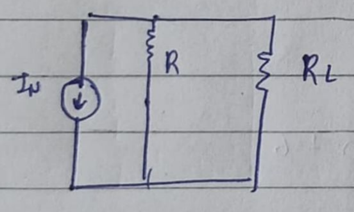
$\Rightarrow \dfrac{0.300}{14.5}$

$= \dfrac{0.3}{14.5}$

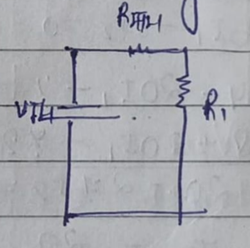
$\Rightarrow 3/145$

$\Rightarrow 0.02$ A

Dual Property :- Norton's Equivalent Circuit change into thevenims Equivalent Circuit & Thevenims Equivalent Circuit into Nortons Equivalent Circuit by Source Conversion.



$I_N R_N = R_{TH}$ R_{TH}

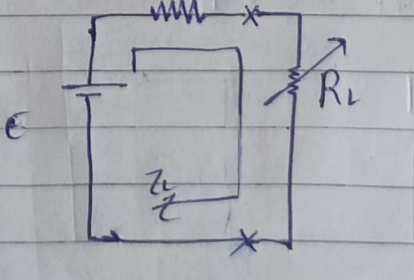


$$R_N = R_{TH}$$

Maximum Power Transfer form :-

$I_L = \dfrac{E}{(R+R_L)}$

Power $= I_L^2 R_L = \left[\dfrac{E}{(R+R_L)}\right]^2 \times R_L$



Power $= \dfrac{E^2 + R_L}{(R+R_L)^2}$

$\dfrac{dP}{dR_L} = \dfrac{dP}{dR_L} \Rightarrow \left[\dfrac{E^2 R_L}{(R+R_L)^2}\right]$

$$E^2 = \left[\frac{(R_1+R_L)^2 \frac{d(R_L)}{d R_L} - R_L \frac{d}{dR_L} (R+R_L)^2}{(R+R_L)^4} \right]$$

$$E^2 \Rightarrow \left[\frac{(R_1+R_L)^2 \times 1 - 2R_L (R+R_L)}{(R_1+R_L)^4} \right] = 0$$

$$E^2 = \left[\frac{(R+R_L)^2 - 2R_L(R+R_L)}{(R+R_L)^4} \right] = 0$$

$$(R_1+R_L)^2 - 2R_L(R_1+R_2) = 0$$

$$(R_1+R_L)^2 = 2R_L(R_1+R_2)$$

$$\Rightarrow R = R_L.$$

$$\frac{dP}{dR_1} = E^2 \left[\frac{(R+R_L)^2 \times 1 - 2R_L(R+R_L)}{(R_1+R_2)^4} \right]$$

$$\Rightarrow E^2 \Rightarrow \left[\frac{R^2 + R_L^2 + 2RL - 2R_LR - 2R^3{}_2}{(R+R_L)^4} \right]$$

$$\Rightarrow \frac{dP}{dR_L} = E^2 \left[\frac{R^2 - R_L^2}{(R+R_L)^4} \right]$$

$$\Rightarrow \frac{d}{dR_L} = \frac{dP}{dR_L} = \frac{d}{dR_L} \left[\frac{E^2 (R^2 - R_L^2)}{(R+R_1)^4} \right]$$

$$\Rightarrow E^2 \left[\frac{(R_1+R_2)^4 \times -2RL - (R^2 - R^2_L) \times 4 \times (R+R_L)^3}{R+R_L} \right]$$

$$R_L = R$$

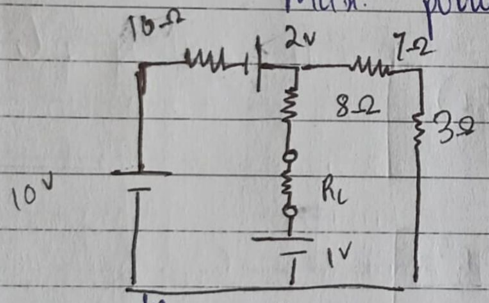
$$\frac{d^2P}{dR_L^2} = -ve$$

$$P = \frac{E^2}{(R_1+R_L)^2} R_L \Rightarrow \frac{E^2 \times R}{(R+R)^2} = \frac{E^2 R}{4R^2}$$

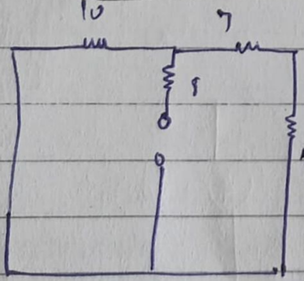
$$P_{max} = \frac{E^2}{4R}. \qquad P_{max} = \frac{V_{TH}^2}{4R_{TH}}.$$

In a active linear bilateral circuit max. power will occur when low resistance is equivalent to total internal Resistance of the circuit excluding load Resistance

Max. power occur is 50% in a circuit.



What will be the value of R_L in shown circuit for the max power occurence & also calculate max power across this.



$$R_L = 8 + 10 \| 10$$

$$\Rightarrow 8 + \frac{10 \times 10}{10+10}$$

$$R_L = 13\ \Omega$$

$$10 - 10I + 2 - 7I - 3I = 0$$

$$12 = 20I$$

$$I = .6$$

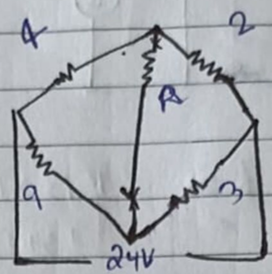
$$V_A = -8 \times 0 - 7I - 3I + 1 = V_B$$

$$V_A - V_B = 10I - 1$$

$$= 6 - 1$$

$$V_{TH} = 5V$$

Find the value of R in the shown circuit for the max. transfer theorem & also calculate Max. power.



$R_{eq} \Rightarrow 4 \parallel 2 + 9 \parallel 3$

$\Rightarrow \frac{4\times 2}{4+2} + \frac{9\times 3}{9+3} \Rightarrow \frac{8}{6} + \frac{27}{12} \Rightarrow \frac{16+27}{12}$

$\Rightarrow \frac{43}{12} = 3.58$

$R_L = 3.58$

$I_1 \quad \frac{24V}{4+2} \Rightarrow \frac{24}{6} = 4A \quad I_2 \quad \frac{24}{9+3} \Rightarrow \frac{24}{12} = 2A$

$V_A - 2I + 3I_2 = V_B$

$V_A - V_B = +2I_1 - 3I_2$

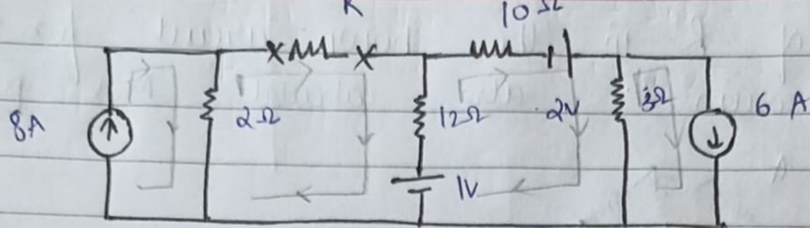
$\Rightarrow 2\times 4 - 3\times 2$

$\Rightarrow 8-6$

$V_{TH} = 2V$

$P_{max} = \frac{E^2}{4R} \Rightarrow \frac{(2)^2}{}$

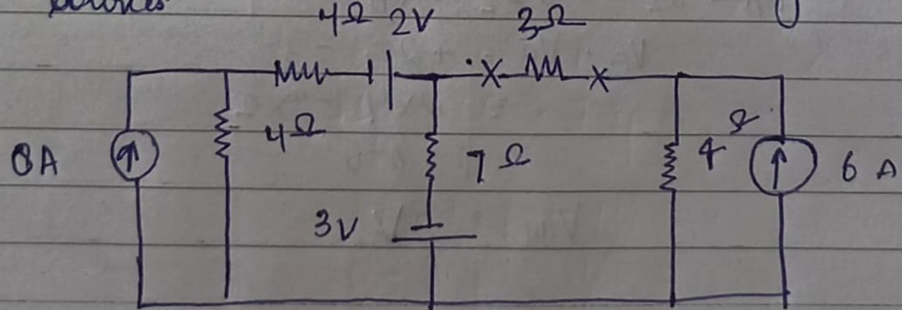
Find the value of R for Max. Power transfer theorem also calculate the Max. Power



$R \Rightarrow 8 + \left(\frac{13 \times 12}{13+12}\right) = 8.24\ \Omega$

$\Rightarrow$

Superposition theorem:- In a active linear bilateral network the superposition theorem is used for the calculation of a current in a specific element by the summing of (Algebric) individual current by the diff sources.

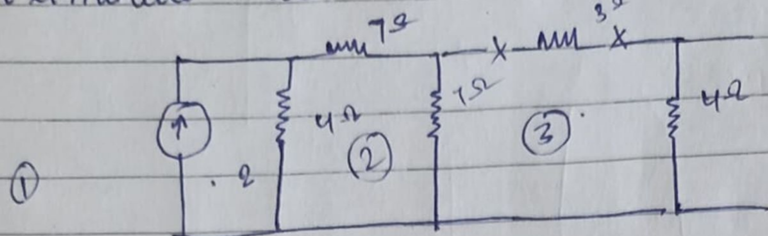


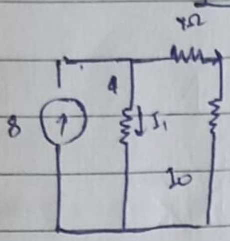
Calculate the current in 3Ω resistor in 3Ω Resistor

Step 1. Mark all the sources with specific number 1, 2 & 3

Step 2 Take source 1 & remove other sources. to calculate the current in specific element

Eliminate all the other sources in except 1.





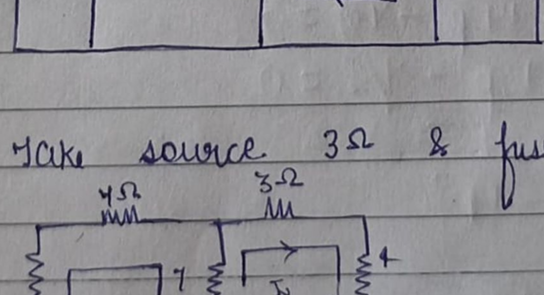
$4 \parallel 7 \Rightarrow \frac{4 \times 7}{4+7} = \frac{49}{14} = 3.5$

$I_0 \Rightarrow \frac{8 \times 4}{10.5+4} \Rightarrow \frac{32}{14.5} = \cancel{3.04}\ 2.20$

$I_x = \frac{\cancel{2.20} \times 4}{7+7} \Rightarrow \frac{3.04 \times 4}{14} = \frac{3.04}{2} = 1.02$

Due to source 1 current in 3Ω resistor is $\xrightarrow{\quad}$ 1.02

Step 4-) Take source 2 for the calculation of current in the desired element by eliminating others source.

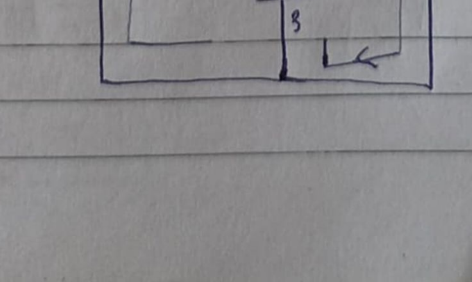


6 A $\Rightarrow 2.7(I_1 - I_2) - 4I_4 - 7I_4 = 0$ (1)

$0 - 3I_2 - 4I_2 - 7(I_1 - I_2) = 0$

$I_2 = 0.06$

=> step-5 Take source 3Ω & fuse all the sources.



$3 - 4I_m - 4I_m - 7(I_m + I_N) = 0$

$3 - 4I_N - 3I_N - 7(I_N + I_m) = 0$

$3 \cdot 4I_m - 7I_m - 7I_m + 7I_N = 0$

$3 - 4I_N - 3I_N - 7I_N + 7I_m = 0$

$3 - 10m + 7I_N = 0$

$3 - 7I - 3 - 7I_m = 0$

$\Rightarrow \quad 3 - 10I_m + 7I_N = 0$

$3 - 4I_m = 0$

$4I_m = 3$

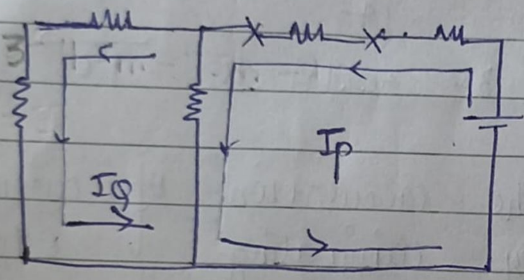
$I_m = 1/3$

I_m

0.42

$3 - 10 \times 0.42 + 7 \times 0.42 = 0$

$\boxed{I_N \quad 0.16}$



$24 - 4I_p - 3I_p - 7(I_p - Q) = 0$ ①

$0 - 7I_Q - 4I_Q - 7(I_Q - I_p) = 0$

$24 - 4I_p - 3I_p - 7(I_p - Q) = 0$

$24 - 7p - 7p - 7Q = 0$ X

$0 - 11p - 7I_Q - 7I_p = 0$

$24 - 14p - 7Q = 0$

$0 - 18p - 7Q = 0$

$24 - 1 \quad 32$

$\boxed{24 - 4}$

$$\begin{array}{r} 14 \\ -18 \\ \hline 32 \end{array}$$

Source 1 = $\overrightarrow{1.10}$

Source 2 = $\overrightarrow{0.06}$

Source 3 = $\overrightarrow{0.16}$

Source 4 = $\overleftarrow{2.10}$

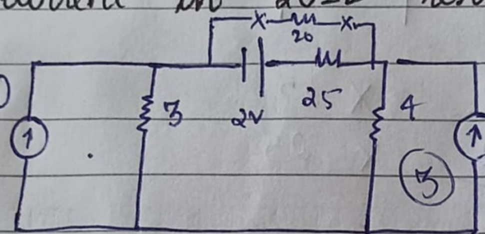
Find the summation of all current with its direction Y individual sources 1, 2, 3 & 4 ctr

source 1	$\overrightarrow{1.10}$	}	$\overrightarrow{1.16}$
source 2	$\overrightarrow{0.06}$		
source 3	$\overleftarrow{0.16}$	}	$\overleftarrow{2.26}$
source 4	$\overleftarrow{2.10}$		

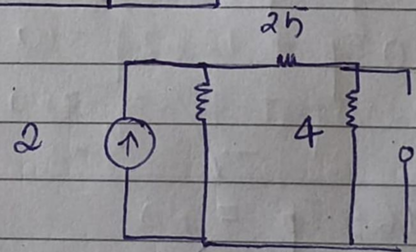
Suppose $\rightarrow 1.10$

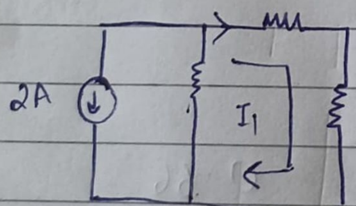
Find the current in $20\,\Omega$ resistor by superposition theorem.

(1)



$$\frac{20 \times 25}{20+25} = 11.11$$

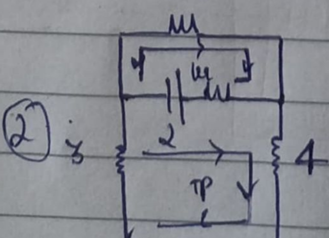




$$I_1 = \left(\frac{2 \times 3}{15.11 + 3}\right) \quad \frac{6}{18.11} = 0.33.$$

$$\Rightarrow \frac{0.33 \times 25}{20+25} \quad = \frac{8.25}{45} \quad = 0.18\ \text{A}$$

Source $\xrightarrow[0.18]{}$



$2-25(I_p+I_q)-4I_p-3I_p=0$ — (1)

$2-25(I_p+I_p)-20I_q=0$ — (2)

$2-25I_p+25I_q-4I_p-3I_p$

$2-25I_p+25I_q-20I_q=0$.

$\Rightarrow$ $2-28I_p+25I_q-4I_p$

$\cancel{2-20I_q=0}$. $2-25I_p+5I_q=0$.

$\Rightarrow$ $2-32I_p+25I_q=0$

$\cancel{2-20I_q=0}$ $2-25I_p+5I_q=0$

$32I_p+25I_q=2 \quad \times 5$

$25I_p+5I_q=2 \quad \times 25$

$\Rightarrow$ $160I_p+125I_q=10$

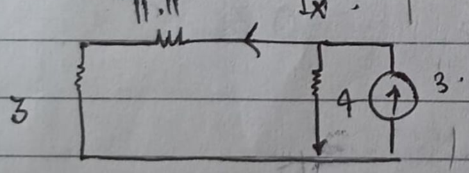
$625I_p+125I_q=10$

$465I_p=20$

$I_p=465/20$

$I_p = 0.02$

$I_q = 0.04$



$Ix = \dfrac{3\times 4}{4+11.11+3} = 0.66$

12

18.11

$Iy = \dfrac{0.66\times 25}{25+20}$

$\Rightarrow 0.36$

0.66

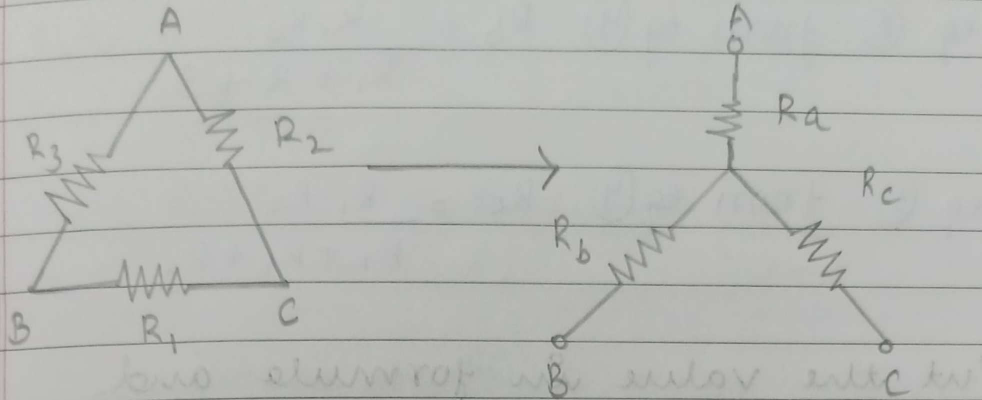
0.37-18

0.19 A

Star Delta Transformation :

convert Δ to λ

$\Delta \rightarrow$ delta
$\lambda \rightarrow$ star



for CA in λ

$R_{CA} = R_A + R_C$

for CA in Δ

$R_{CA} = (R_1 + R_3) \parallel R_2$

$$R_a + R_c = \frac{(R_1 + R_3) R_2}{R_1 + R_2 + R_3} \quad \text{— (1)}$$

for AB in Δ

$R_{AB}\ (R_1 + R_2) \parallel R_3$

$$\frac{(R_1 + R_2) \parallel R_3}{(R_1 + R_2 + R_3)}$$

for AB in λ

$R_{AB} = R_a + R_b$

$$R_a + R_b = \frac{(R_1 + R_2) R_3}{R_1 + R_2 + R_3} \quad \text{— (2)}$$

for BC in λ

$R_{BC} = R_b + R_c$

for BC in Δ

$R_{BC} = (R_2 + R_3) \parallel R_1$

$$= \left(\frac{(R_1 + R_3) R_1}{R_1 + R_2 + R_3} \right)$$

$$R_b + R_c = \frac{(R_2 + R_3) R_1}{R_1 + R_2 + R_3} \quad \text{— (3)}$$

Adding eq (1) + (2) + (3)

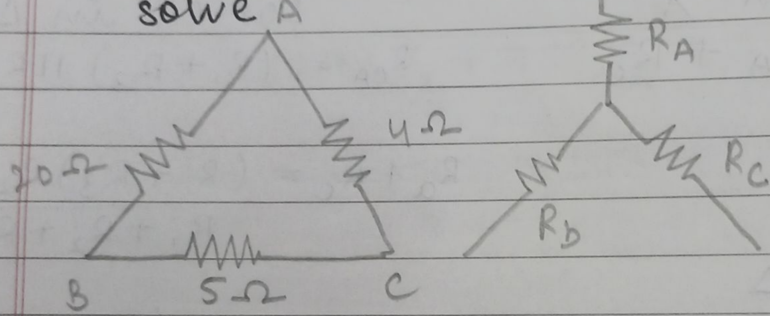
$$R_a + R_b + R_c = \frac{1}{2} \left[\frac{(R_1 + R_2) R_3}{R_1 + R_2 + R_3} + \frac{(R_1 + R_3) R_2}{R_1 + R_2 + R_3} + \frac{(R_2 + R_3) R_1}{R_1 + R_2 + R_3} \right] \quad \text{— (4)}$$

Sub eq ① from eq ④ $R_a = \dfrac{R_2 + R_3}{R_1 + R_2 + R_3}$

Sub eq ② from eq ④ $R_b = \dfrac{R_1 R_3}{R_1 + R + 3}$

Sub eq ③ from eq ④ $R_c = \dfrac{R_1 R_2}{R_1 + R_2 + R_3}$

Q Put the value in formula and solve



converting λ into Δ

$$R_a \times R_b = \frac{(R_2 R_3)(R_1 R_3)}{(R_1 + R_2 + R_3)^2} \quad \text{——— ④}$$

$$R_b \times R_c = \frac{(R_1 R_3)(R_1 R_2)}{(R_1 + R_2 + R_3)^2} \quad \text{——— ⑤}$$

$$R_c \times R_a = \frac{(R_2 R_3)(R_1 R_2)}{(R_1 + R_2 + R_3)^2} \quad \text{——— ⑥}$$

Add eq ④, ⑤ and ⑥ will give eq ⑦

$$\Rightarrow \frac{R_1 R_2 R_3}{R_1 + R_2 + R_3}$$

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$$R_1 = \frac{R_b R_c + R_c R_a + R_a R_b}{R_a}$$

$$R_2 = \frac{R_b R_c + R_c R_a + R_a R_b}{R_b}$$

$$R_3 = \frac{R_b R_c + R_c R_a + R_a R_b}{R_c}$$

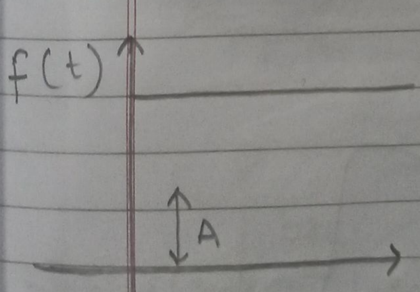
to calculate eq 7

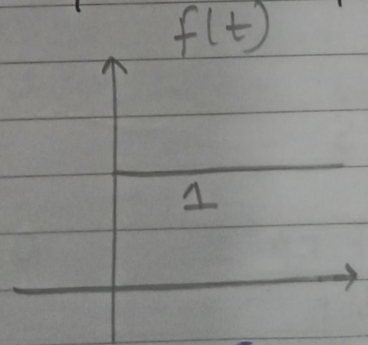
$$R_a R_b + R_b R_c + R_c R_a = \frac{R_1^2 + R_3 R_3 + R_1 R_2^2 R_3 + R_1 R_2 R_3^2}{(R_1 + R_2 + R_3)^2}$$

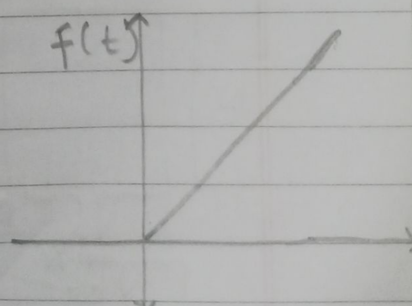
$$= \frac{R_1 R_2 R_3 [R_1 + R_2 + R_3]}{(R_1 + R_2 + R_3)^2}$$

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

Step signal | unit step signal



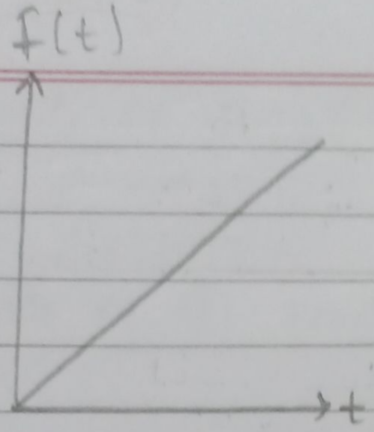


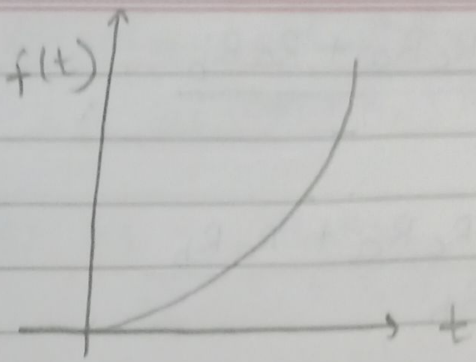


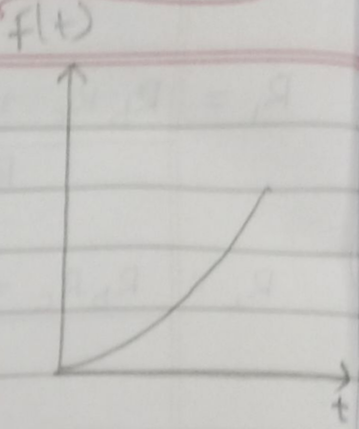
$$f(t) = \begin{bmatrix} A & t > 0 \\ 0 & t < 0 \end{bmatrix}$$

$$f(t) \Rightarrow \begin{bmatrix} 1 & t > 0 \\ 0 & t < 0 \end{bmatrix}$$

$$f(t) = \begin{bmatrix} At & t > 0 \\ 0, & t < 0 \end{bmatrix}$$







$$f(t) \begin{bmatrix} t & , & t > 0 \\ 0 & , & t < 0 \end{bmatrix}$$

$$ft = \begin{bmatrix} At^2, & t > 0 \\ 0, & t < 0 \end{bmatrix}$$

$$f(t) = \begin{bmatrix} t^2 & , & t > 0 \\ 0 & , & t < 0 \end{bmatrix}$$