2/8/18.

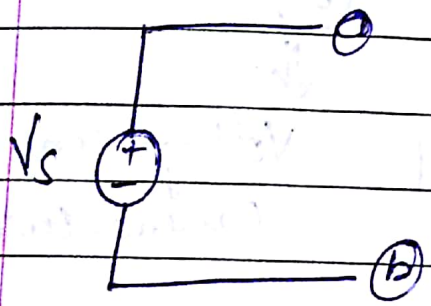
Circuit Analysis.

1. Active Element: It is one which will posses energy of its own.
   Ex: Voltage Source, Current Source.
2. Passive Element: It will take energy from another Source Instantaneously
   Ex: R, I, C.

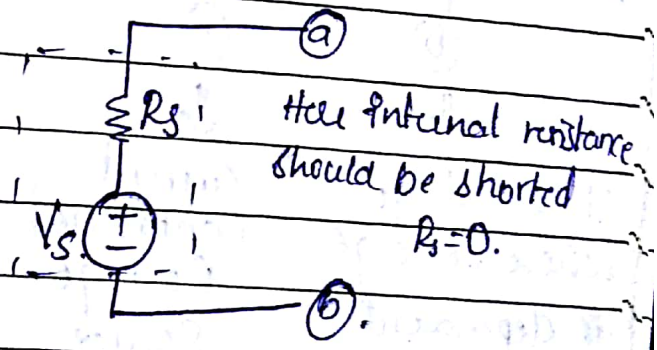
⇒ Voltage Source: Current Source } either it can Ideal Sources or practical sources.

⇒ Ideal Sources: ① Dependent Sources / Controlled Sources.
② Independent Sources.

I.V.S

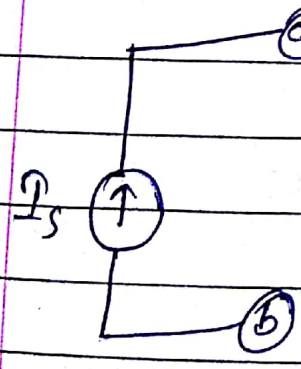


P.V.S.

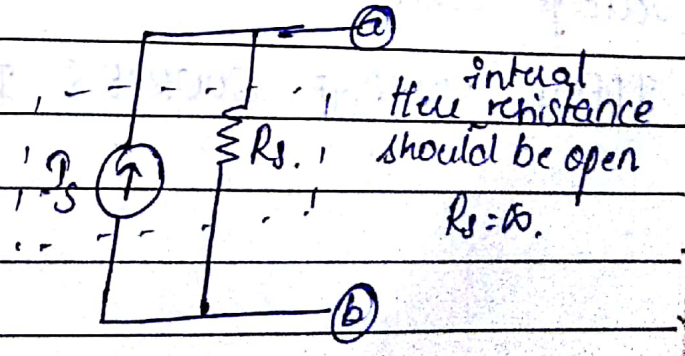


Here internal resistance should be shorted $R_s = 0$.

I.I.S



P.I.S



Internal Here resistance should be open $R_s = \infty$.

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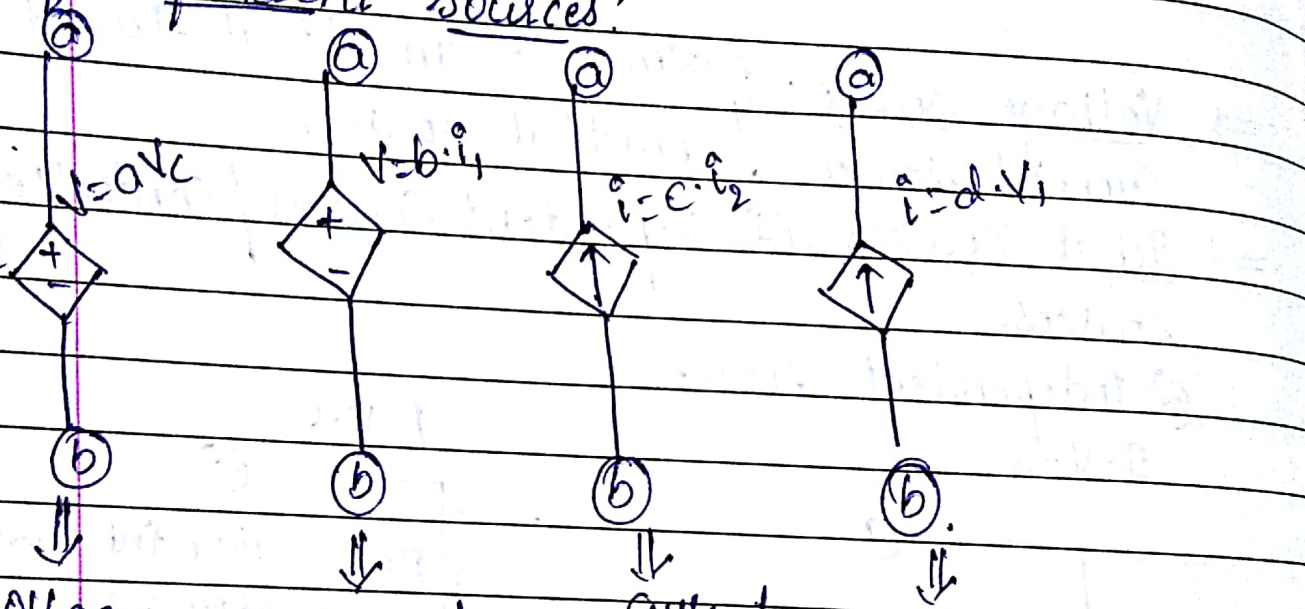
Independent Sources: Its value does not change with any V and I in ckt.

Ex: Battery ⟹ 

Dependent sources: Its value changes w.r.to change in V, I, in ckt.

Types of dependent sources:



VCVS voltage control voltage source

It is voltage whose voltage is dependent on some other voltage source

Current controlled voltage source

Current controlled current source

Voltage controlled current source

IDEAL VOLTAGE SOURCES IN SERIES:

" " " " **PARALLEL:**

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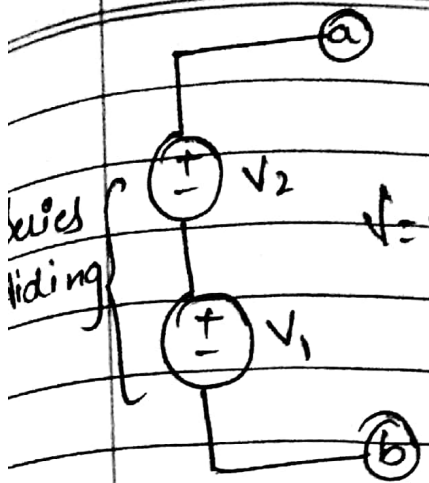
D·V·S·S

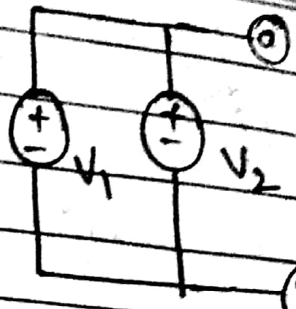


Series adding

$V = V_1 + V_2$.

Ckt ①.

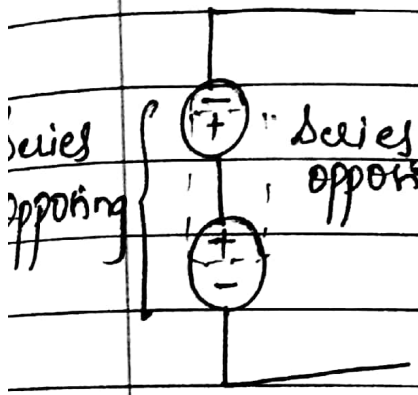
D·V·S·P.



If $V_1 > V_2$ $V_0 = V_1$

If $V_2 > V_1$ $V_0 = V_2$.

Ckt ①.



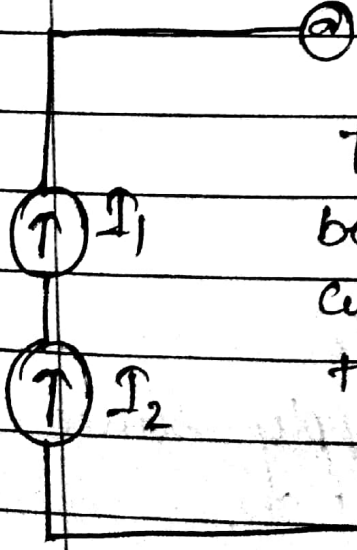
Series opposing

G-S.

Series opposite $V_0 = V_1 - V_2$

Ckt ②.

D·C·S·S.



It is no use because output current will be higher one, the higher one also drag lower one to that level. So no use

Ckt ①.

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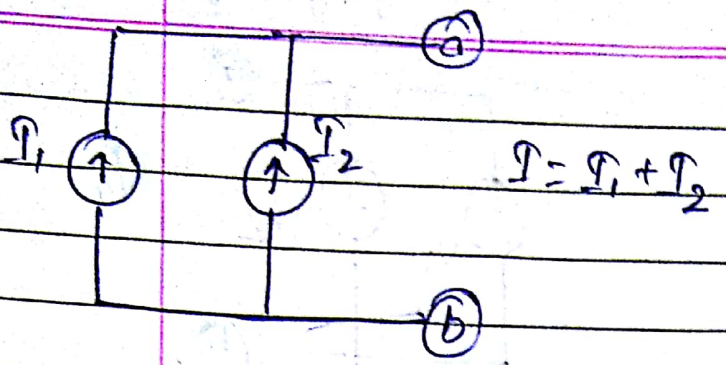
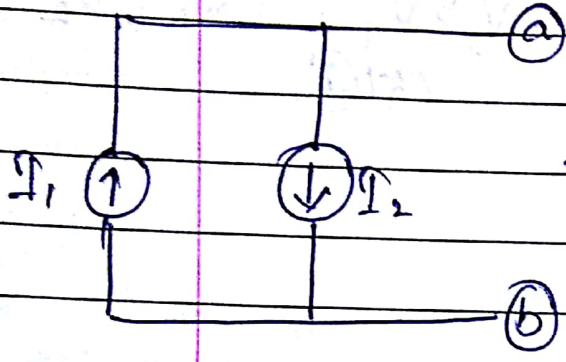


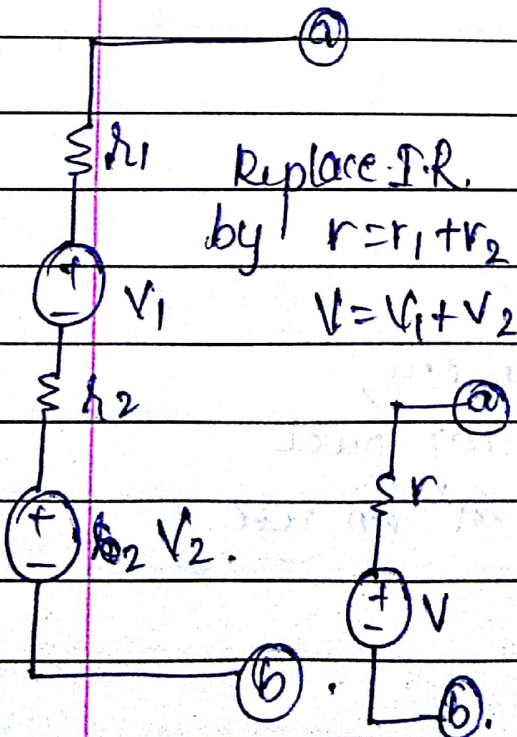
Ckt ②



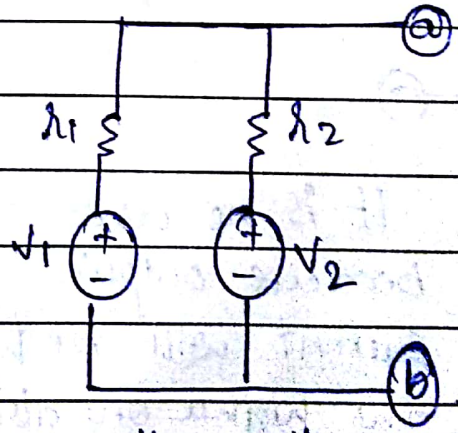
Ckt ③.

Practical Voltage sources.

P·V·S·S



P·V·S·P (CSI)



Here will apply Source Transformation.

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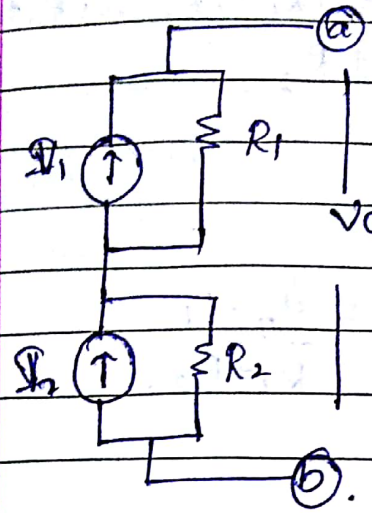
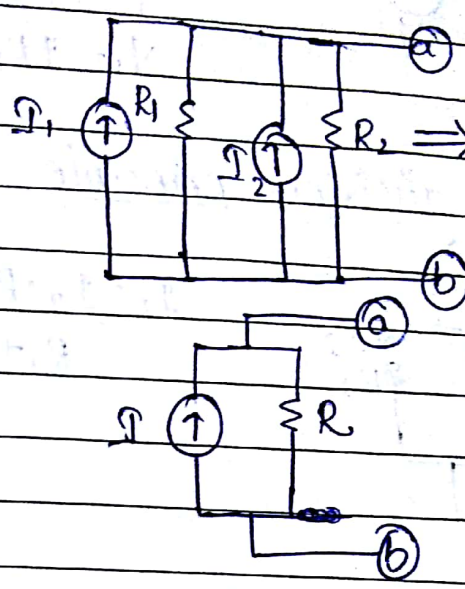
P.V.S.P : To determine V_o source Transformation Req^d.

P.P.S.S. (S2)

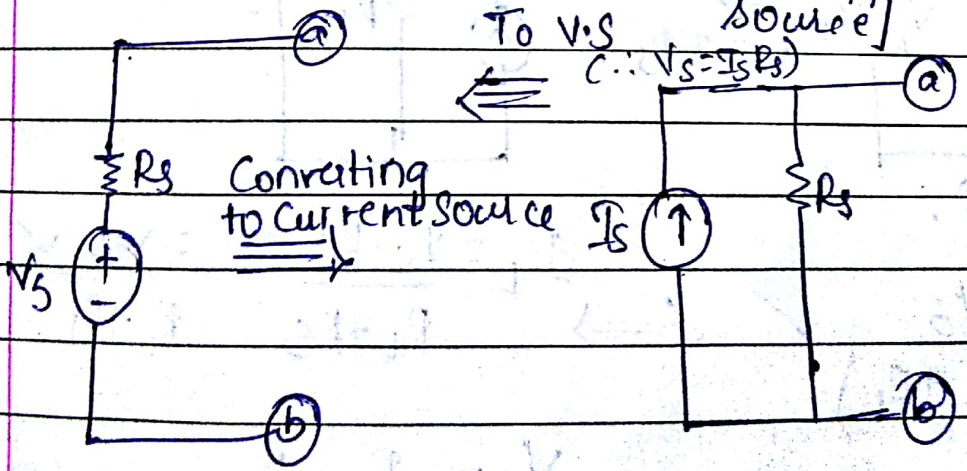


P.P.S.P.



V_o is obtained using source Transformation.

SOURCE TRANSFORMATION: [It is applied only for practical source]



It is done only when

$$V_s = I_s R_s \;,\; I_s = \frac{V_s}{R_s}$$

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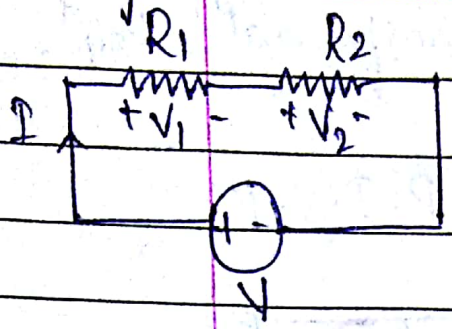
Voltage Division principle.

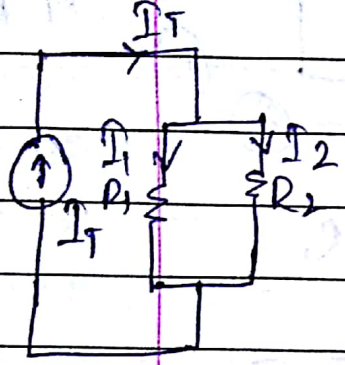


Current flowing in both Resistors is same as they are connected in series.

$V = V_1 + V_2$ $\quad V = IR_1 + IR_2 = I(R_1 + R_2)$

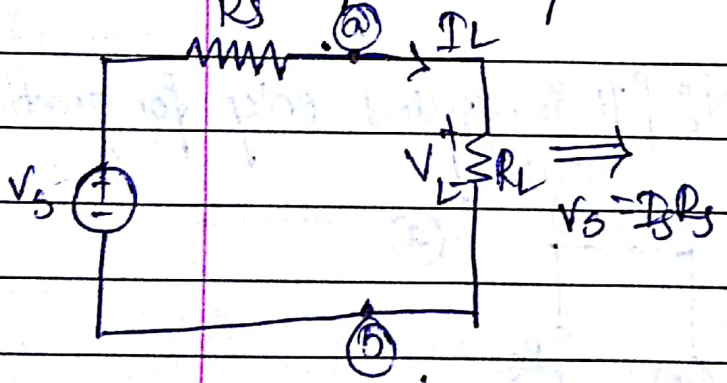
$V_1 = IR_1$ $\quad V_2 = IR_2$.

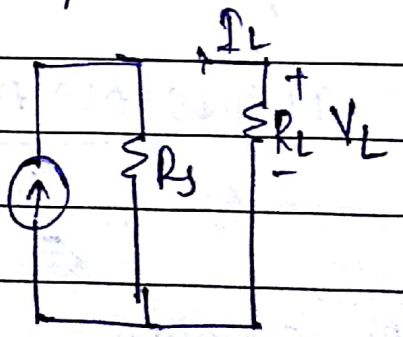
current division principle.



$I_1 = \frac{I_T \cdot R_2}{R_1 + R_2}$ $\quad I_2 = \frac{I_T \cdot R_1}{R_1 + R_2}$.

Source Transformat° for closed ckt.





$I_L = \frac{V_S}{(R_S + R_L)}$ ✓ $\Longleftrightarrow$ $I_L = \frac{I_S \cdot R_S}{R_L + R_S} = \frac{V_S}{R_L + R_S}$ ✓

$V_L = I_L \cdot R_L$.

$V_L = I_L R_L$

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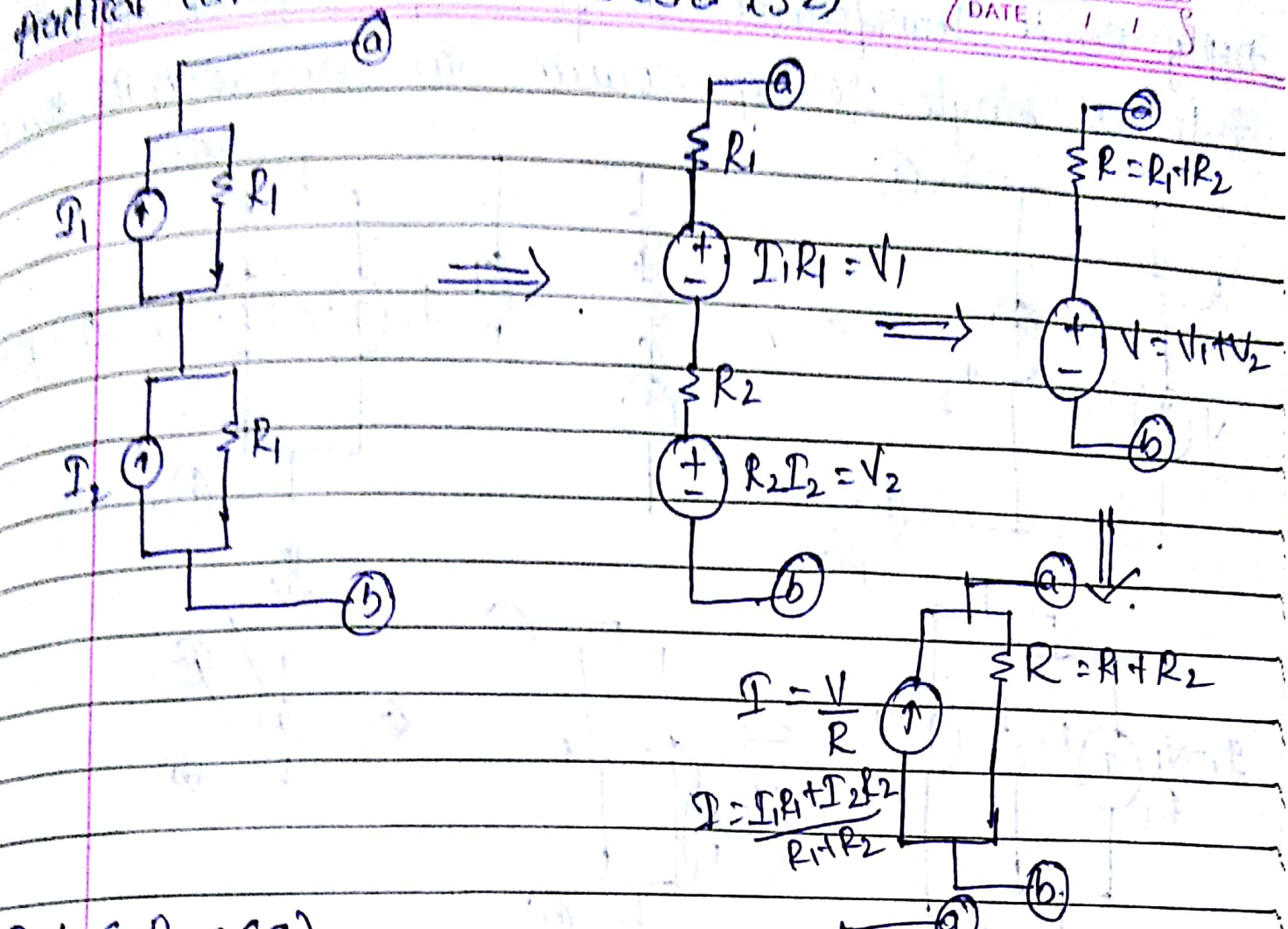
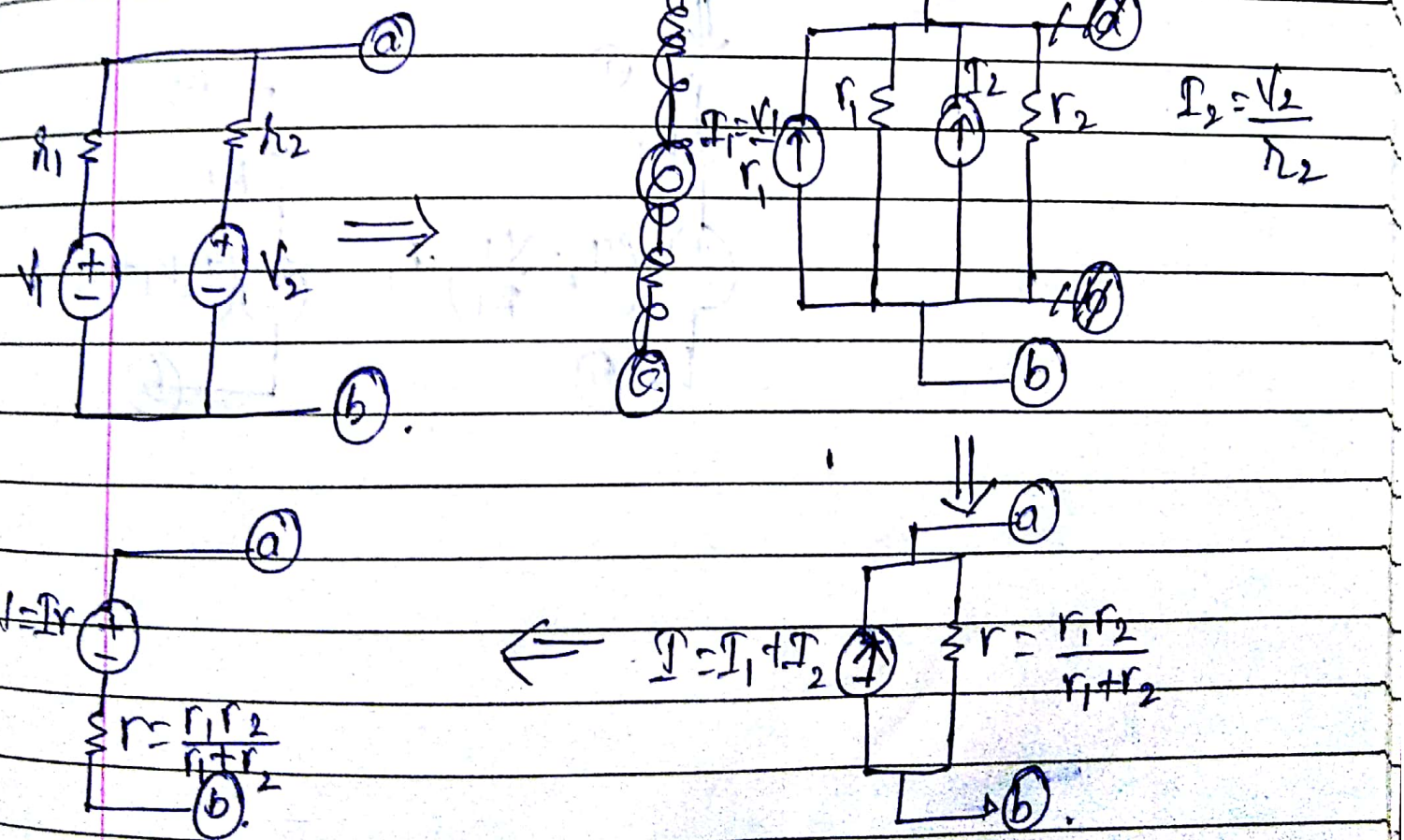
Practical current source in series (S2)



P.V.S.P. (S3)



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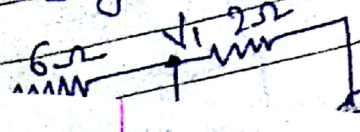
Nodal



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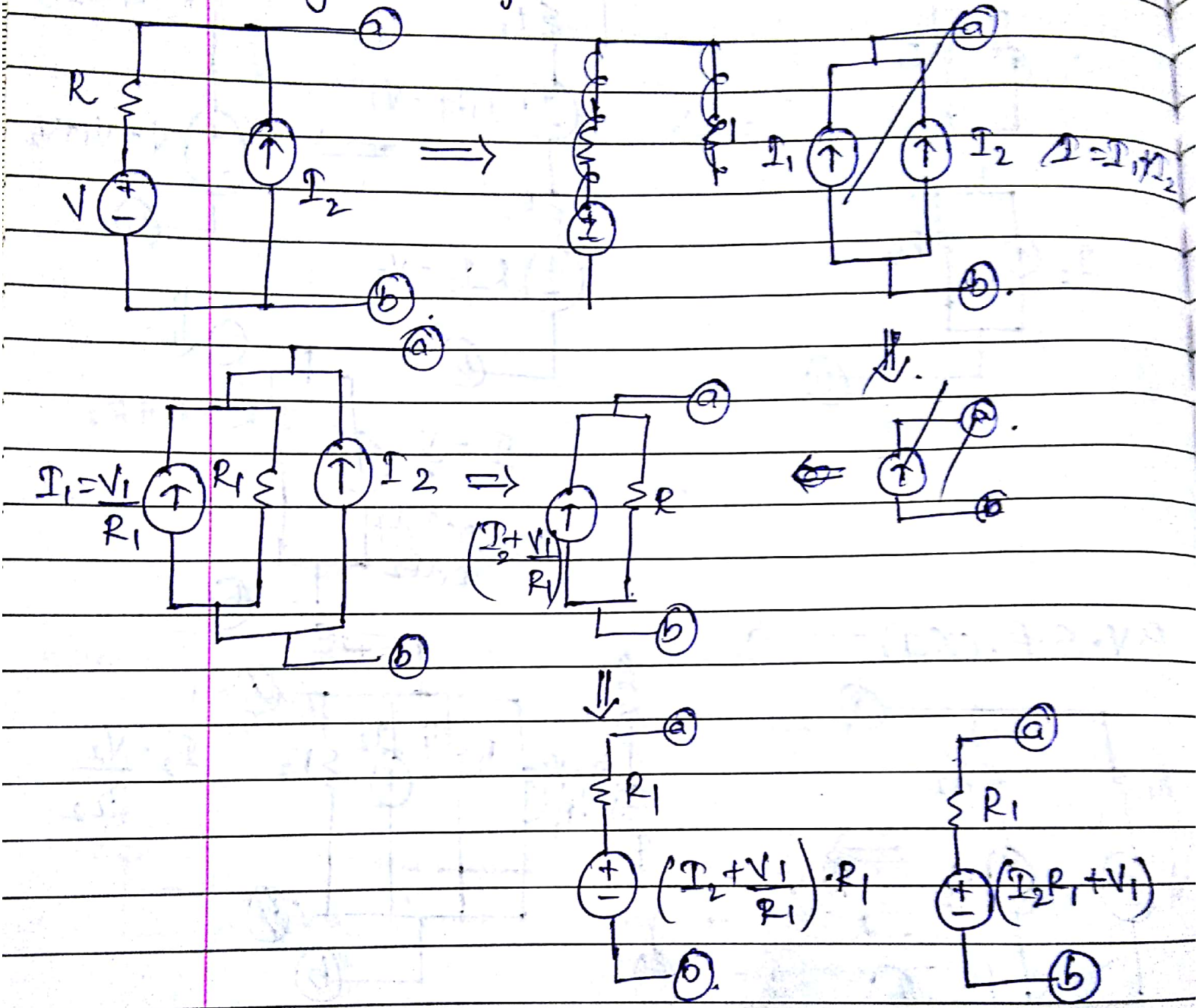
Apply Source Transformation to following ckt and convert this into a single voltage source in series with its r.



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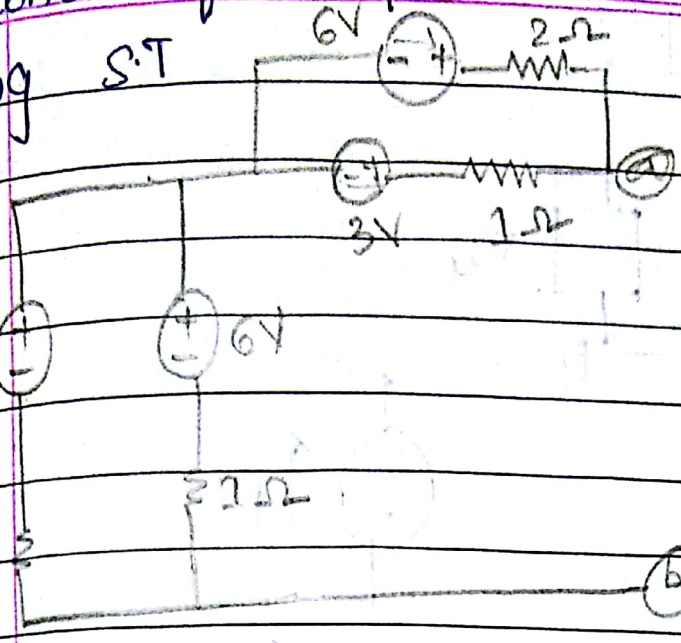
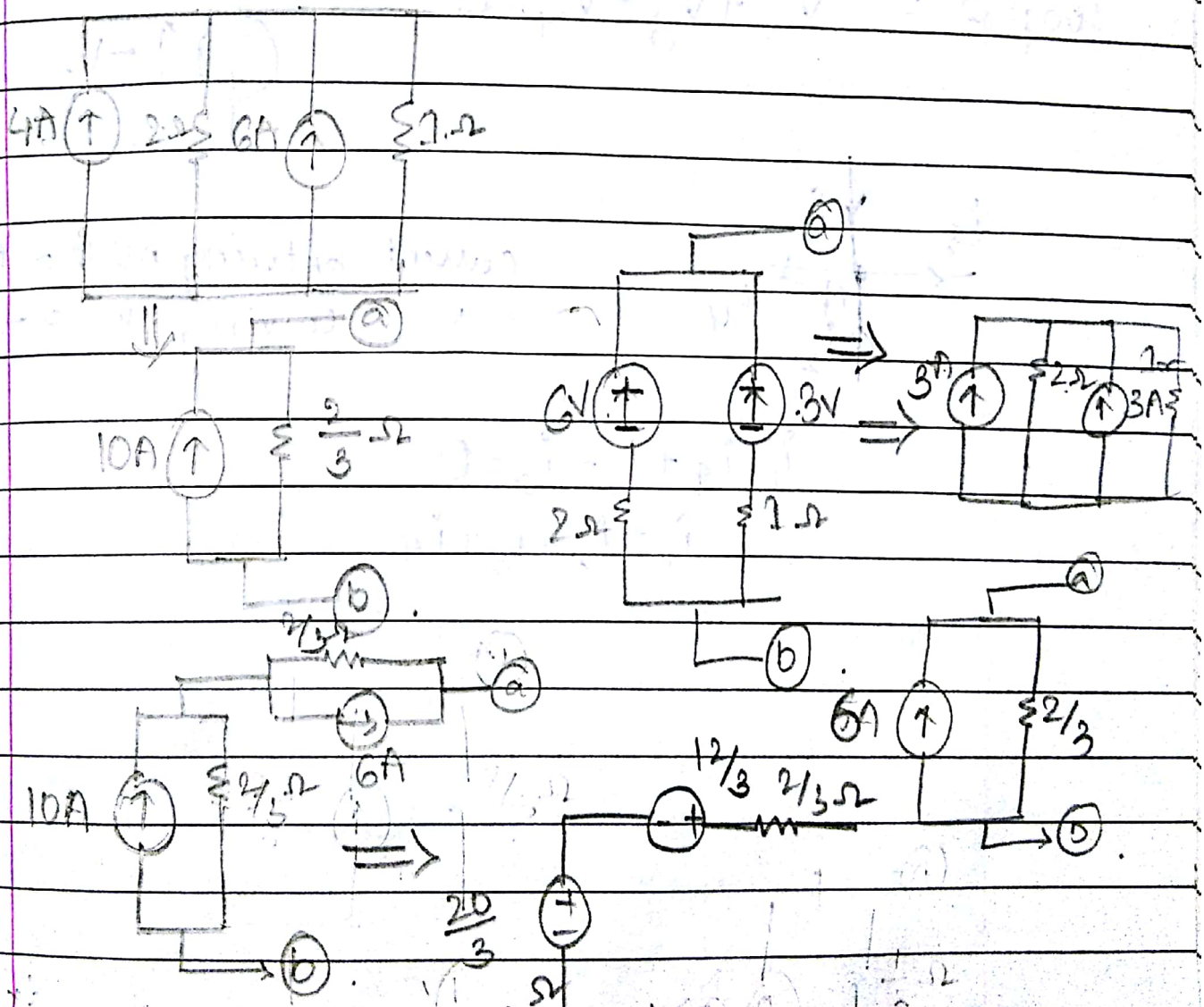
② Convert foll' ckt into a single voltage source using S.T





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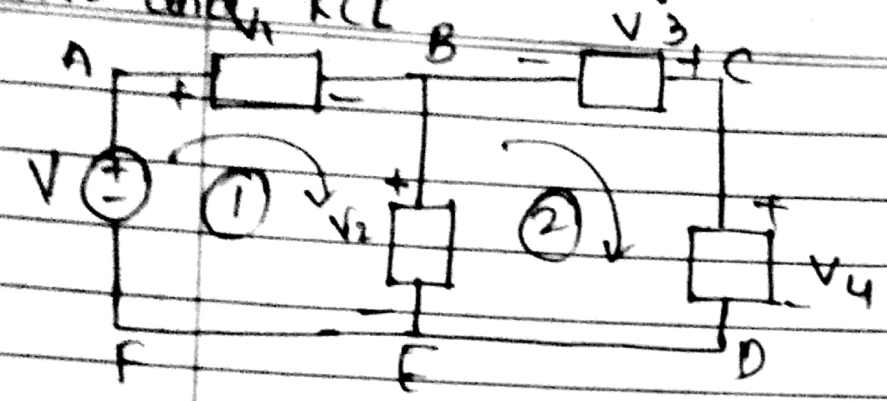
analysis

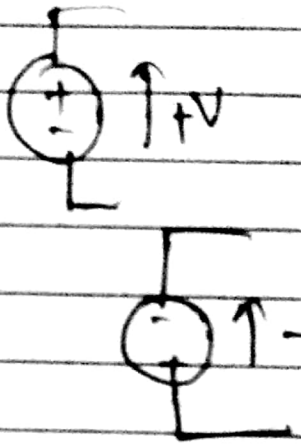
KVL and KCL

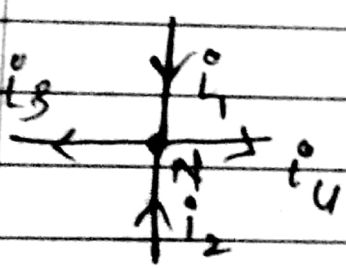
Current Entering = Current Leav.



Loop 1 $V - V_1 - V_2 = 0$

Loop 2 = $V_2 + V_3 - V_4 = 0$





current Entering node = +I

" Leaving " = -I

$$i_1 - i_4 + i_2 - i_3 = 0$$

$$i_1 + i_2 - i_3 + i_4$$

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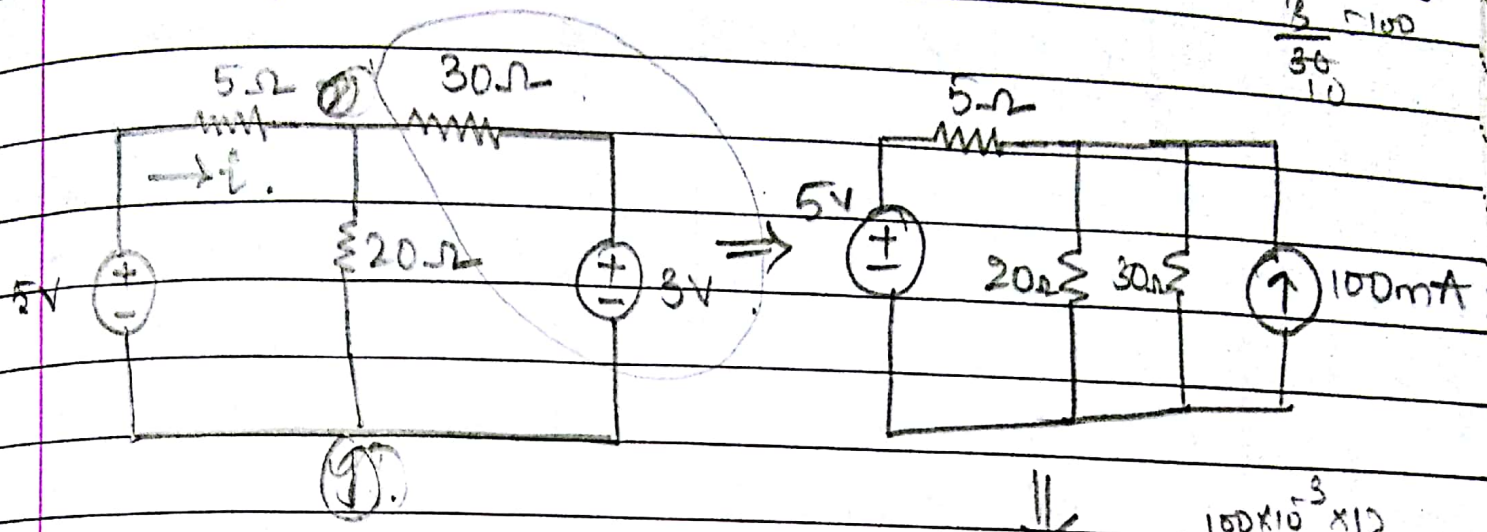
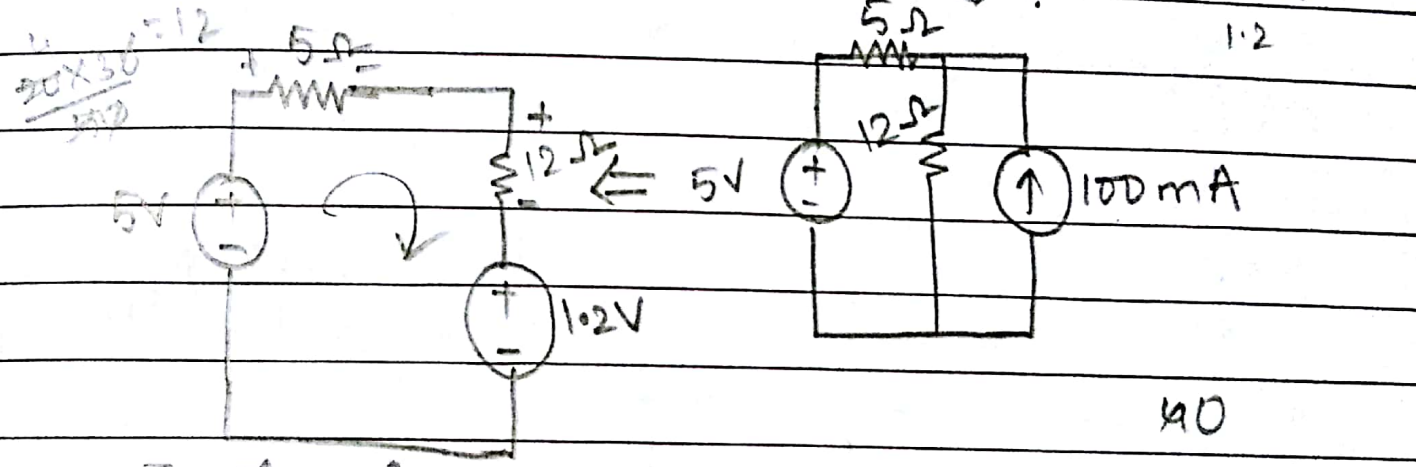
Q. Find the current I by reducing the ckt to the right side of terminals x, y to its simplest form using source transformatn





$5 - 5i - 12i - 1.2 = 0.$

$3.8 = 17i$

$i = \frac{3.8}{17} = \frac{2.2}{17} \times 10^{-1} = 0.22A = 220mA.$

without calculator

Ω

0.2235A.

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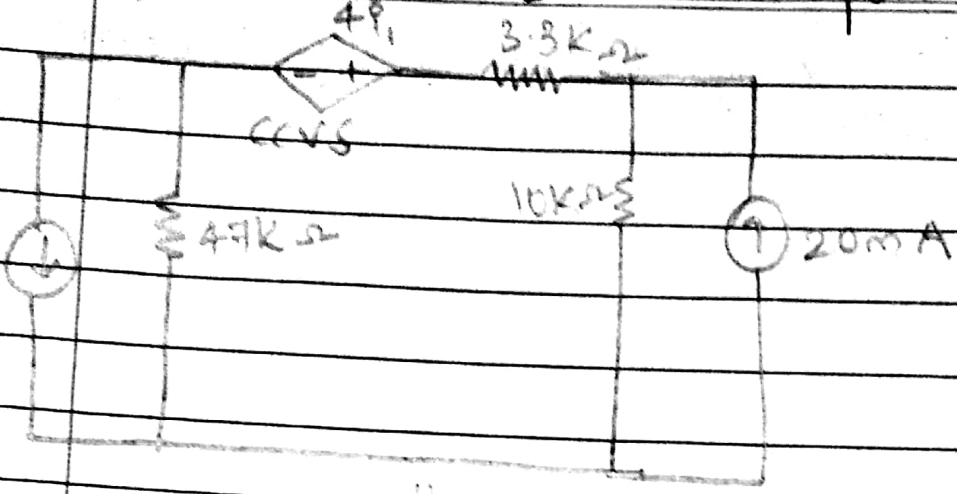
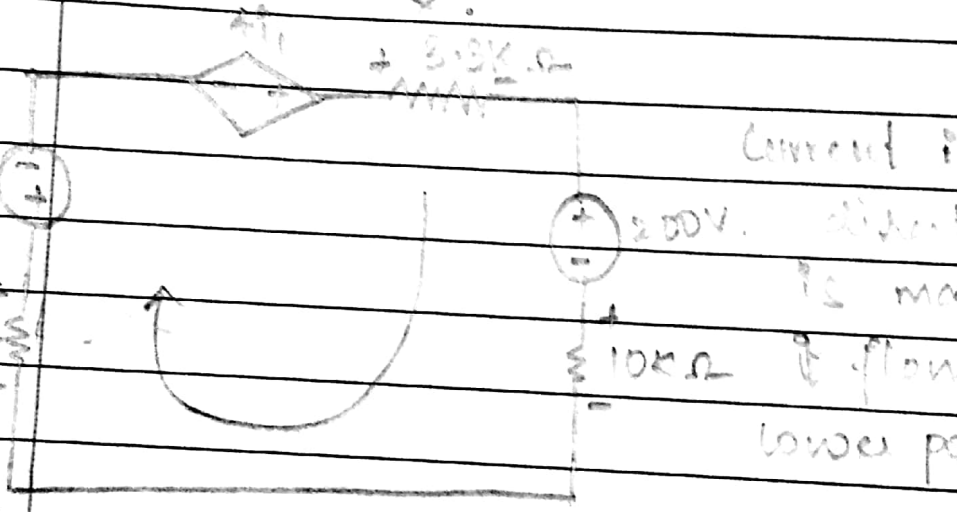
(*). Determine current i_1 in the foll^n ckt using S.T.





Current is flowing in opp direct^n bcz 200V is max voltage it flows from 200V to lower potential.

$$-47K\times i_1 - 47 + 4i_1 - 3.3Ki_1 - 200 - 10Ki_1 = 0$$

$$(-47 - 3.3 - 10)\,i_1 \times 10^3 + 4i_1 = 247$$

$$-60.3\times 10^3 i_1 + 4i_1 = 247$$

$$i_1 = \frac{247}{60296} = -4.09\text{mA}.$$

or

-4.387mA.

$4i_1 = -17.548$ approx direct^n

-43
+39.3
-56.3

503

4.387×4
17.548

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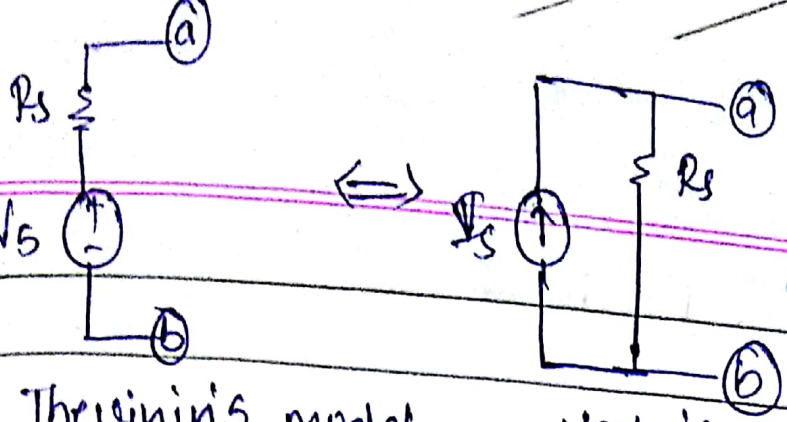

Thevinin's model Norton's Equi model.

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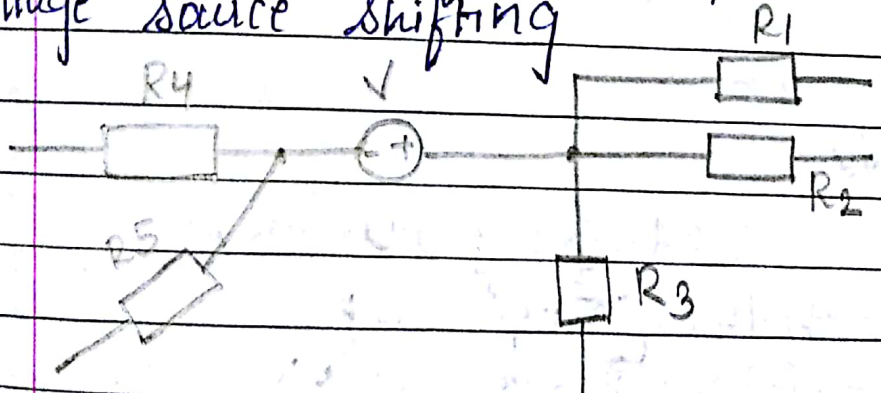
SOURCE SHIFTING: ① When Ideal Sources are present in the network then source transformation cannot be done as these ideal sources will not be having Internal resistance ② In order to solve such problems source shifting method is used which is as shown below and there are two types of source shifting

(i) A Voltage Source shift (E-Shift)
(ii) A Current " " (I- ") $I \to 0 \Rightarrow O/C$. $V \to 0 \Rightarrow S/C$.

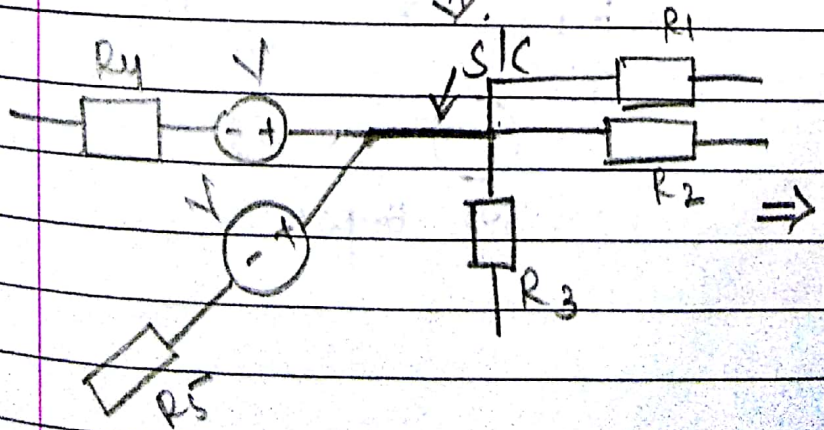
Let us consider foll^n examples.

Voltage Source shifting

①



at a time one side is applied



⇒

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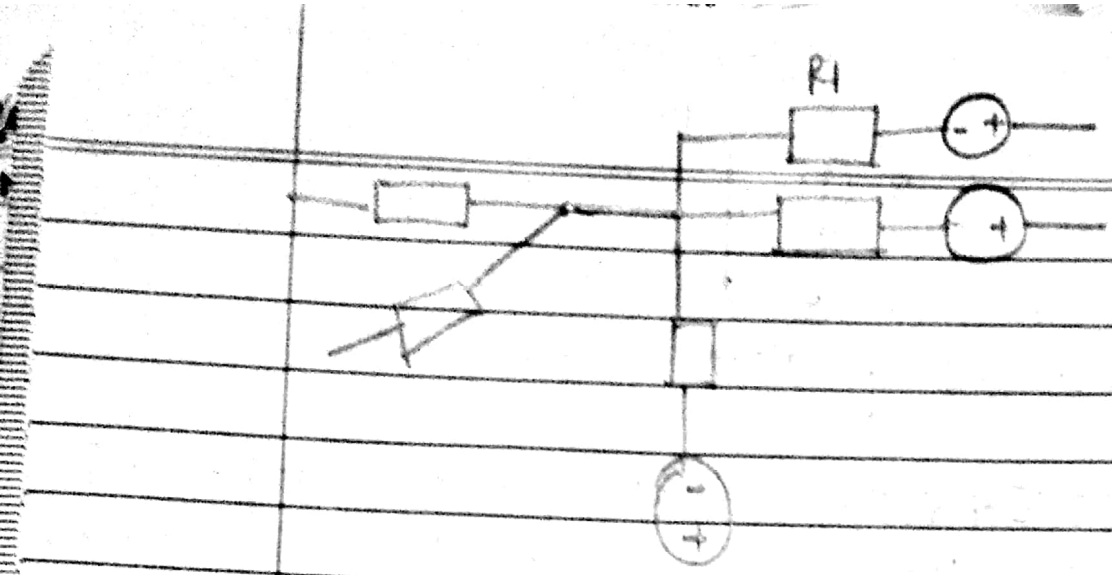

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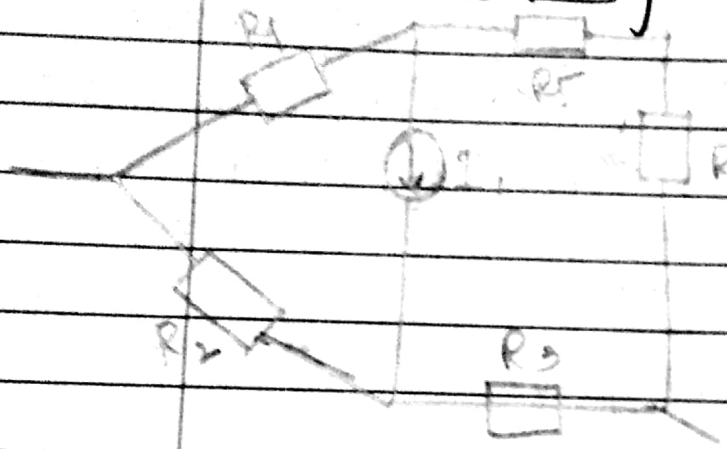
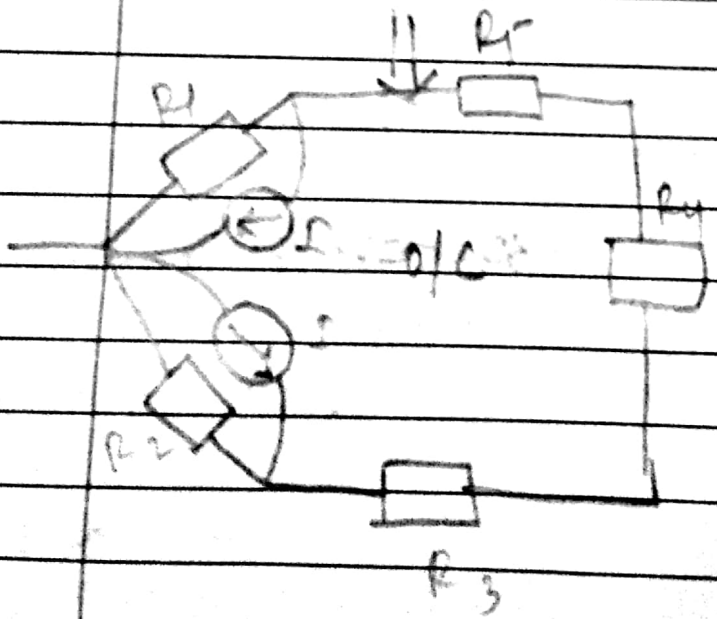
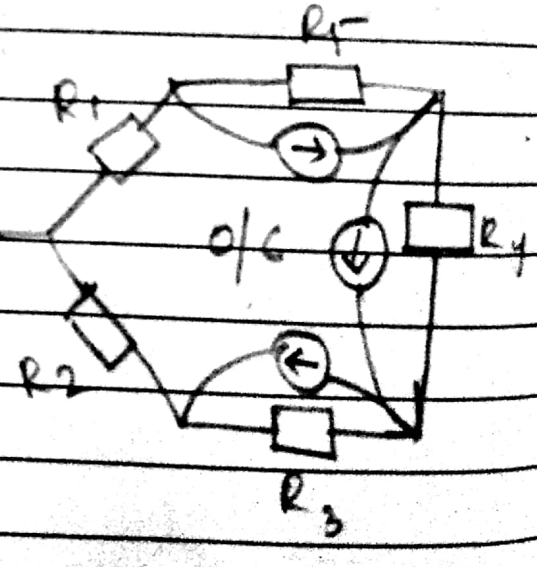
Current Source Shifting:





(or)



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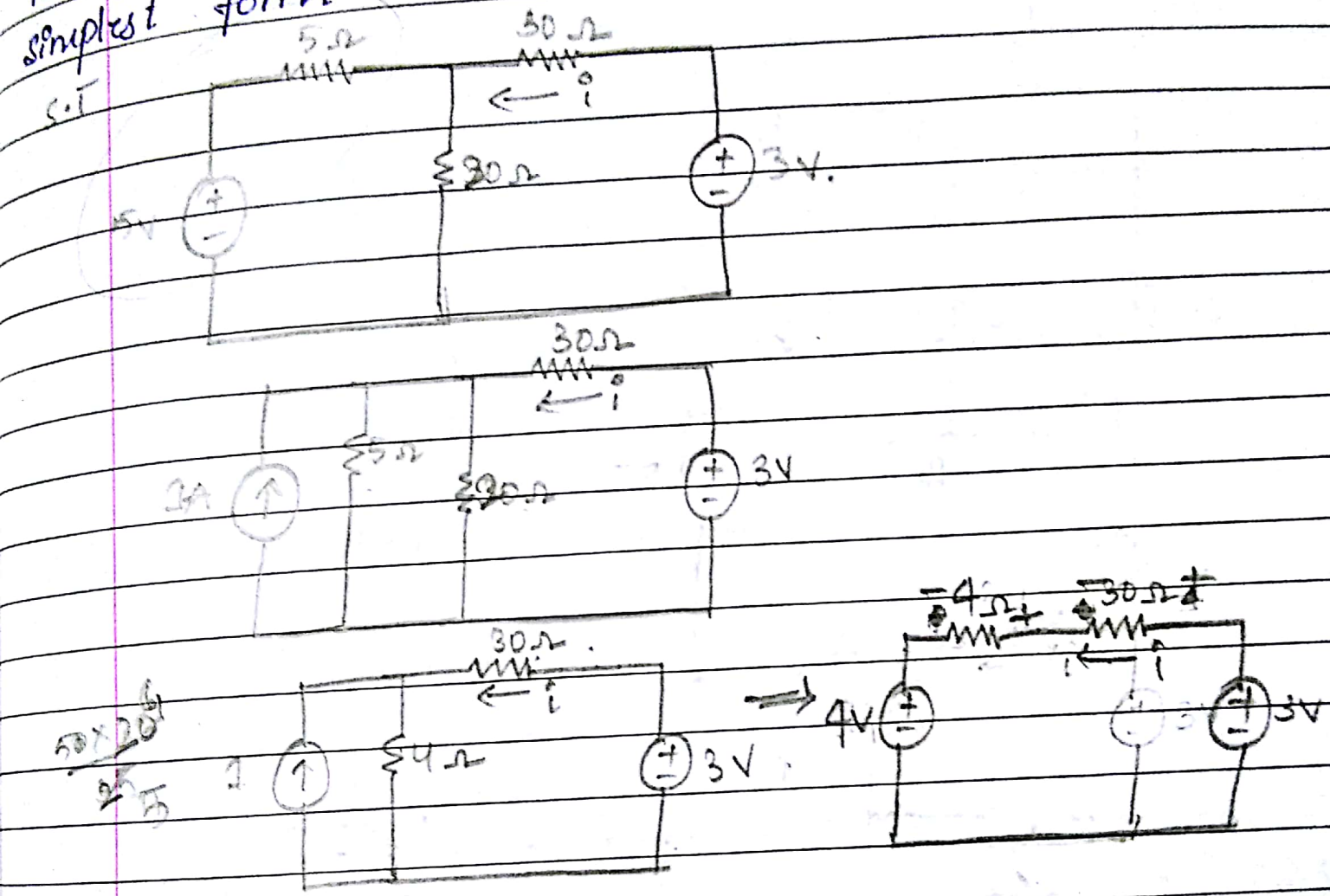
Q) Find current I in the foll^n ckt using Source Transformat^n by reducing the foll^n ckt into its simplest form



$+30i - 4i - 4 + 3 = 0$

$-34i = 1$

$i = -1/34$

$i = -29.41\,mA$

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Om Sai:

and Parameter:

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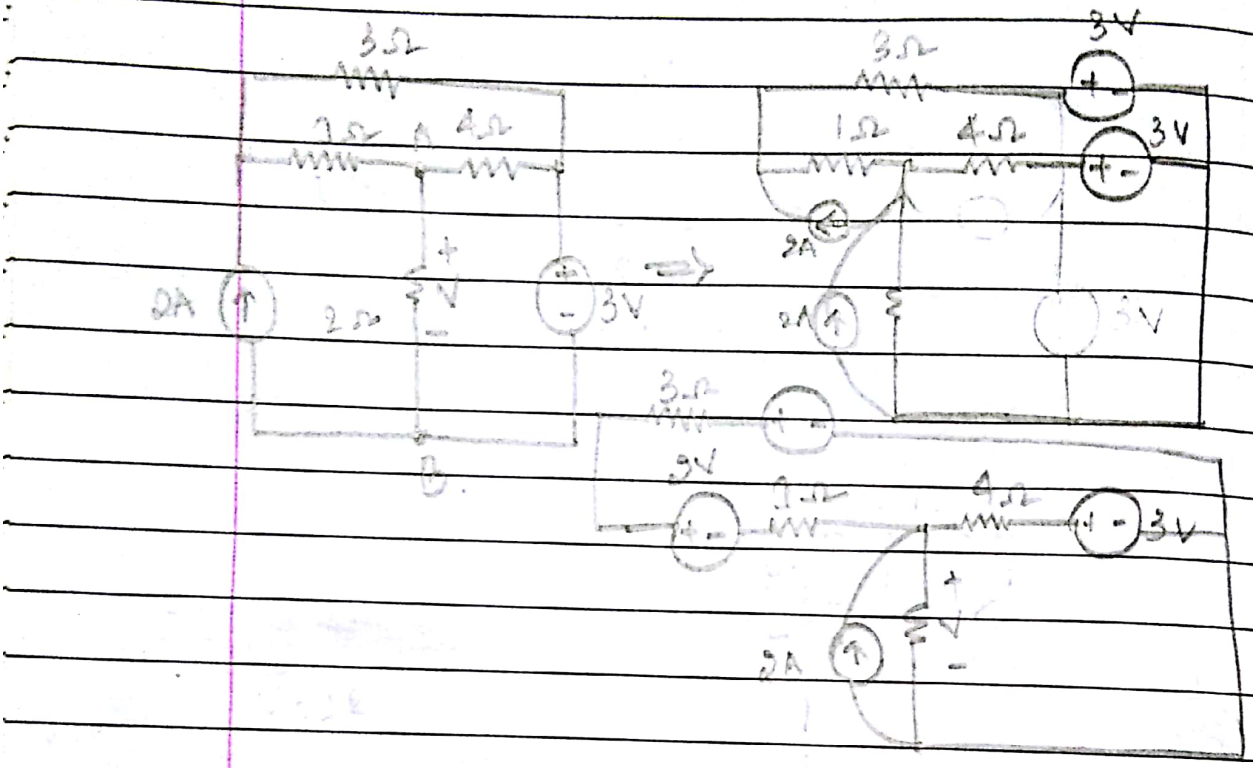
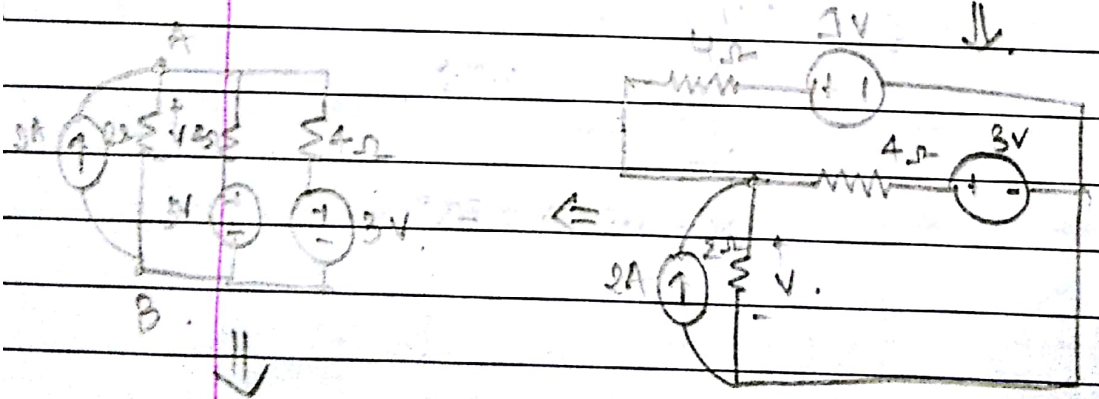
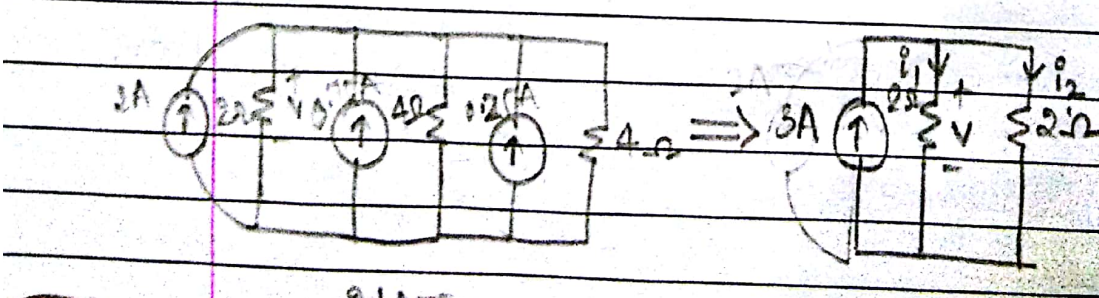
⑤. Use source shifting and source Transformation to determine the voltage across 2Ω resistor in the following ckt.







2+0.75+0.25 = 3A.

$\frac{2 \times 4}{6} = 2\Omega$.

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current division principle. P = 3

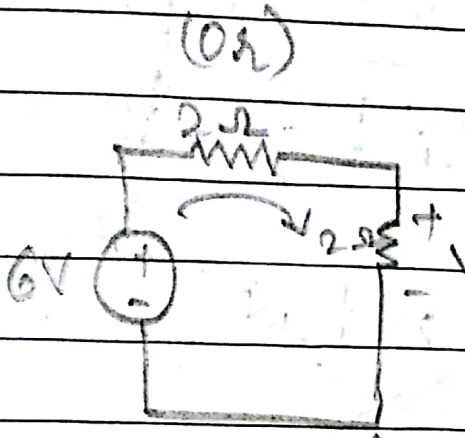
same resistor $\therefore 3/2 = 1.5A = i_1 = i_2$

$$i_1 = \frac{i \times R_1}{R_1 + R_2}$$

$$i_1 = \frac{3 \times 2}{2+2} = \frac{6}{4} = 1.5A.$$

$$V = i_1 \times 2 = 3V.$$

(Or)



$$6 - i(4) = 0$$

$$i = 6/4 = 1.5A.$$

$$V_1 = 1.5 \times 2 = 3V$$

5. Apply Source shifting And Source transformation for four cct to determine voltage V_{ab} in four network.

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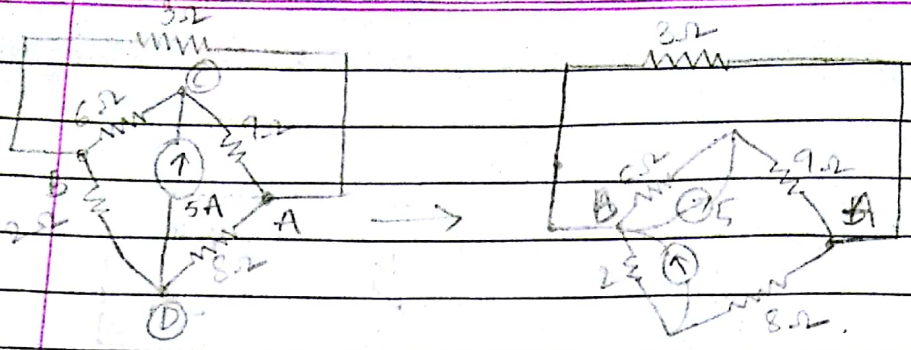

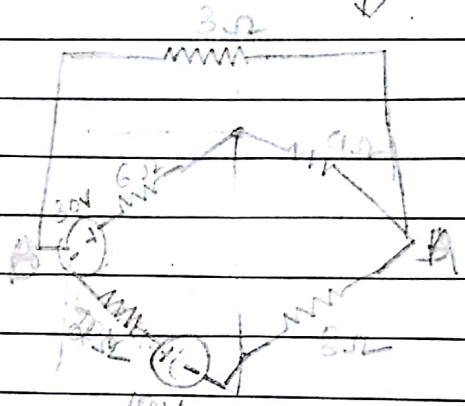

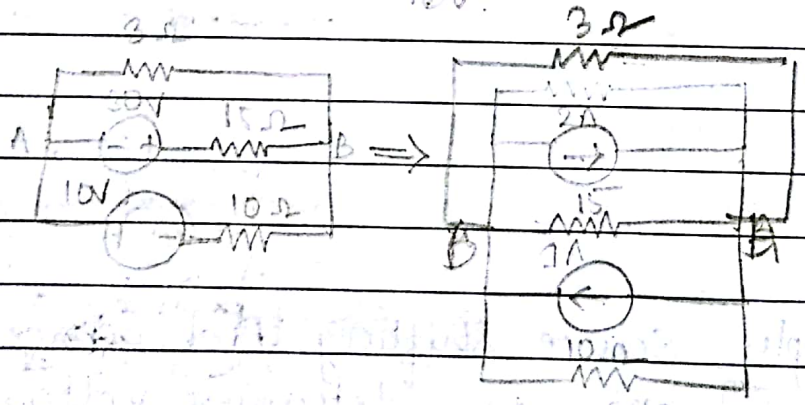

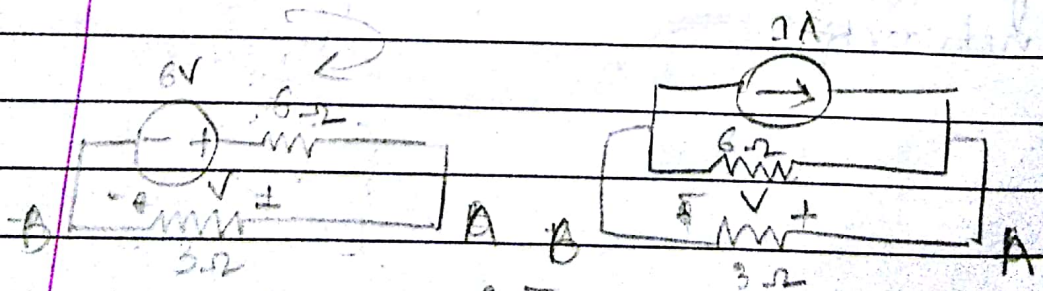

$+6 - 6i + 3i = 0$

$6 = 9i$

$i = 2/3$

$i = 2A$

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$V = 2 \times 3 = 2V \quad -2V$

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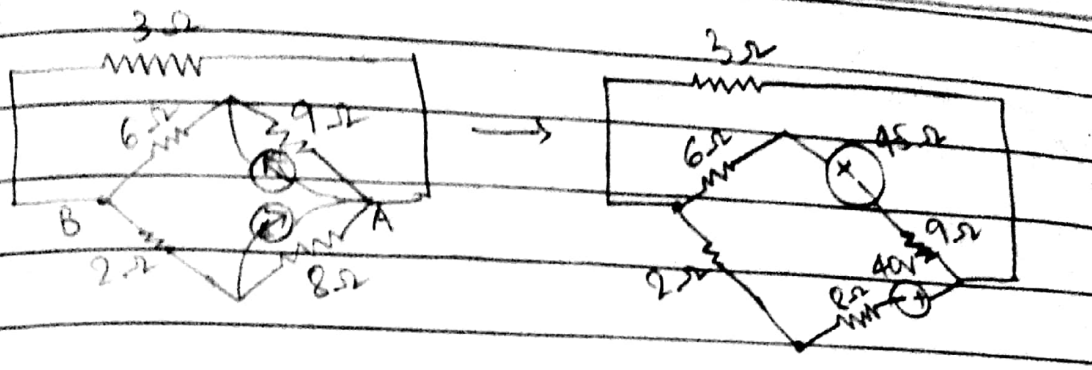
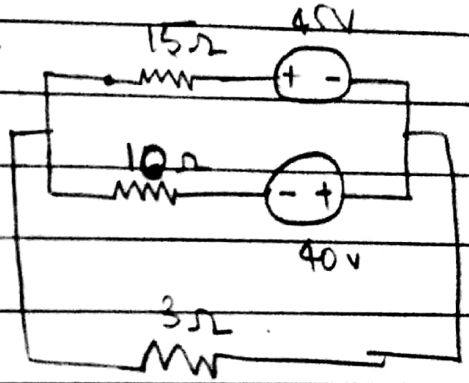
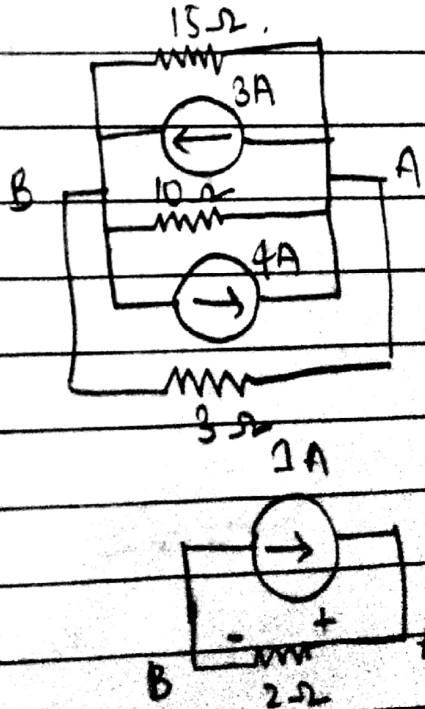
$V_{ba} = 2V \quad V_{ab} = -2V$







$V_{ab} = -2 \times 1 = -2V$
$V_{ab} = 2 \times 1 = 2V$

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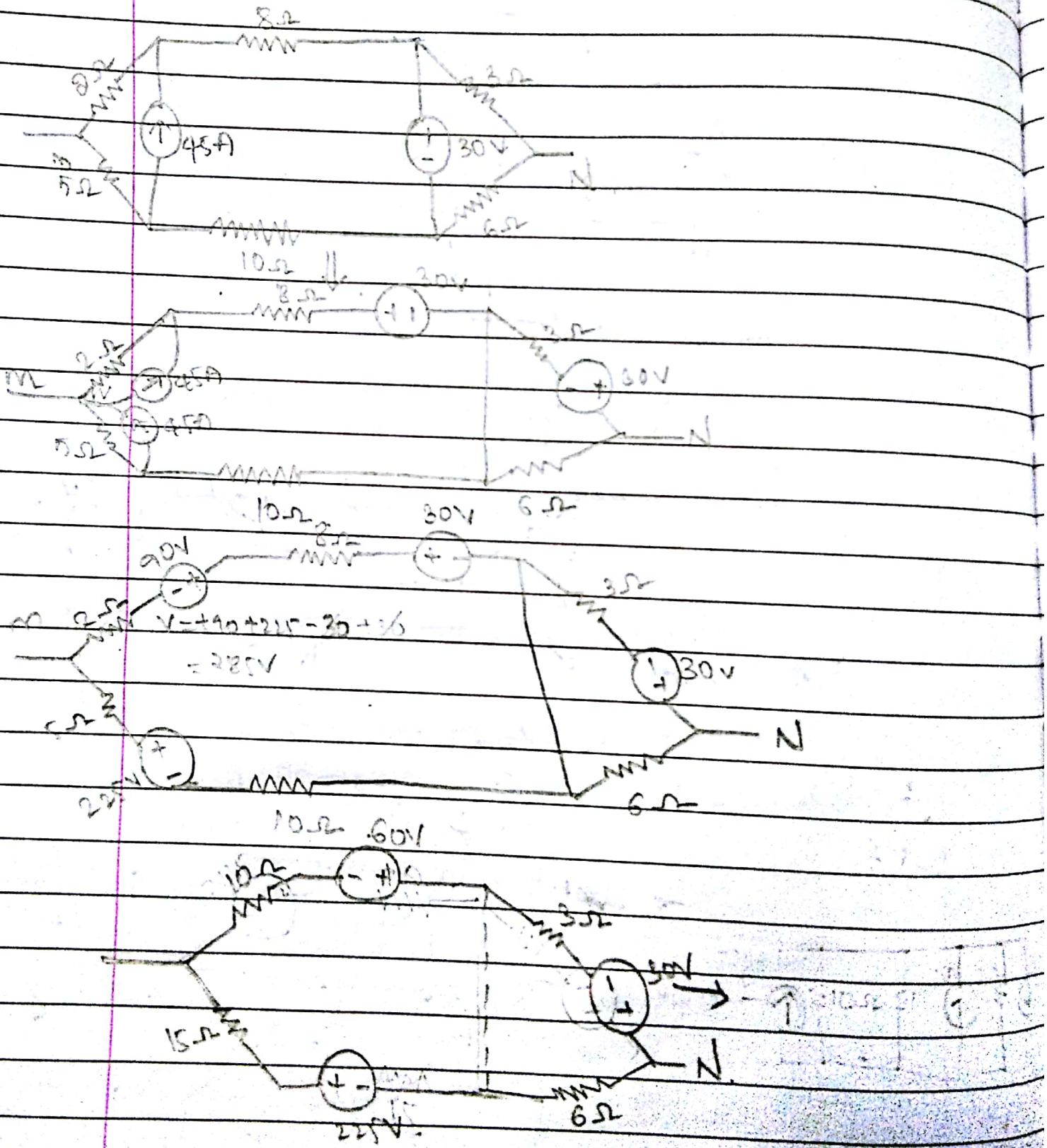
(4) Convert the fou^n ckt into single voltage source by applying source shifting and source Transformat



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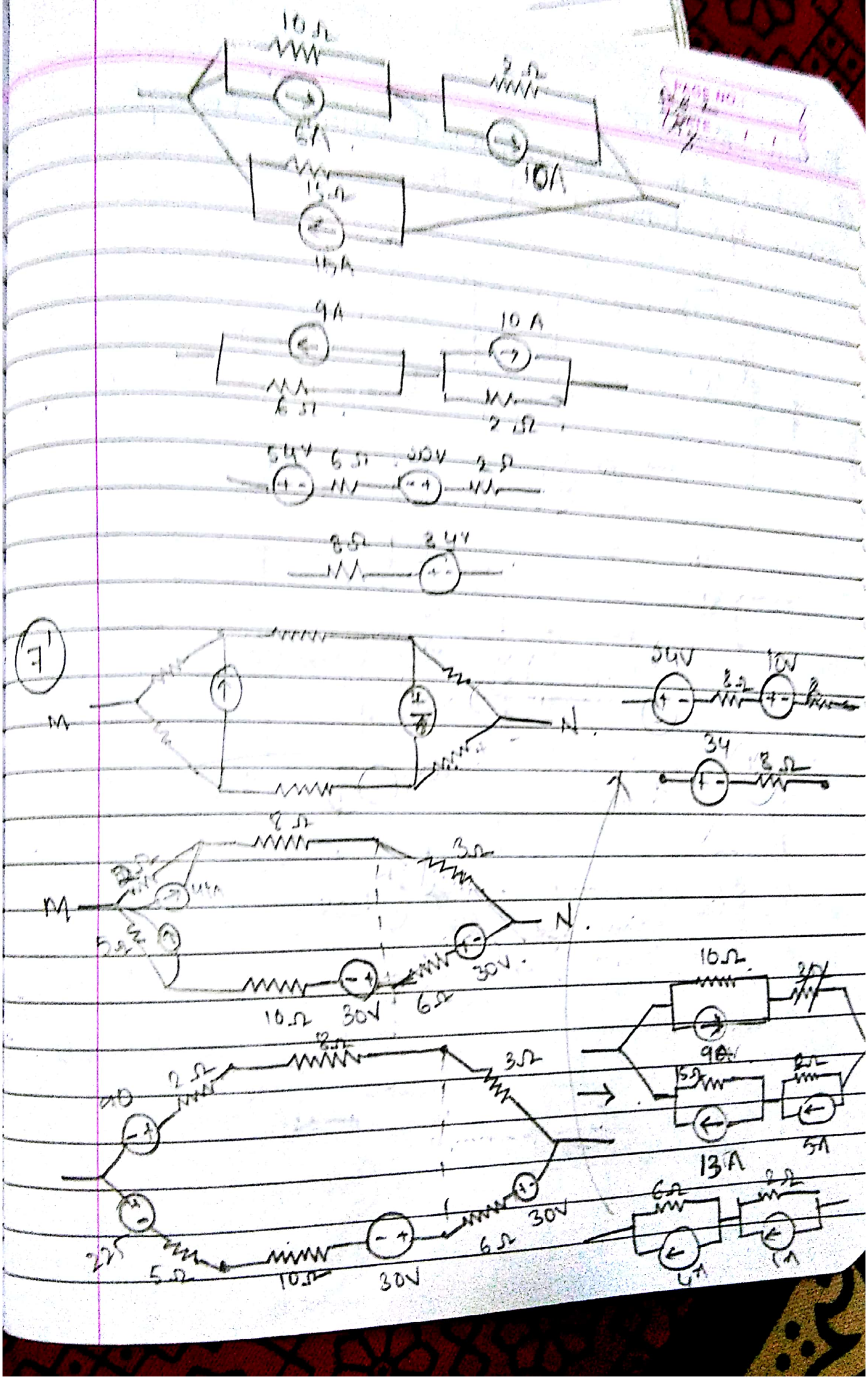

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Resistance in Series and Parallel:

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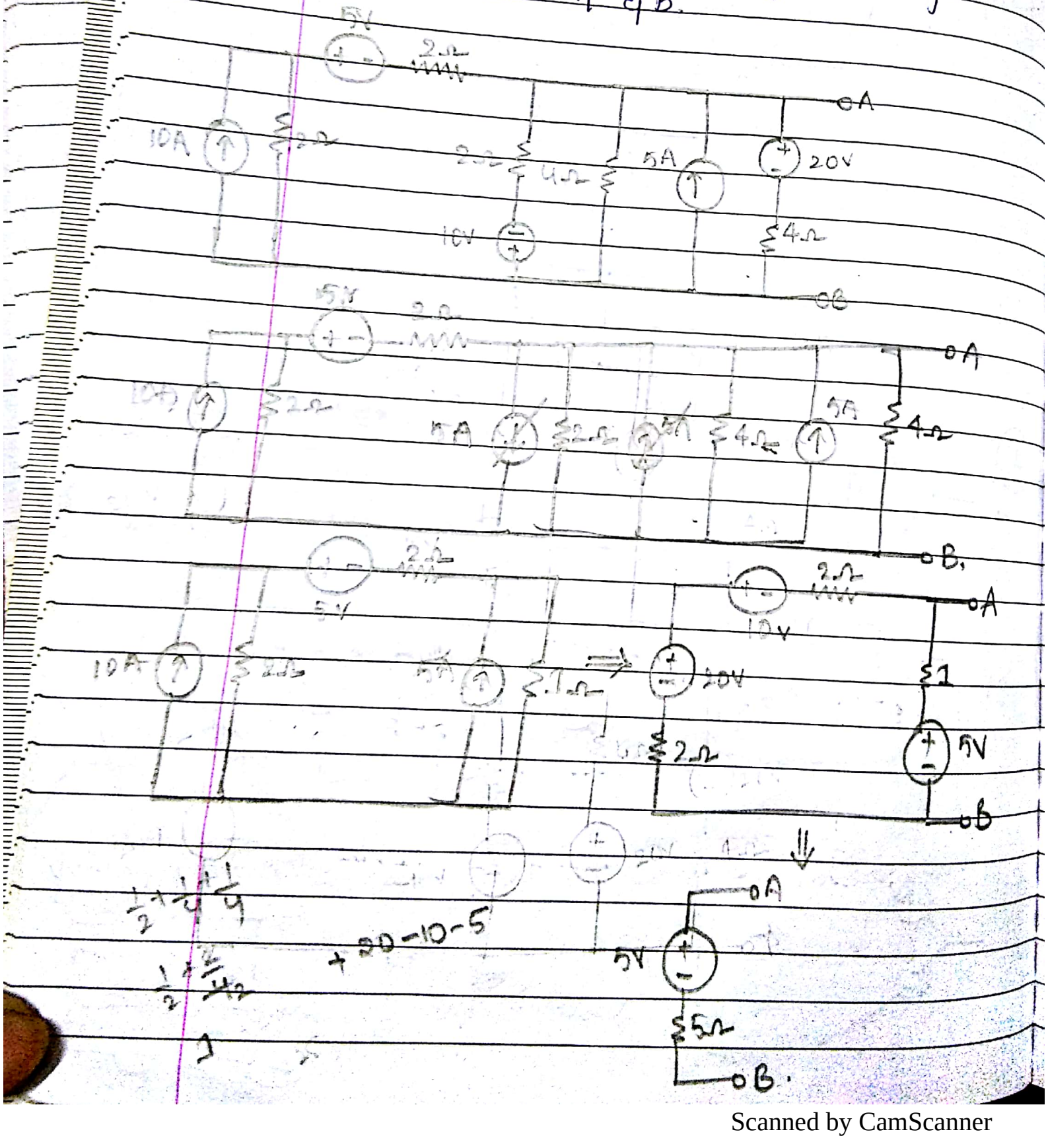
(1). Reduce the Circuit shown to single voltage source b/w terminals A & B.



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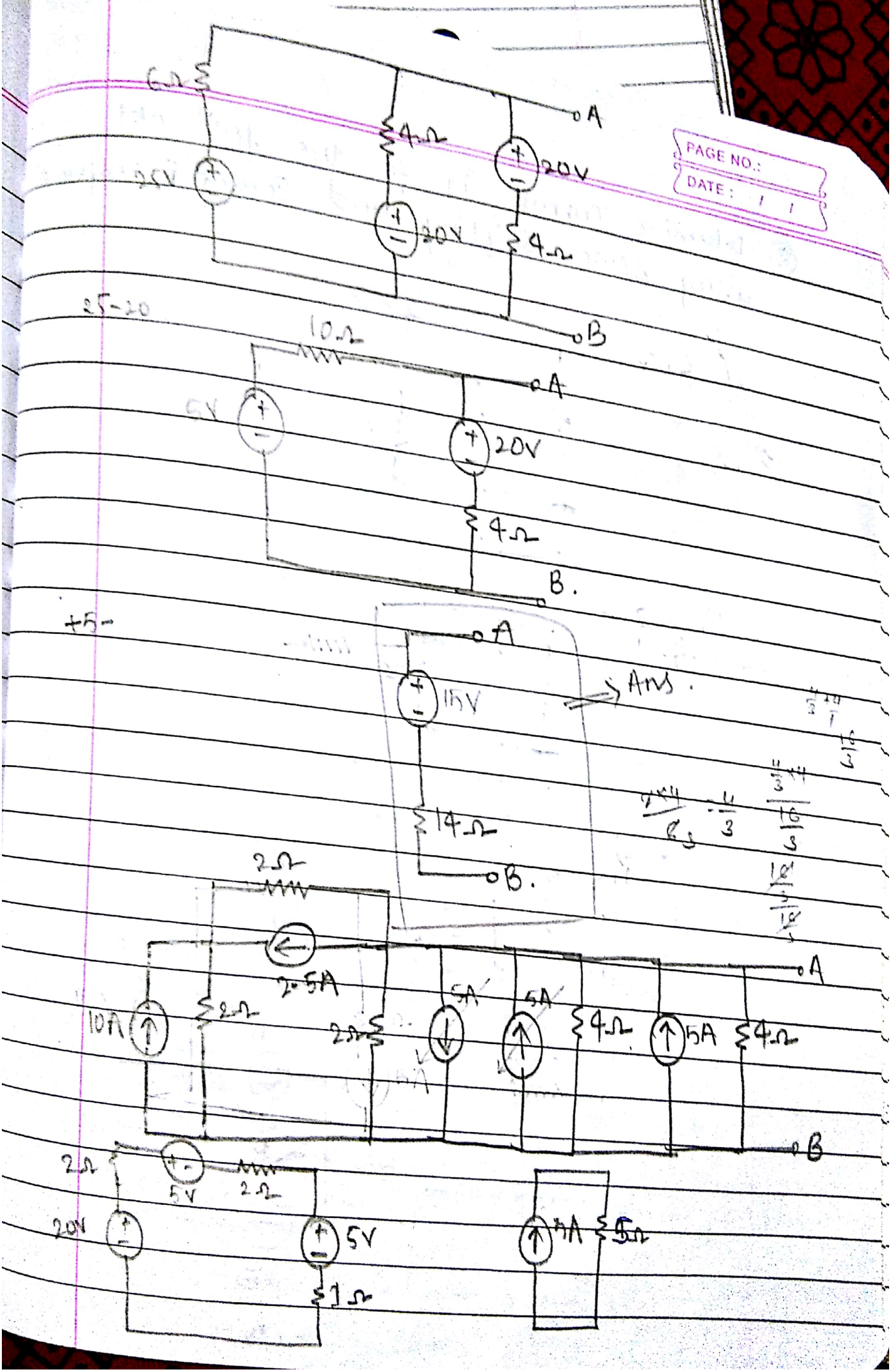

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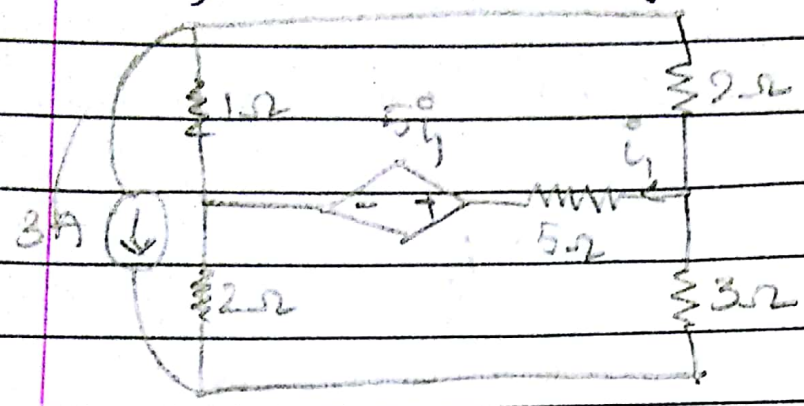
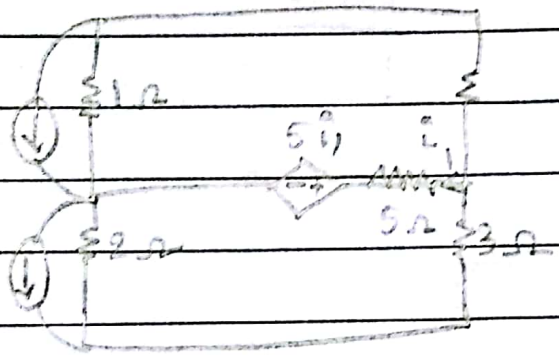
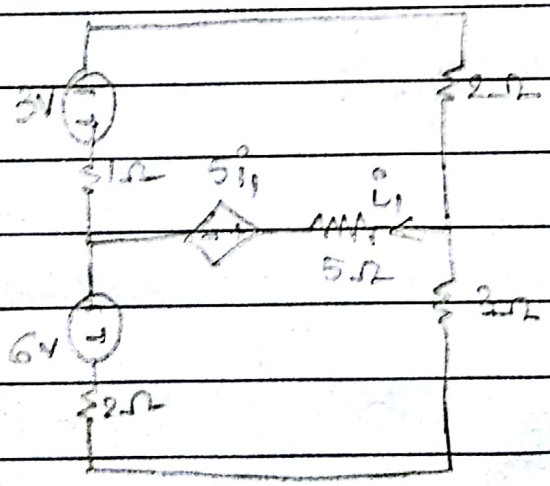
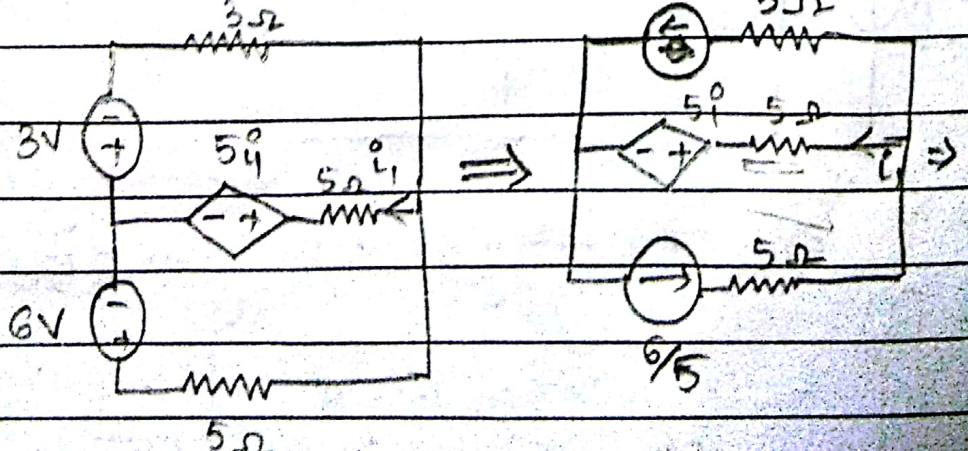
(8) Determine current I_1 for the foll^n ckt using source shifting and source Transformat^n







$$-1+\frac{6}{5}=\frac{1}{5}$$



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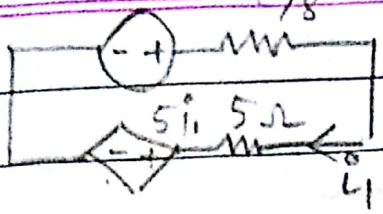
3×5

3/8 15/8 Ω



$-5i_1 - 5i_1 + \frac{3}{8} - \frac{15}{8}i_1 = 0$

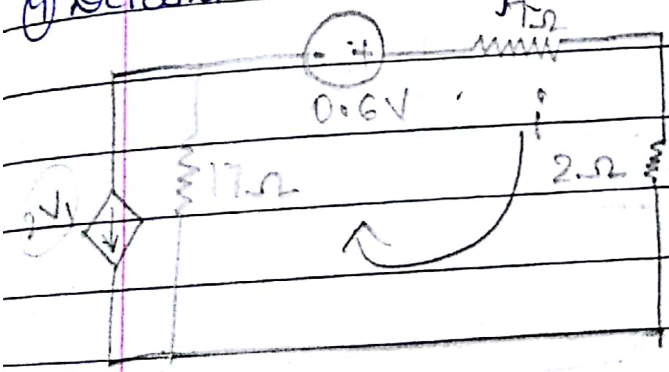
$i_1\left(-10 - \frac{15}{8}\right) = -\frac{3}{8}$

$i_1 \frac{95}{8} = 3$

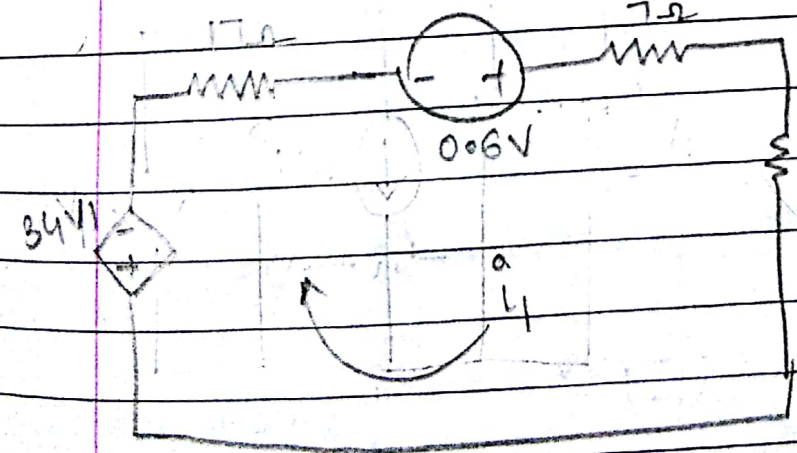
$i_1 = 3/95$

$i_1 = 31.578\,mA$

Q Determine Voltage V_1 using Source Transformation.



$V = 2i$



$V_1 = i_1 R$

$= 2i_1$

$V_1 = 2 \times 12.76\,mV$

$-34V_1 - 17i_1 + 0.6 - 7i_1 - V_1 = 0$ $\quad i_1 = 6.382$

$-68i_1 - 17i_1 + 0.6 - 7i_1 - 2i_1 = 0$

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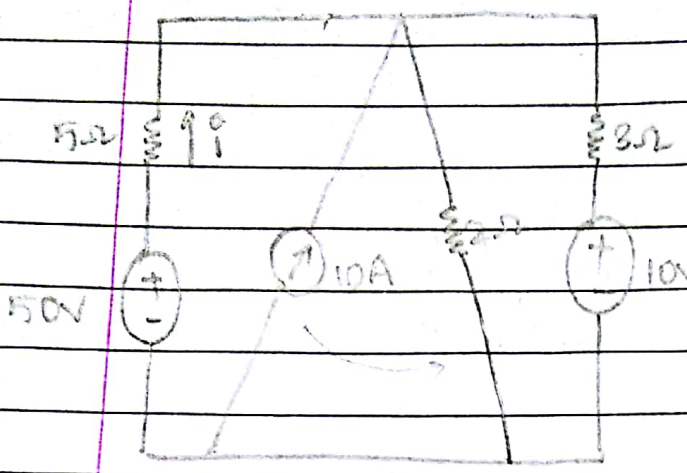
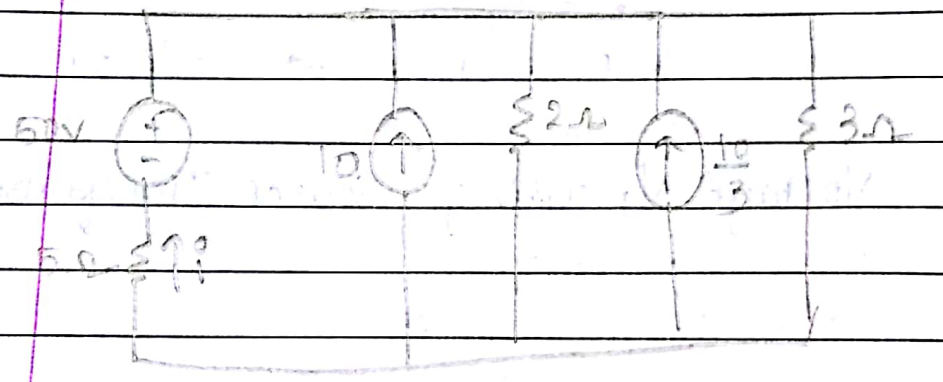
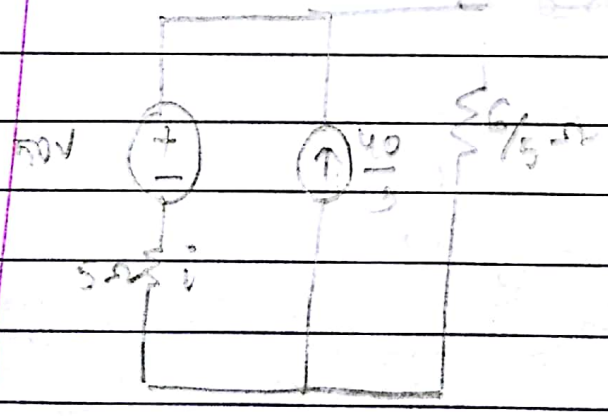
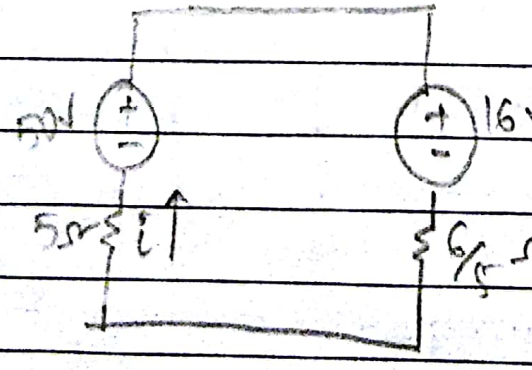
Find current i and also power delivered by 50V

(10).









$-5i + 50 - 16 - \frac{6}{5}i = 0$

$34 = \left(5 + \frac{6}{5}\right)i$

$34 = \frac{31}{5}i$

$\frac{170}{31} = i \quad i = 5.48$

$P = VI = 50 \times 5.48 = 274.19\,W$

MESH ANALYSIS:

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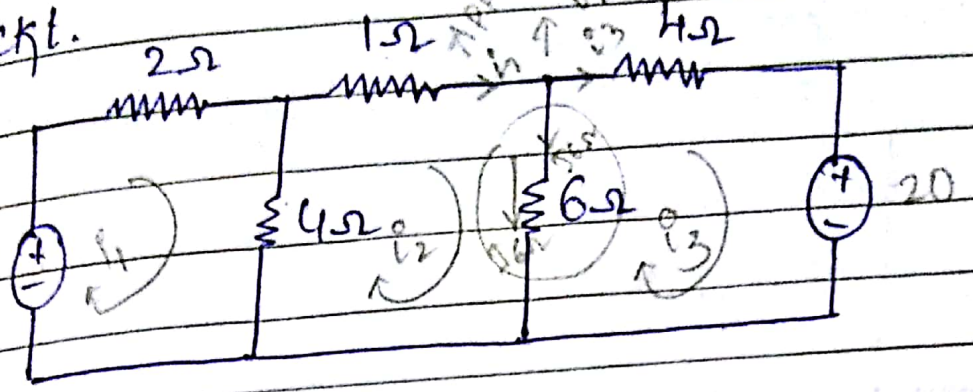
① Determine current through 6Ω Resistor in following ckt.



$10 - 2i_1 - 4(i_1 - i_2) = 0$

$10 - 2i_1 - 4i_1 + 4i_2 = 0$

$10 = 6i_1 - 4i_2$

$0 = 10 - 6i_1 + 4i_2 \rightarrow (1)$

$-4(i_2 - i_1) - i_2 - 6(i_2 - i_3) = 0$

$-4i_2 + 4i_1 - i_2 - 6i_2 + 6i_3 = 0$

$-11i_2 + 4i_1 + 6i_3 = 0 \rightarrow (2)$

$-6(i_3 - i_2) - 4i_3 = 20$

$-6i_3 + 6i_2 - 4i_3 = 20$

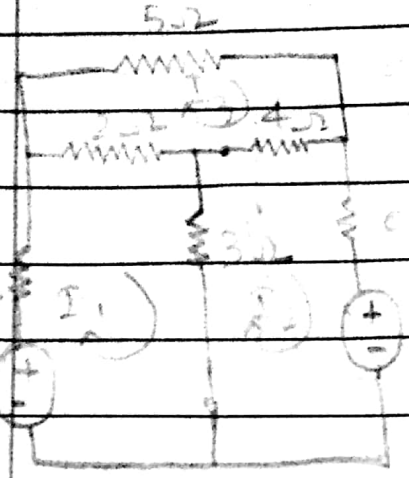
$6i_2 - 10i_3 = 20 \rightarrow (3)$

$$\begin{bmatrix} 6 & -4 & 0 \\ 4 & -11 & 6 \\ 0 & 6 & -10 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \\ 20 \end{bmatrix}$$

$x = 65/11 \quad y = -80/11 \quad z = -190/11$

$i_1 = 0.9152 \quad i_2 = -1.126 \quad i_3 = -2.676$

(9) Determine all loop currents in ckt.



$$-3(I_1-I_2)-4(I_1-I_3)-0.2I_1=15$$

$$-3I_2+3I_1-4I_2+4I_3-0.2I_2=15$$

$$-7.2I_2+3I_1+4I_3=15$$

$$-5(I_3-I_1)-5I_3-4(I_3-I_2)=0$$

$$-2I_3+2I_1-5I_3-4I_3+4I_2=0$$

$$2I_1+4I_2-11I_3=0$$

$$\begin{bmatrix} -5.2 & 3 & 2 \\ 3 & -7.2 & 4 \\ 2 & 4 & -11 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -10 \\ 15 \\ 0 \end{bmatrix}$$

$\Delta = 0.1104$ $I_2 =$

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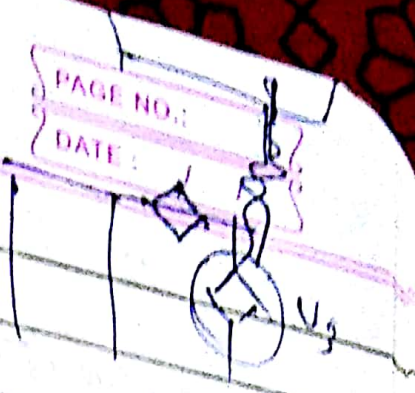
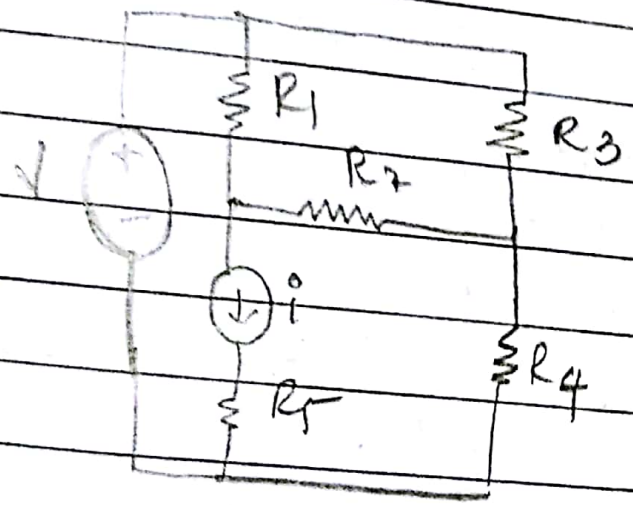
$$I_1 = \frac{\begin{vmatrix} -10 & 3 & 2 \\ 15 & 7.2 & 4 \\ 0 & 4 & 11 \end{vmatrix}}{\begin{vmatrix} 5.2 & 3 & 2 \\ 3 & -7.2 & 4 \\ 2 & 4 & -11 \end{vmatrix}}$$

$I_1 = 0.11\,A$



ckt Analysis using SuperMesh:



(*) Find i_o in the foll^n ckt using Supermesh.

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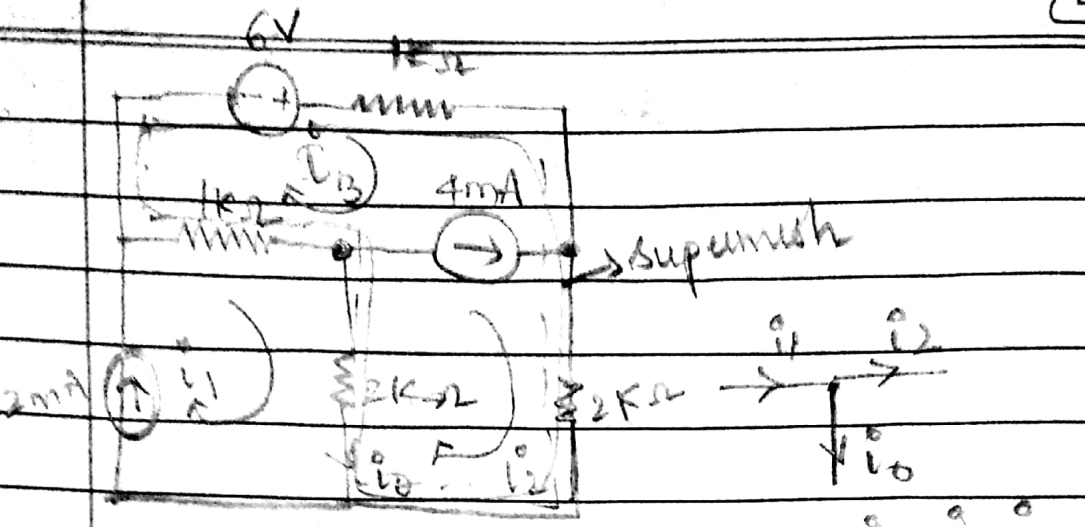


$i_0 = i_1 - i_2$

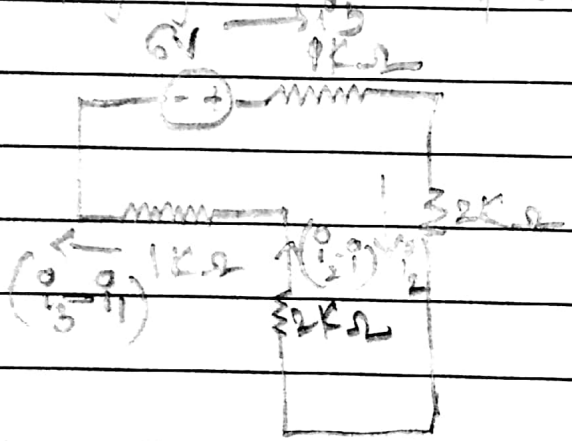
Constraint Eqn.

$i_1 = 2mA$

$i_0 = i_1 - i_2$

$i_2 - i_3 = 4mA$.

Applying KVL to supermesh.



$$6 - 1i_3 - 2i_2 - 2(i_2 - i_1) - (i_3 - i_1) = 0$$

$$6 - i_3 - 2i_2 - 2i_2 + 2i_1 - i_3 + i_1 = 0$$

$$6 - 2i_3 - 4i_2 + 3i_1 = 0$$

$$6 = 3i_1 + 4i_2 + 2i_3$$

$$6 = -3i_1 + 4i_2 + 2i_3$$

$$6 = -6 + 4i_2 + 2i_3$$

$$12 = 4i_2 + 2i_3$$

$$= 6$$

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$2i_1 - 2i_3 = 8\,mA$

$4i_2 + 2i_3 = 12\,mA$

$3i_2 = 20\,mA$

$i_2 = 3.3\,mA$

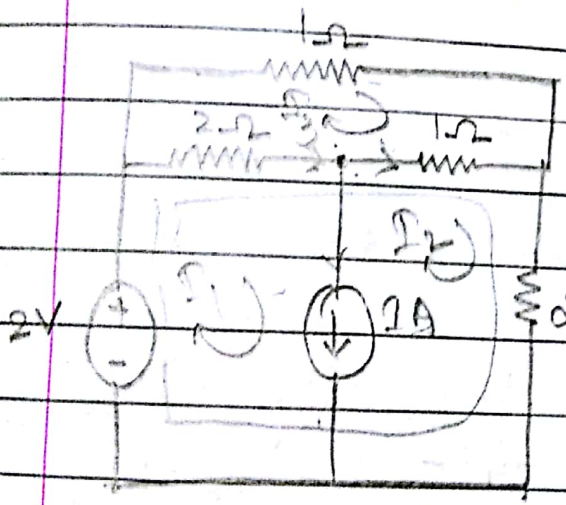
$3.3 - i_3 = 4\,mA$

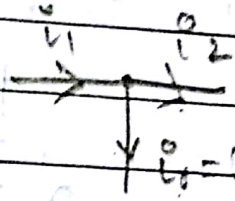
$i_3 = -0.667\,mA$

$i_o = i_1 - i_2$

$i_o = -1.3\,mA$

(*) Determine I_1, I_2, I_3 in the foll^n using supermesh





$-i_o - i_2 = -i_1$

$+1 = i_1 + i_2$

$i_1 - i_2 = 1$

$2 - 2(I_1 - I_3) + 1(I_2 - I_3) - 2I_2 = 0$

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

$2 - 2I_1 + 3I_3 - 3I_2 = 0$

$2 = 2I_1 + 3I_2 - 3I_3$

$-I_3 - 1(I_3 - I_2) - 2(I_3 - I_1) = 0$

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

$2I_1 + I_2 - 4I_3 = 0$

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$2I_1 + I_2 = 4I_3$

$2I_1 + 3I_2 - \frac{3}{4}(2I_1 + I_2) = 2$

$8I_1 + 12I_2 - 6I_1 - 3I_2 = 8$

$2I_1 + 9I_2 = 8$

$9I_1 - 9I_2 = 9$

$11I_1 = 17$

$I_1 = 17/11 = 1.5$

$I_1 - I_2 = 1$

$\frac{17}{11} - 1 = I_2$

$0.54 = \frac{6}{11} = I_2$

$\frac{2 \times 10}{11} + \frac{6}{11} = 4I_3$

$\frac{30 + 6}{11} = 4I_3$ $\quad \frac{10}{\frac{40}{11}} = 4I_3$

$I_3 = \frac{10}{11}$

$= 0.90$

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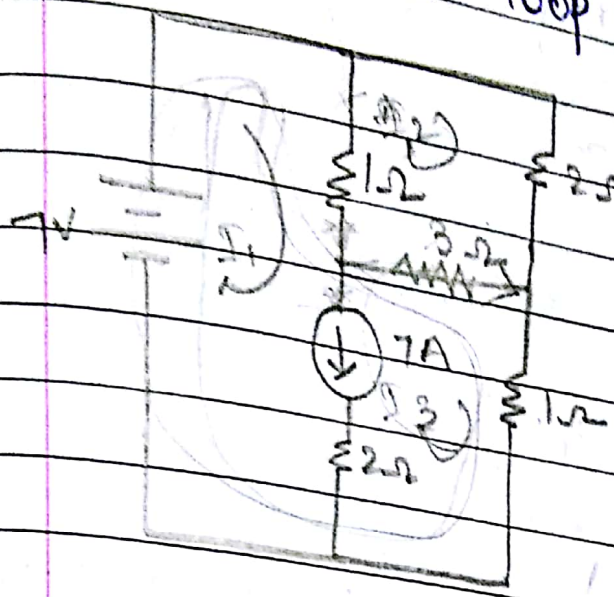
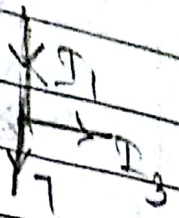
(*) Determine all 3 loop current in ckt





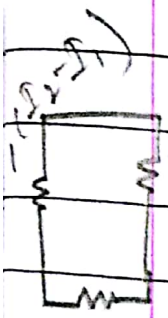
$I_1 - I_3 = 7$

$7 - 1(I_1 - I_2) - 3(I_3 - I_2) - 1(I_3) = 0$

$7 - I_2 + I_1 - 3I_3 + 3I_2 - I_3 = 0$

$7 + 2I_2 + I_1 - 4I_3 = 0$

$7 = -I_1 - 2I_2 + 4I_3$



$-1(I_2 - I_1) - 2I_2 - 3(I_2 - I_3) = 0$

$-I_2 + I_1 - 2I_2 - 3I_2 + 3I_3 = 0$

$I_1 - 6I_2 + 3I_3 = 0$

$I_1 + 3I_3 = 6I_2$

$I_2 = \frac{I_1 + 3I_3}{6}$

$7 = -I_1 - 2\left(\frac{I_1 + 3I_3}{6}\right) + 4I_3$

$42 = -6I_1 - 2I_1 - 6I_3 + 4I_3$

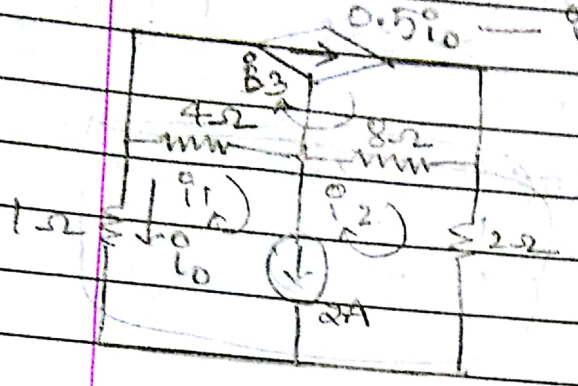
$42 = -8I_1 - 2I_3$

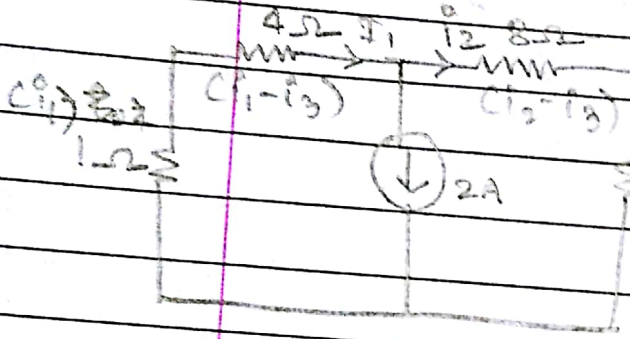
$42 = 8I_1 - 8I_3$

$I_3 = 2.33A$

$I_2 =$

⑤ Determine current i_o using supermesh.





Applying KVL to Supermesh

$$-i_1 - 4(i_1 - i_3) - 8(i_2 - i_3) - 2i_2 = 0$$
$$-i_1 - 4i_1 + 4i_3 - 8i_2 + 8i_3 - 2i_2 = 0$$
$$-5i_1 + 12i_3 - 10i_2 = 0$$

$$i_1 - 2 - i_2 = 0$$
$$i_1 - i_2 = 2$$

and also $i_o = -i_1$

$$0.5i_o = -0.5i_1$$

$$-4(i_3 - i_1) - 0.5i_1 - 8(i_3 - i_2) = 0$$
$$-4i_3 + 4i_1 - 0.5i_1 - 8i_3 + 8i_2 = 0$$
$$3.5i_1 - 12i_3 + 8i_2 = 0$$
$$3.5i_1 + 12 \times 0.5i_1 + 8i_2 = 0$$
$$9.5i_1 + 8i_2 = 0$$

don't take because current flowing in loop

$$8i_1 - 8i_2 = 16$$
$$9.5i_1 + 8i_2 = 0$$
$$17.5i_1 = 16$$
$$i_1 = \frac{16}{17.5}$$

$$i_1 = 0.9142$$

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$i_o = -i_1 = -0.9142A$

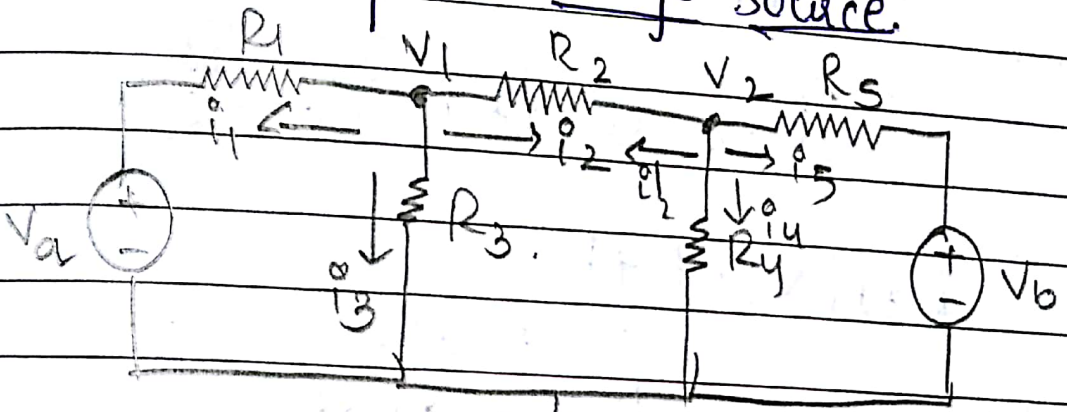
$9.5 \times 0.9142 + 8 i_2 = 0$

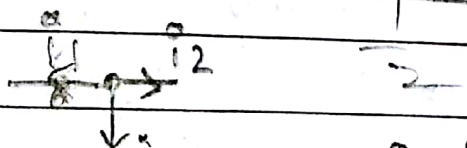
$i_2 = -1.085A$

$-5 \times 0.9142 + 12 i_3 + 10 \times 1.085 = 0.$

$i_3 = -0.4571A$

NODAL ANALYSIS | Node Voltage Source





$i_1 + i_2 + i_3 = 0.$

At node V_1

$$\frac{V_1 - V_a}{R_1} + \frac{V_1}{R_3} + \frac{V_1 - V_2}{R_2} = 0$$

$$\frac{V_1}{R_1} - \frac{V_a}{R_1} + \frac{V_1}{R_3} + \frac{V_1}{R_2} - \frac{V_2}{R_2} = 0$$

$$V_1\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) - \frac{V_2}{R_2} = \frac{V_a}{R_1}$$

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At node V_2

$$-i_2 - i_4 - i_5 = 0$$

$$i_2 + i_4 + i_5 = 0$$

$$\frac{V_2 - V_1}{R_2} + \frac{V_2 - V_b}{R_5} + \frac{V_2}{R_4} = 0$$

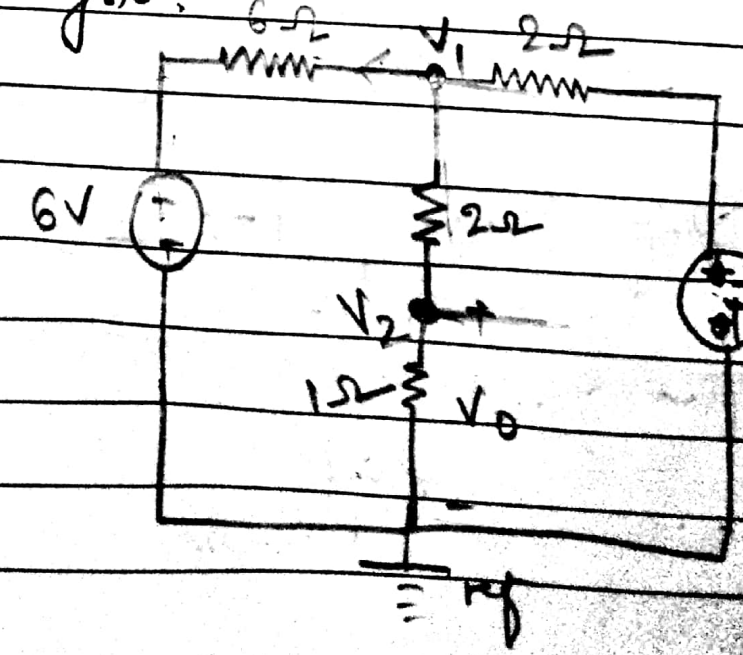
$$\frac{V_2}{R_2} - \frac{V_1}{R_2} + \frac{V_2}{R_5} - \frac{V_b}{R_5} + \frac{V_2}{R_4} = 0$$

$$V_2\left(\frac{1}{R_2} + \frac{1}{R_4} + \frac{1}{R_5}\right) - \frac{V_1}{R_2} = \frac{V_b}{R_5}$$

$$[G][V] = [I]$$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} & -\frac{1}{R_2} \\ -\frac{1}{R_2} & \frac{1}{R_2} + \frac{1}{R_4} + \frac{1}{R_5} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} V_a/R_1 \\ V_b/R_5 \end{bmatrix}$$

Ex: (1). Determine voltage V_o in fⁿ ckt using Nodal Analysis.



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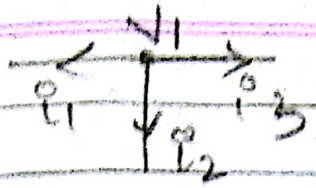

$i_1 + i_2 + i_3 = 0$

$$\frac{V_1 + 6}{6} + \left(\frac{V_1 - V_2}{2}\right) + \frac{V_1 + 3}{2} = 0$$

$$\frac{V_1}{6} + 1 + \frac{V_1}{2} - \frac{V_2}{2} + \frac{V_1}{2} + \frac{3}{2} = 0$$

$$V_1\left(\frac{1}{6} + \frac{1}{2} + \frac{1}{2}\right) - \frac{V_2}{2} = -1 - \frac{3}{2}$$

$$V_1 \frac{7}{6} - \frac{V_2}{2} = -\frac{5}{2}$$

$$\left(\frac{V_2 - V_1}{2}\right) + \frac{V_2}{1} = 0$$

$$\frac{V_2}{2} - \frac{V_1}{2} + \frac{V_2}{1} = 0$$

$$V_2\left(\frac{3}{2}\right) - \frac{V_1}{2} = 0$$

$$-\frac{V_1}{2} + V_2\left(\frac{3}{2}\right) = 0$$

$$\begin{bmatrix} 7/6 & -1/2 \\ -1/2 & 3/2 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} -5/2 \\ 0 \end{bmatrix}$$

$V_1 = 2.5\,V$

$V_2 = 0.167\,V - 0.833\,V$

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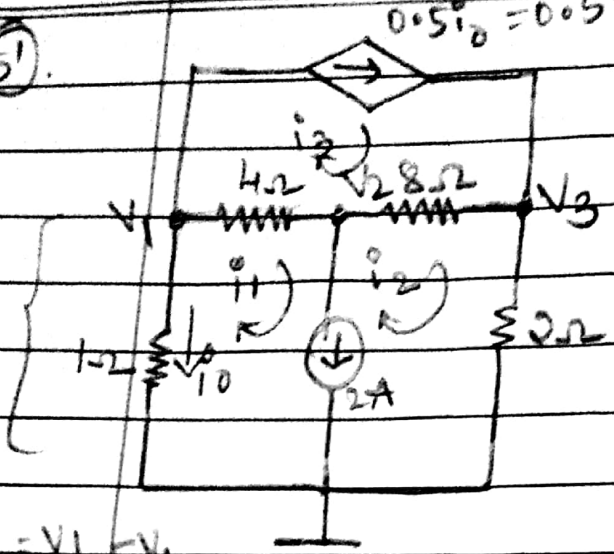
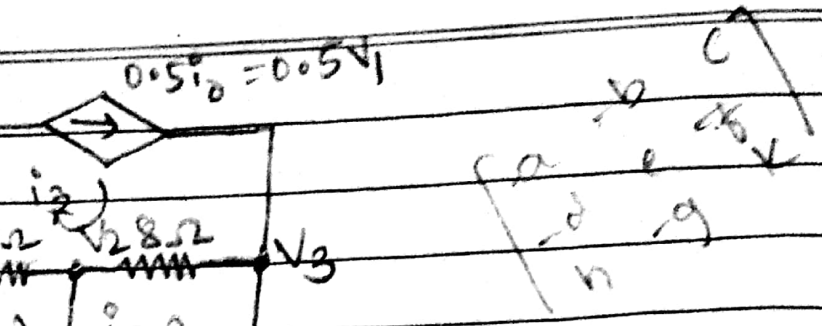
(5)





$i_0 = \frac{V_1}{1} = V_1$

$\frac{V_1 - V_3}{4} + 0.5V_1 + \frac{V_1}{1} = 0$

$V_1(0.25 + 0.5 + 1) = \frac{V_2}{4}$

$V_1(1.75) = \frac{V_2}{4}$

$\frac{V_2 - V_1}{4} + 2 + \frac{V_2 - V_3}{8} = 0$

$\frac{V_2}{4} - \frac{V_1}{4} + 2 + \frac{V_2}{8} - \frac{V_3}{8} = 0$

$\frac{-V_1}{4} + \frac{V_3}{8} + 0.375V_2 = -2$

$\frac{V_1}{4} - 0.375V_2 + \frac{V_3}{8} = 2$

$\frac{V_3}{2} + \frac{V_3 - V_2}{8} - 0.5V_1 = 0$

$\frac{V_3}{2} + \frac{V_3}{8} - \frac{V_2}{8} - 0.5V_1 = 0$

$0.625V_3 - \frac{V_2}{8} - 0.5V_1 = 0$

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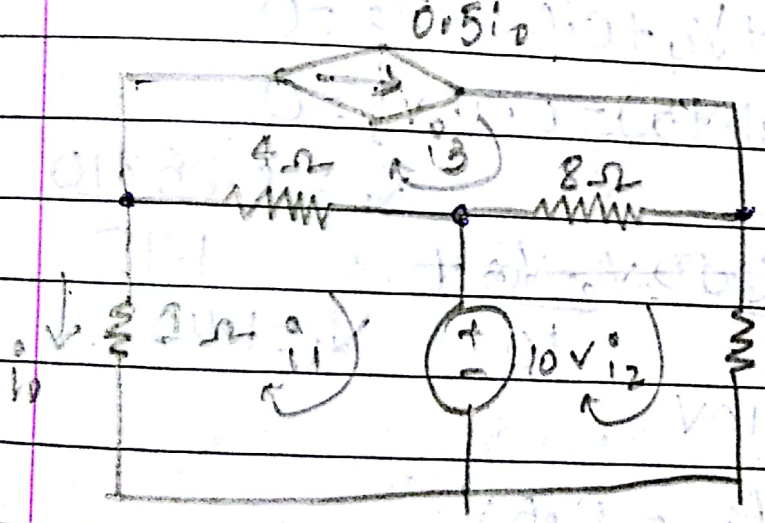
$V_1 = -0.952V$

$V_2 = -6.6V$

$V_3 = -2.09V$.

$$\begin{bmatrix} 1.75 & -1/4 & 0 \\ 1/4 & -0.375 & 1/8 \\ -0.5 & -1/8 & 0.625 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

(4) Determine Current I_o using Mesh and Nodal Analysis for foll^n ckt



$i_o = -i_1$

loop 1 $-i_1 - 4(i_1 - i_3) = 10$

$-i_1 - 4i_1 + 4i_3 = 10$

$-5i_1 + 4i_3 = 10$

loop 2 $10 - 8(i_2 - i_3) - 2i_2 = 0$

$10 - 8i_2 + 8i_3 - 2i_2 = 0$

$10 = +10i_2 - 8i_3$

loop 3 $-4(i_3 - i_1) + 0.5i_o - 8(i_3 - i_2) = 0$

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$-4i_3 + 4i_1 + 0.5i_0 - 8i_3 + 8i_2 = 0$

$-4i_3 + 4i_1 - 0.5i_1 - 8i_3 + 8i_2 = 0$

$-12i_3 - 4.5i_1 + 8i_2 = 0$

$+5i_0 + 4(0.5i_0) = 10$

$5i_0 + 2i_0 = 10$

$$\boxed{i_0 = \frac{10}{7}\,A}$$

Nodal Analysis:

$i_0 = \frac{V_1}{1}$.

$\frac{V_1}{1} + \frac{V_1 - V_2}{4} = -0.5i_0$

$= -0.5V_1$

$V_1 + \frac{V_1}{4} - \frac{V_2}{4} + 0.5V_1$.

$V_1(1 + V_4 + 0.5) - \frac{V_2}{4} = 0$

$V_1(1.75) - 0.25V_2 = 0$

$V_1 = \frac{0.25 \times 10}{1.75}$

$V_1 = 1.428$.

~~$\frac{V_2 - V_1}{4} + \frac{V_2}{10} + \frac{V_2 - V_3}{10}$~~

$V_2 = 10V$

$\frac{V_3 - V_2}{8} + \frac{V_3}{2} = 0.5V_1$

$\frac{V_3}{8} - \frac{V_2}{8} + \frac{V_3}{2} - 0.5V_1 = 0$

$V_3\left(\frac{1}{8} + \frac{1}{2}\right) - \frac{V_2}{8} - 0.5V_1 = 0$

$V_3(0.625) - V_2(0.125) - 0.5V_1 = 0$

$V_3(0.625) - 1.25 - 0.5V_1 = 0$

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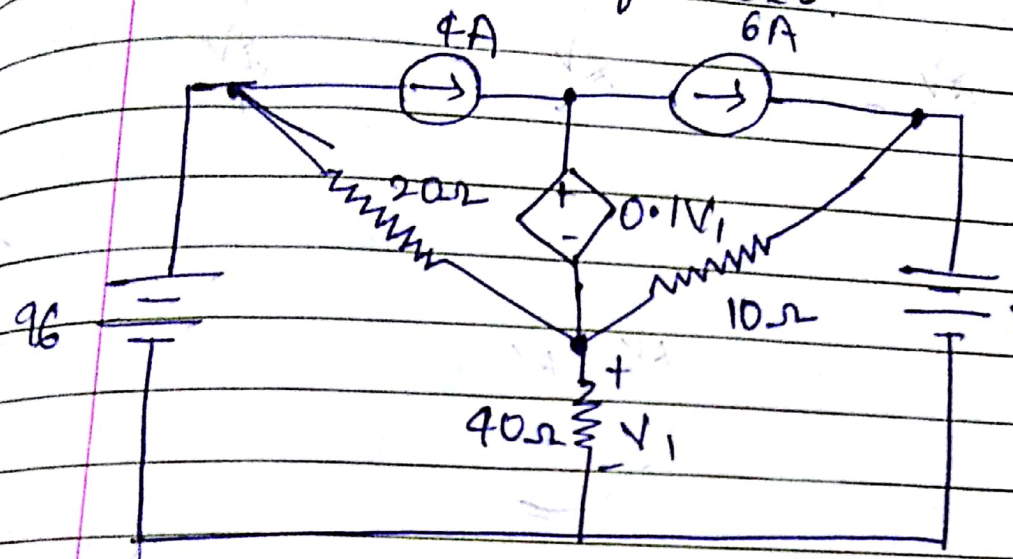
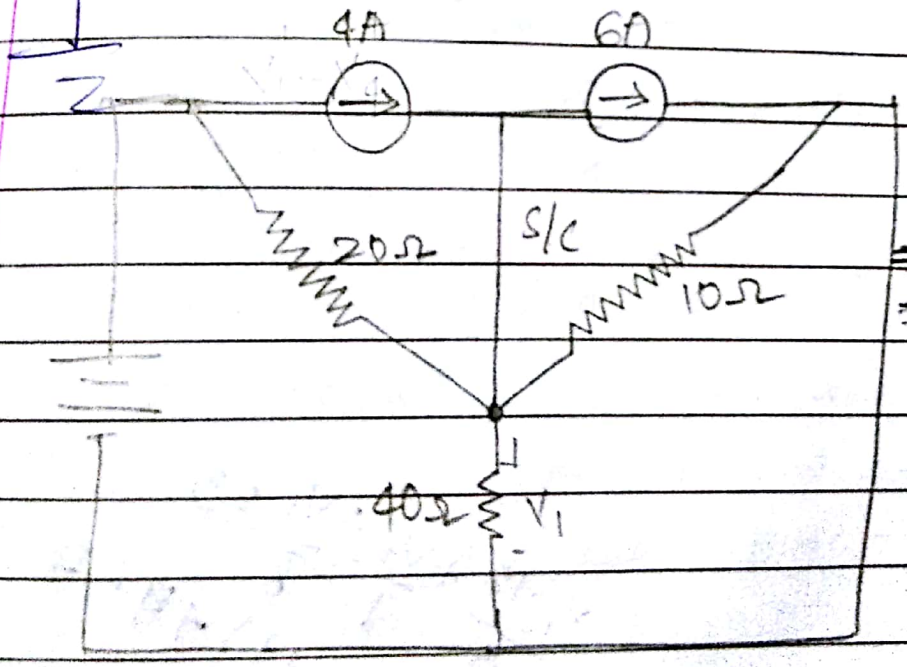
$V_3(0.625) - 1.25 - 1.428 \times 0.5 = 0$

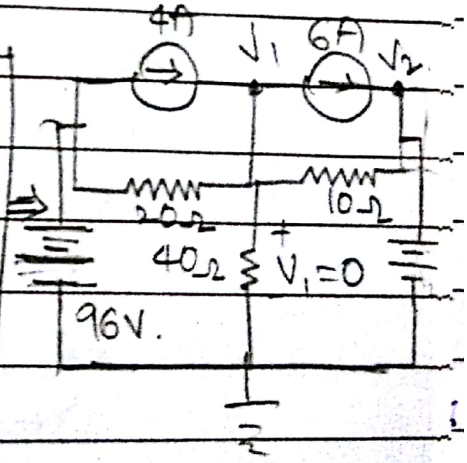
$V_3 = \frac{1.964}{0.625}$

$V_3 = 3.1424.$

Use Nodal Analysis to determine value of V_2 that will result in $V_1 = 0$ in fun ckt.







$\frac{V_1 - 96}{20} + \frac{V_1 - V_2}{10} + \frac{V_1}{40} = -6 + 4$

$\frac{-96}{20} - \frac{V_2}{10} = -2$

$V_2 = -28V$

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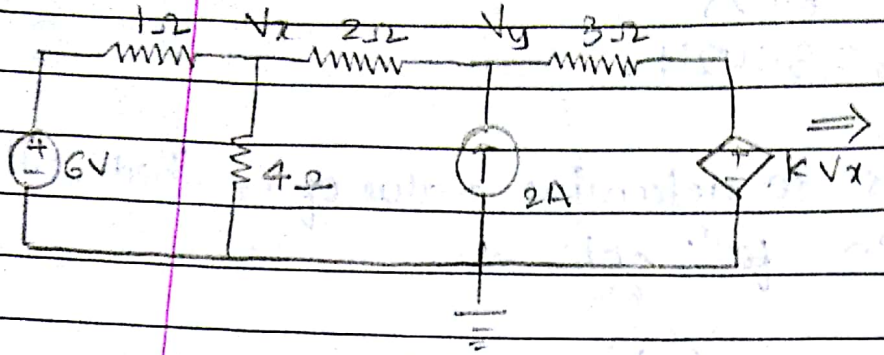
Using Nodal Analysis Determine value of K which we cause $V_y = 0$.



$$\frac{V_x - 6}{1} + \frac{V_x - V_y}{2} + \frac{V_x}{4} = 0$$

$$\frac{V_y - K}{3}$$

$$V_x - 6 + \frac{V_x}{2} + \frac{V_x}{4} = 0$$

$$V_x(1 + 1/2 + 1/4) = 6$$

$$V_x = 3.42\,V$$

$$+2 = \frac{V_y - KV_x}{3} + \frac{V_y - V_x}{2}$$

$$2 = \frac{-K(3.42)}{3} - \frac{3.42}{2}$$

$$K = -3.25\,V$$

$$\frac{V_1 - 12}{8} + \frac{V_1}{1} + \frac{V_1}{8} = 3$$

$$\frac{V_1}{8}\left(\frac{1}{3} + 1 + \frac{1}{8}\right) + 1.5 = 3$$

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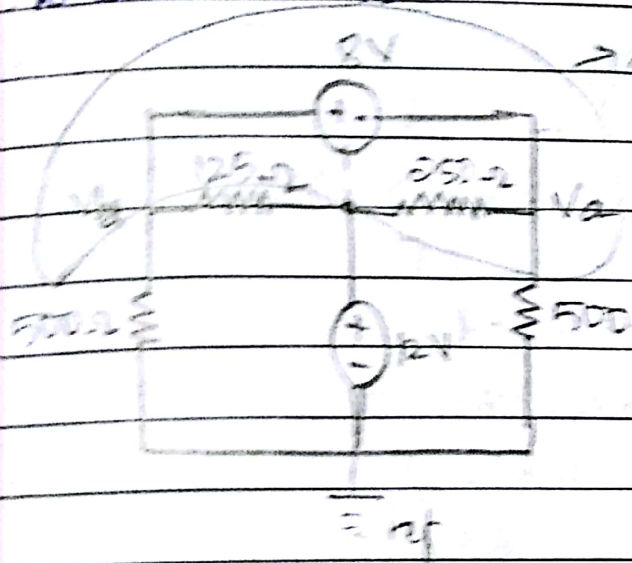
Supernode analysis: [Dependent Voltage Source]

When network has an ideal voltage source as one of its branches then the current through this voltage source cannot be determined and it should be noted that this V.S is present b/w 2 nodes hence these two nodes can be considered as one node which is called as super node using this Supernode w.r.t. KCL eq's can be reduced by 1

[We note that this ideal source must be b/w non-ref nodes. Then only supernode can be considered.]

Ex: Determine V_o



→ supernode

$\frac{V_1-0}{3} + \frac{V_1}{8} = 3$

$\frac{V_1}{3} - 4 + \frac{V_1}{8} = 3$

$V_o = 0$

$V_b - V_a = 8$

$V_b = 8 + V_a$

Applying KCL at supernode.

$$\frac{V_b}{500} + \frac{V_b - 12}{125} + \frac{V_a}{500} + \frac{V_a - 12}{250} = 0$$

$$\frac{8+V_a}{500} + \frac{8+V_a-12}{125} + \frac{V_a}{500} + \frac{V_a-12}{250} = 0$$

$$\frac{8}{500} + \frac{V_a}{500} - \frac{4}{125} + \frac{V_a}{125} + \frac{V_a}{500} + \frac{V_a}{250} - \frac{12}{250} = 0$$

$$V_a\left[\frac{1}{500} + \frac{1}{125} + \frac{1}{500} + \frac{1}{250}\right] = \frac{4}{125} + \frac{12}{250} - \frac{8}{500}$$

$V_a(0.016) = 0.064$

$\boxed{V_a = 4V}$

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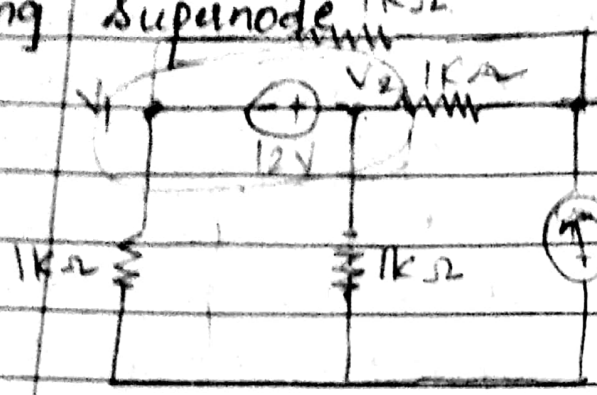
$V_a = 4V = V_0$

$V_b = 12V.$

Using Supernode



$-V_1 + V_2 = 12$

$V_2 = 12 + V_1$

$$\frac{V_1}{1^K} + \frac{V_1 - V_3}{1^K} + \frac{V_2}{1^K} + \frac{V_2 - V_3}{1^K} = 0$$

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

$$2V_1 + 2V_2 - 2V_3 = 0$$

$$V_1 + V_2 - V_3 = 0$$

$$V_1 + 12 + V_1 = V_3$$

$$2V_1 + 12 = V_3$$

$$\frac{V_3 - V_2}{10^3} + \frac{V_3 - V_1}{10^3} = 2 \times 10^{-3}$$

$$2V_2 - V_2 - V_1 = 2 \times 10^{-3} \times 10^3$$

$$2(2V_1 + 12) - 12 - V_1 - V_1 = 2$$

$$4V_1 + 24 - 12 - 2V_1 = 2$$

$$2V_1 + 12 = 2$$

$$2V_1 = -10$$

$$V_1 = -5V$$

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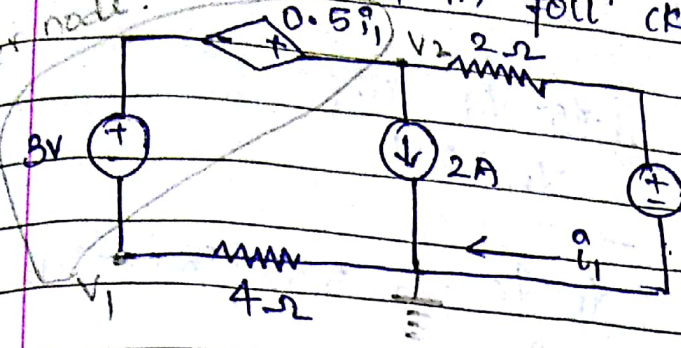
(*) Determine current i_1 in foll^n ckt using nodal Analysis.

Super node.



Constraint eq^n $V_2 - V_1 = 3 + 0.5 i_1$

$i_1 = \frac{V_2 - 4}{2}$

$V_2 - V_1 = 3 + \frac{1}{4}(V_2 - 4)$.

$V_2 - V_1 = 3 + \frac{V_2}{4} - 1$

$V_2 - V_1 = 2 + \frac{V_2}{4}$.

$\frac{V_2 - 4}{2} = -2$

$V_2 - 4 = -4$

$V_2 = 0$

Applying KCL at Supernode.

$\frac{V_1}{4} + \frac{V_2 - 4}{2} = -2$.

$V_1 + 2V_2 - 8 = -8$

$V_1 = -2V_2 = -1.4545V$.

$V_2 + 2V_2 = 2 + \frac{V_2}{4}$.

$11 V_2 = 8$

$V_2 = 8/11$

$3V_2 - \frac{V_2}{4} = 2$

$i_1 = \frac{8/11 - 4}{2}$

$i_1 = -1.63A$

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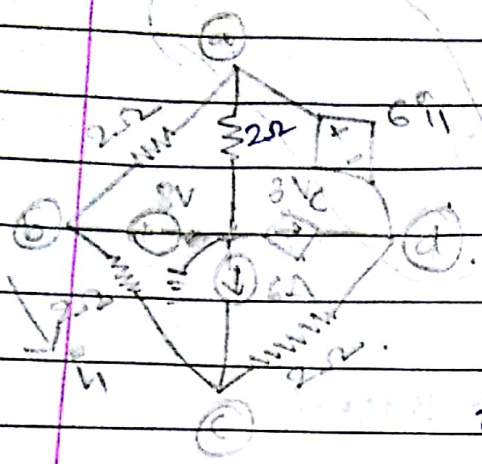
(*) Determine node voltages V_b and V_c in foll^{n} ckt.



$V_a - V_d = 6i_1$

$V_b = 8V$.

$\frac{V_b - V_c}{2} = i_1$; $V_c = 2i_1 + V_b$

KCL at supernode.

$\frac{V_a}{2} + \frac{V_a - V_b}{2} + \frac{V_d - V_c}{2} = 3V_c$

$V_a + V_a - V_b + V_d - V_c = 6V_c$

$V_d + 2V_a - 8 - V_c = 6V_c$

$V_d + 2V_a - 8 = 7V_c$

$V_d + 2V_a - 8 = -14i_1 + 7V_b$.

$V_d + 2V_a - 8 = -14i_1 + 56$.

$V_d + 2V_a + 14i_1 = 64$

$V_d + 2(6i_1 + V_d) + 14i = 64$

$V_d + 12i_1 + 2V_d + 14i = 64$

$V_d + 26i_1 + 2V_d = 64$

$3V_d + 26i_1 = 64$

At C

$\frac{V_c - V_b}{2} + \frac{V_c - V_d}{2} = 6$

$\frac{V_c - 4}{2} + \frac{V_c - V_d}{2} = 6$

$V_c - 8 + V_c - V_d = 12$

$2V_c - 8 - V_d = 12$

$2V_c - V_d = 20$

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~~At B~~

$$\frac{V_b - V_a}{5} + \frac{V_b - V_c}{2}$$

$$2(-2i_1 + V_b) - V_d = 20$$
$$-4i_1 + 16 - V_d = 20$$
$$-4i_1 - 4 - V_d = 0$$
$$3V_d + 12i_1 = -12$$
$$3V_d + 26i_1 = 64$$

$$+14i_1 = 76$$
$$i_1 = \frac{76}{14}$$
$$i_1 = 5.42$$

$$3V_d + 26 \times 5.42 = 64$$
$$3V_d = 64 - 140.92$$
$$V_d = -25.64V$$

$$2V_c = 20 + (-25.64)$$
$$2V_c = 20 - 25.64$$
$$\boxed{V_c = -2.82V}$$

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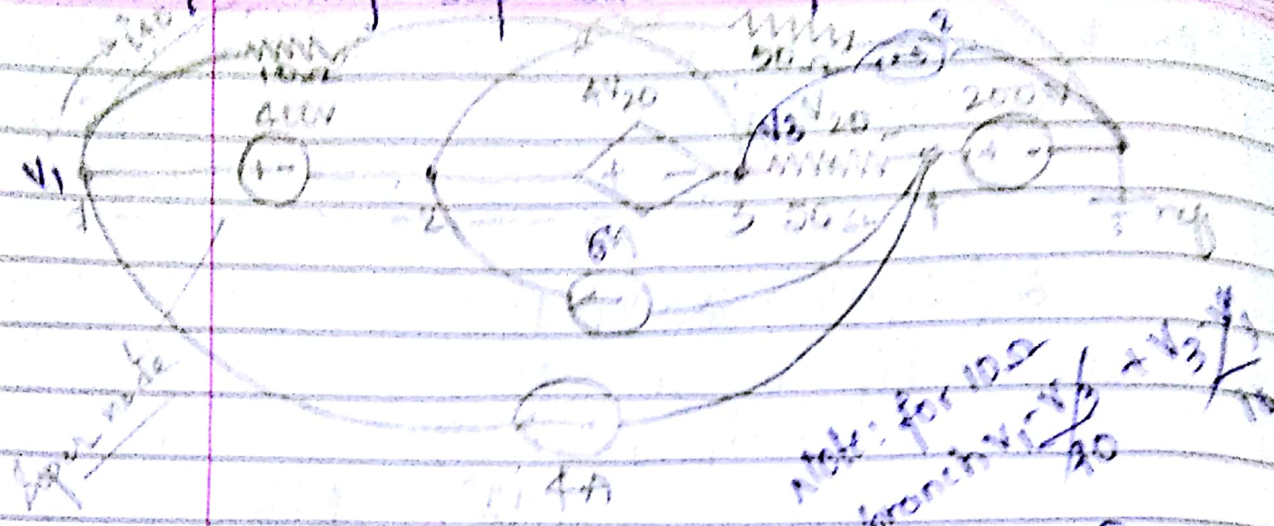
(8) Determine the voltage V_{20} and i_{40} in the four network using supernode concept.



Note: for 100 branch $\frac{V_1 - V_3}{20} + \frac{V_3}{10} = 0$.

$V_1 - V_3 = 400 + 4V_{20}$.

$V_4 = 200V$.

$V_1 - V_2 = 400V$

$V_3 - V_4 = V_{20}$

$V_2 - V_3 = 4V_{20}$

$V_1 - 5V_{20} = 600$

$V_3 - 200 = V_{20}$

$V_3 = V_{20} + 200$.

Applying KCL at supernode

$$-6 + \frac{V_1}{40} + 4 + \frac{V_2}{50} + \frac{V_3 - V_4}{20} + 8 = 0$$

$$\frac{V_1}{40} + 12 + \frac{V_2}{50} + \frac{V_{20}}{20} = 0$$

$$\frac{V_1}{40} + 12 + \frac{V_1}{50} - \frac{400}{50} + \frac{V_{20}}{20} = 0$$

$$-8 + V_1(0.045) + 12 - 8 + V_{20}(0.05) = 0$$

$$0.045V_1 - 4 + V_{20}(0.05) = 0.$$

$$V_1 + 600 - 5V_{20} = 0.$$

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$0.045V_1 + 0.05V_{20} = +22$

$V_1 - 5V_{20} = +1600 \times 0.045$.

$0.045V_1 + 0.05V_{20} = +22$

$-\ 0.045V_1 + 0.225V_{20} = -2.7$

$0.275V_{20} = 19.3$

$V_{20} = 83.63$

$V_1 = 145.45\,V$

$V_{20} = -90.9\,V$

$V_3 = 109.1\,V$

$V_2 = -254.5\,V$

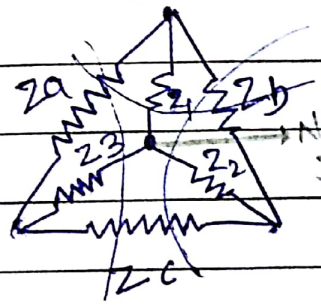
$\frac{V_1}{40} = \frac{0}{i_{40}}$

$\boxed{i_{40} = 3.63\,A}$

Y Δ

⊛ Star - Delta - Transformation:

$\Delta = Y$



$Z_1 = \frac{Z_a Z_b}{Z_a + Z_b + Z_c}$; $Z_2 = \frac{Z_b \cdot Z_c}{Z_a + Z_b + Z_c}$

$Z_3 = \frac{Z_a Z_c}{Z_a + Z_b + Z_c}$

Y - Δ transformation

$Z_A = Z_1 + Z_3 + \frac{Z_1 Z_3}{Z_2}$ $Z_B = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$.

$Z_C = Z_2 + Z_3 + \frac{Z_2 Z_3}{Z_1}$

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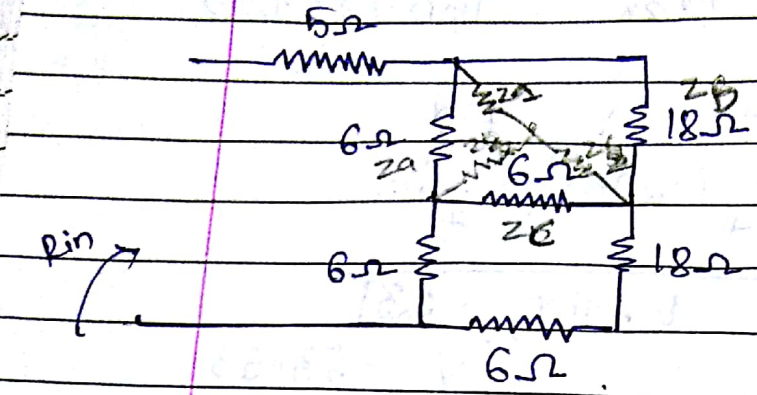
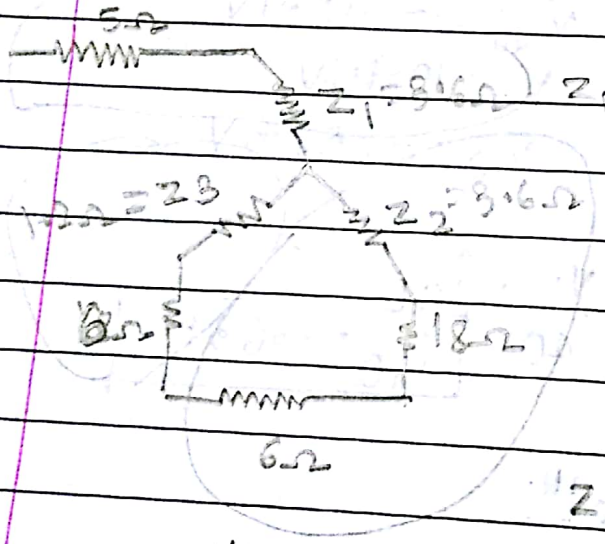
⊛ Determine R_{in} using Y-Δ transformation



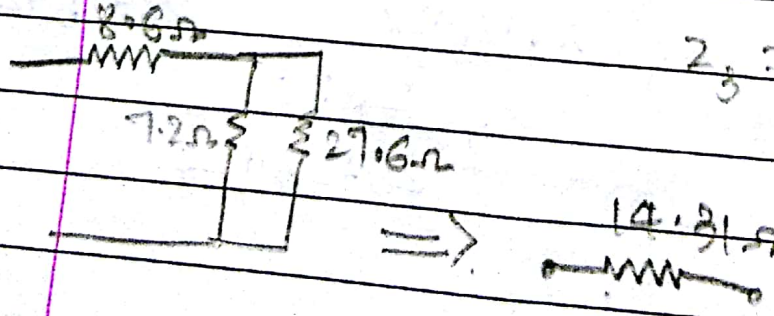
Δ - Y transformation.



$$Z_1 = \frac{Z_a Z_b}{Z_a + Z_b + Z_c} = \frac{6 \times 18}{30} = 3.6\,\Omega$$

$$Z_2 = \frac{18 \times 6}{30} = 3.6\,\Omega$$

$$Z_3 = \frac{6 \times 6}{30} = 1.2\,\Omega$$



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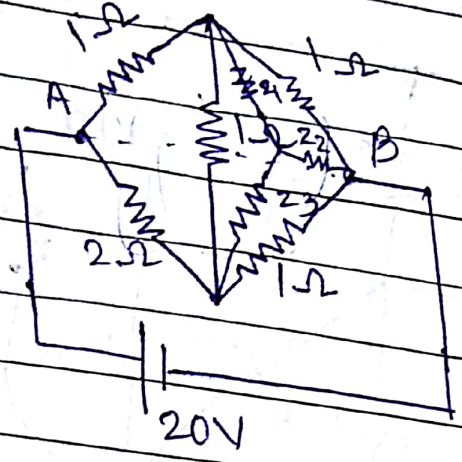
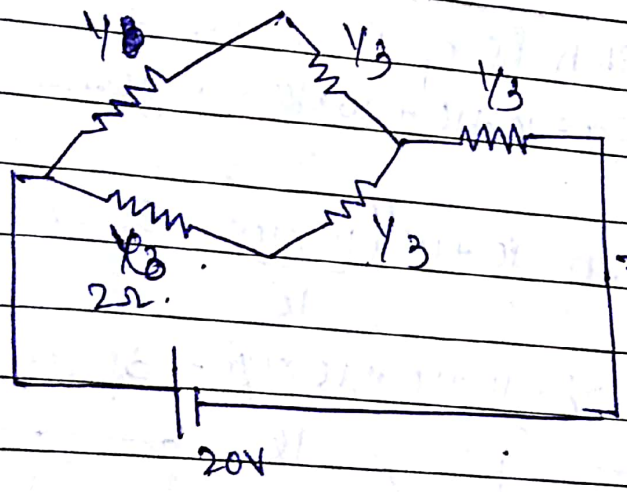
(*) Pol^n bridge determine total Resistance seen b/w terminals A and B using Y-Δ transformat^n.

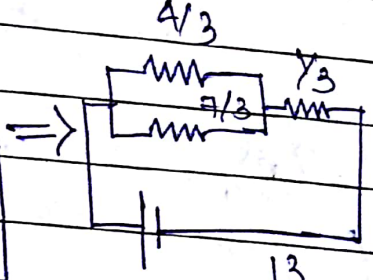


$Z_1 = \frac{1}{3} \cdot = \frac{1}{3}\Omega$

$Z_2 = \frac{1}{3}\Omega$

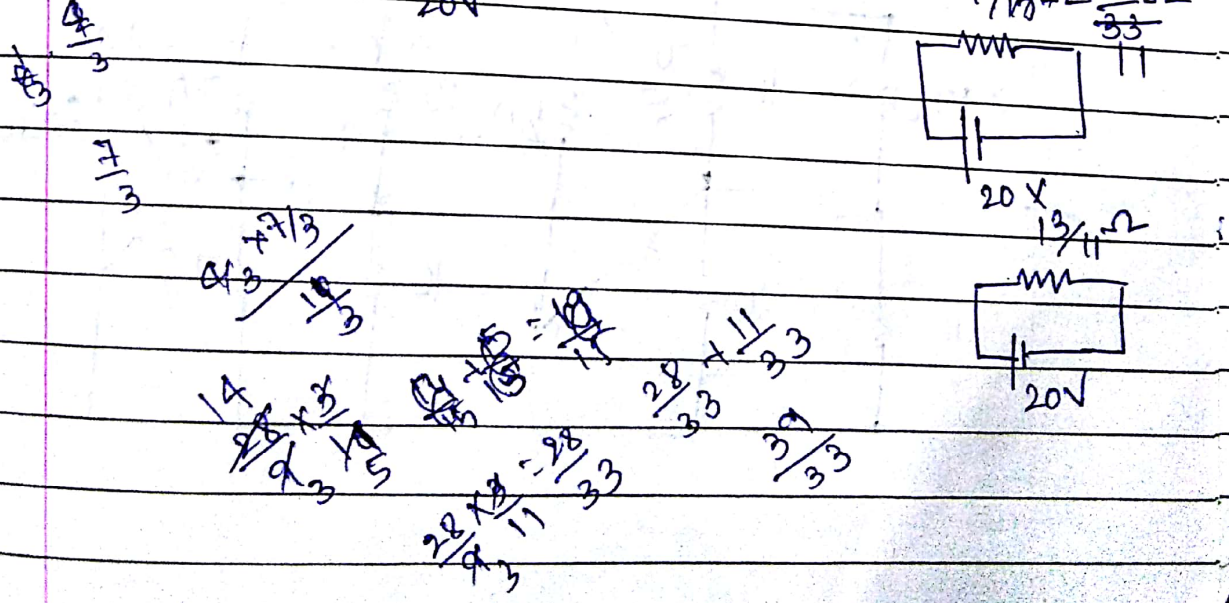
$Z_3 = \frac{1}{3}\Omega$





$\frac{13}{11}\Omega$

20V



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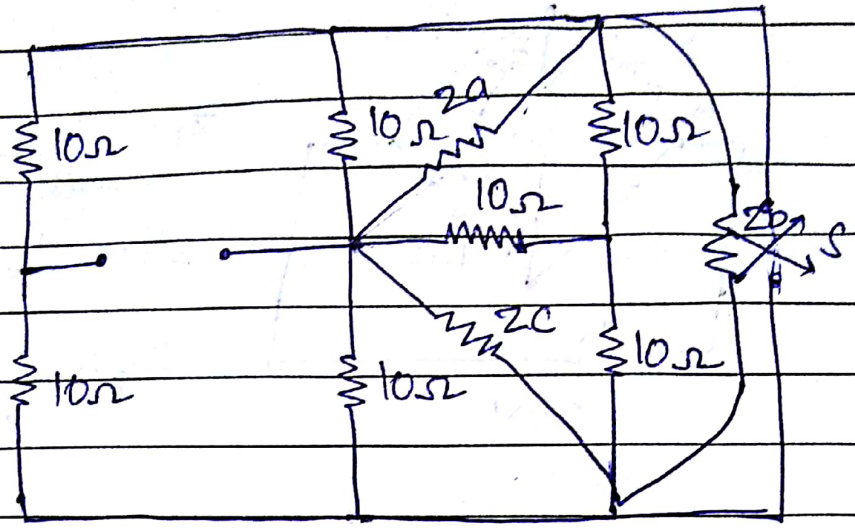
(3) Determine R Equivalent for the foll^{n} network when the switch is open and when switch is closed.

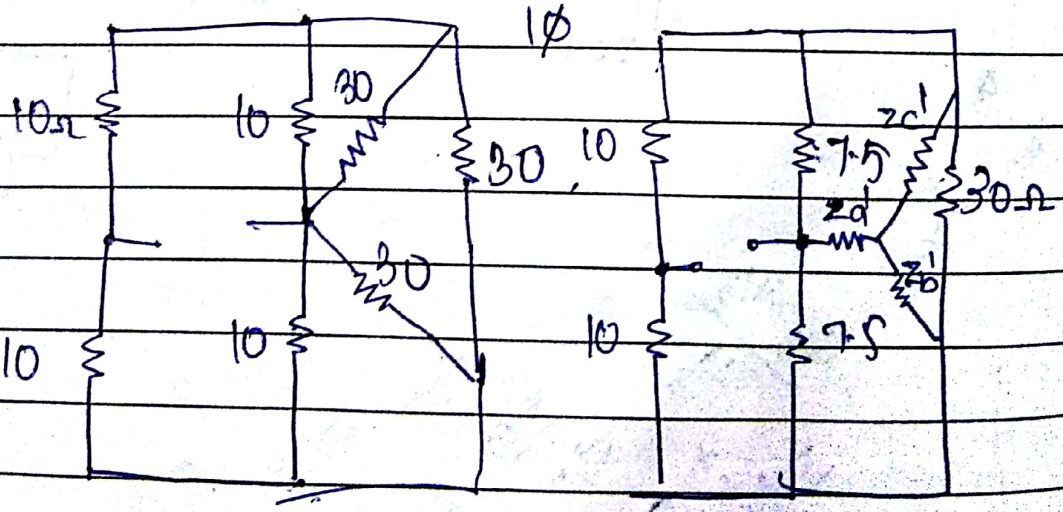


(a) When switch is open.

$$2a = 10+10+\frac{10\times10}{10} = 30\Omega$$

$$2b = 10+10+\frac{10\times10}{10} = 30\Omega$$

$$2c = 10+10+\frac{10\times10}{10} = 30\Omega.$$



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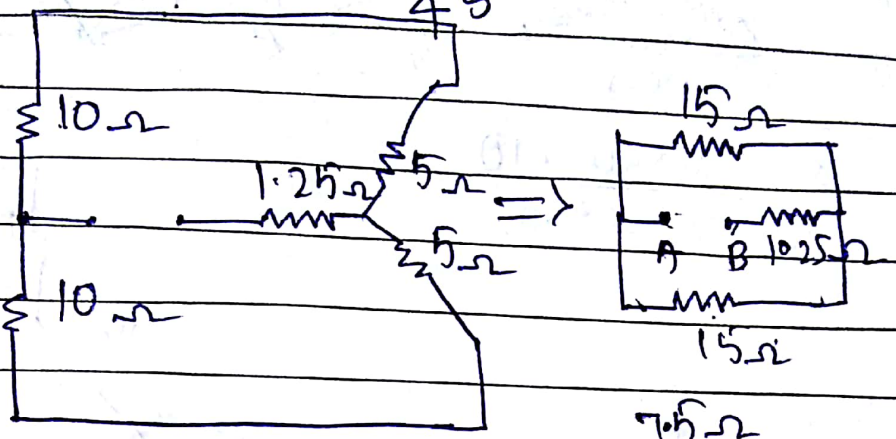
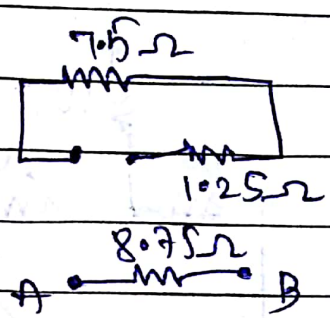
$2a^1 = \frac{7.5 \times 7.5}{45} = 1.25\,\Omega$

$2b^1 = \frac{7.5 \times 30}{45} = 5\,\Omega$

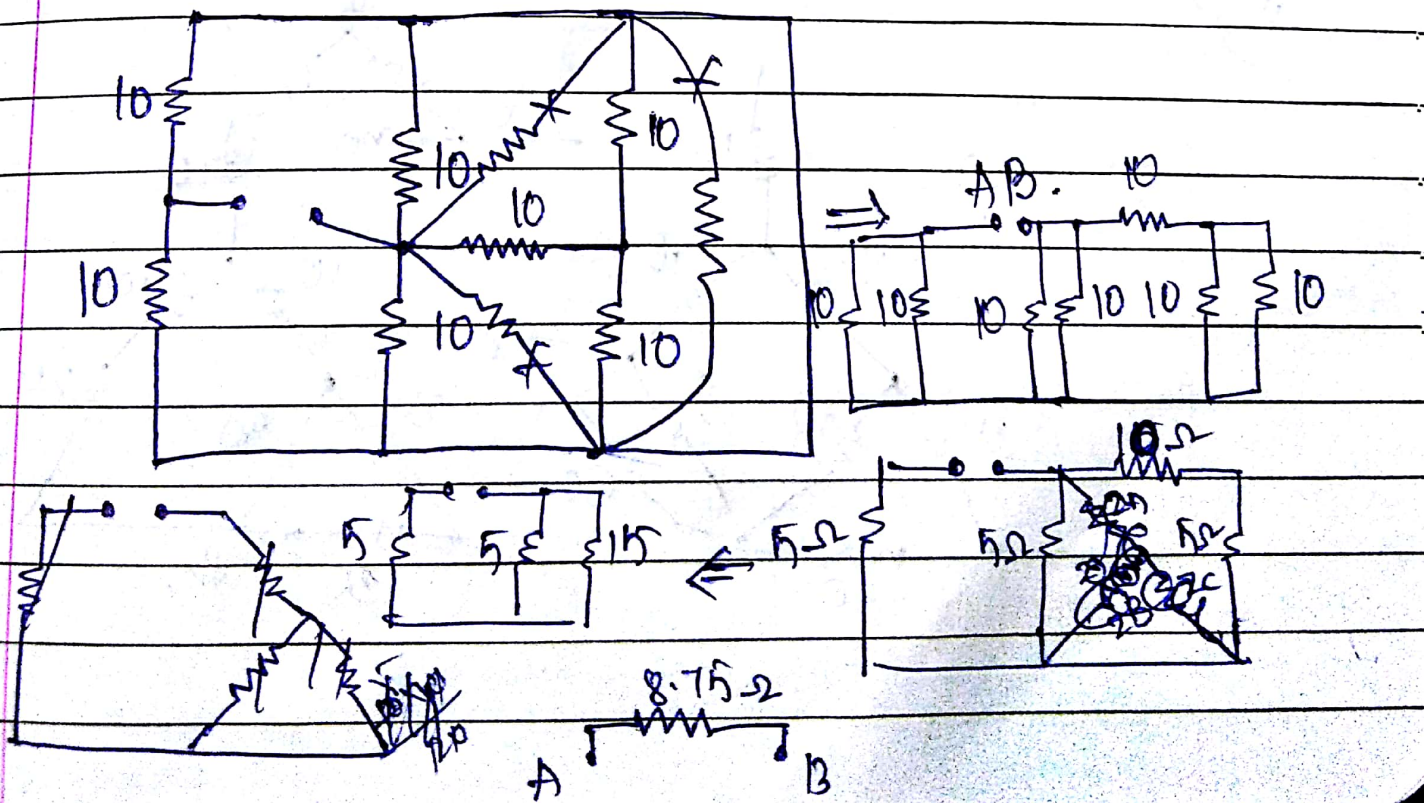
$2c^1 = \frac{7.5 \times 30}{45} = 5\,\Omega$



$\frac{15 \times 15}{30}$



(b) when switch is closed.



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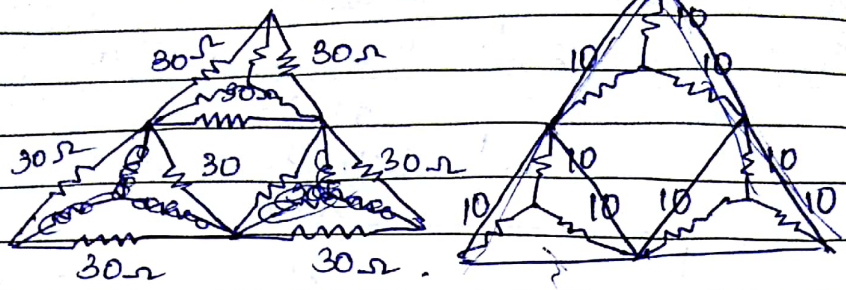
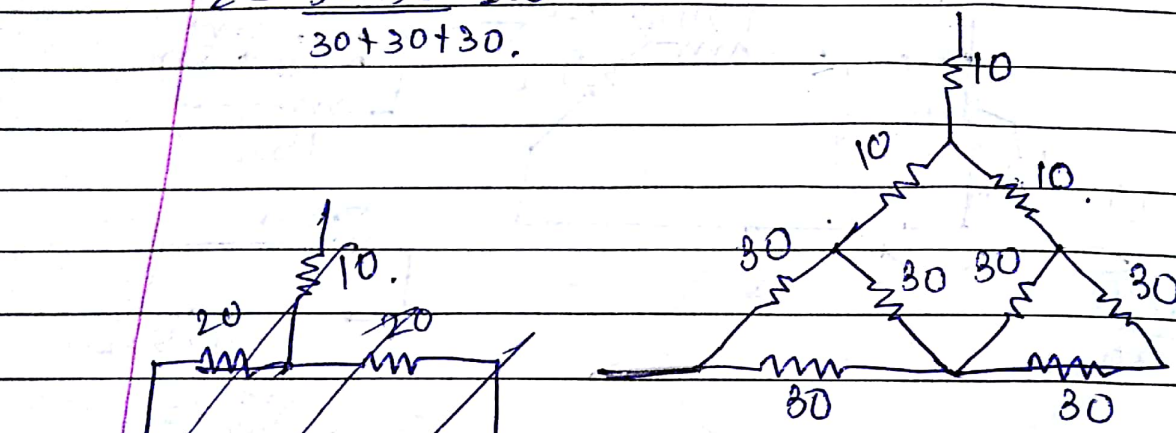
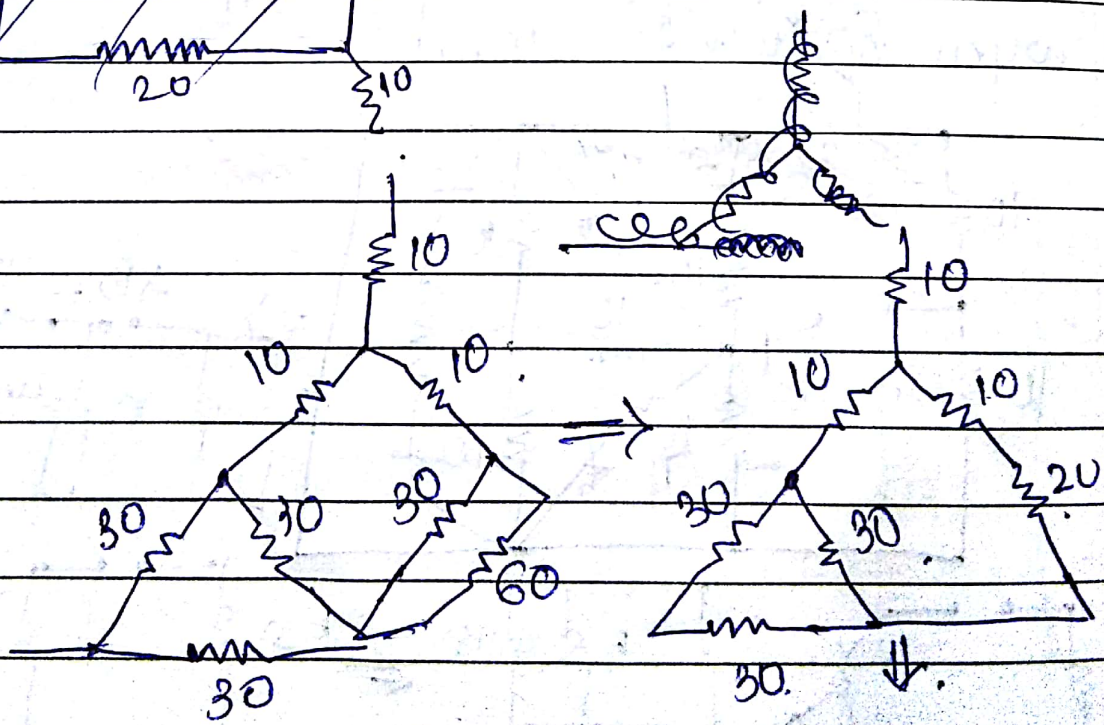
④ Determine R Equivalent for foll^{n} Y-Δ



$$R = \frac{30 \times 30}{30+30+30} = 10$$





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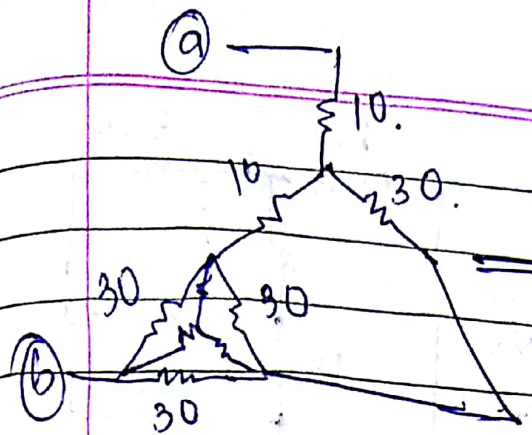
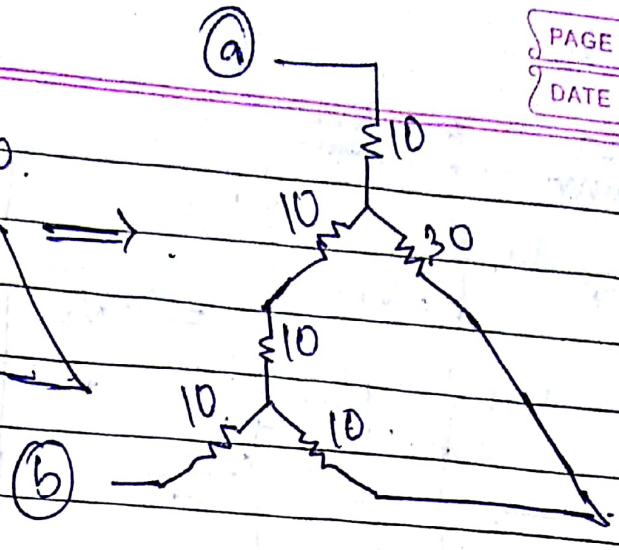
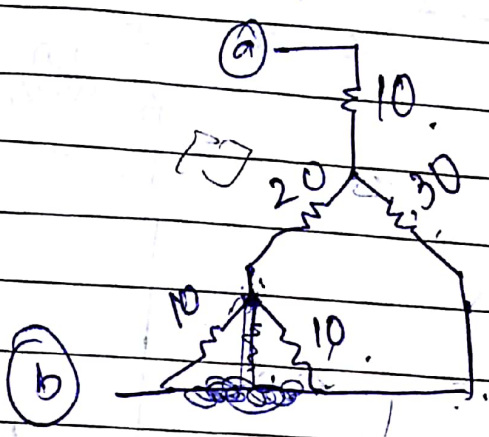
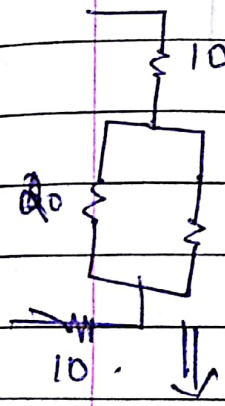
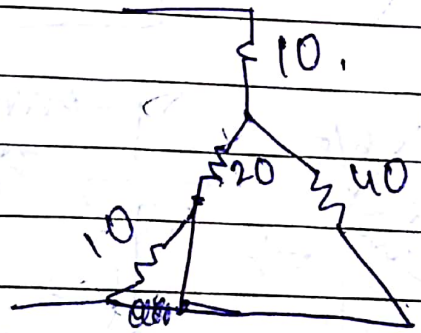










$$\frac{40 \times 20}{60}$$

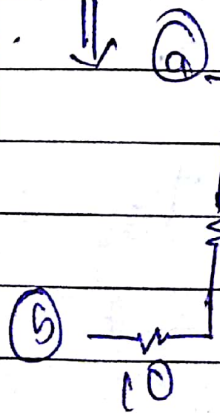
$$3$$

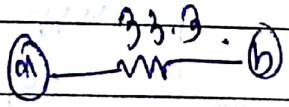
$$20 + 40$$

$$3$$

$$\frac{100}{3}$$

$$= 33.3\Omega$$





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Det V_s

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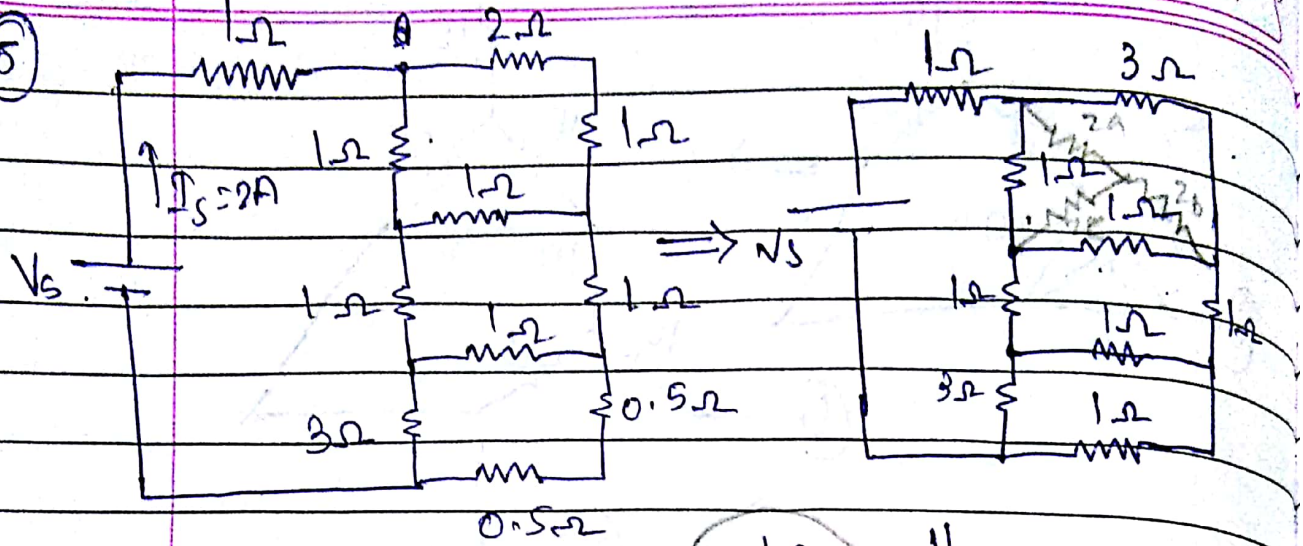
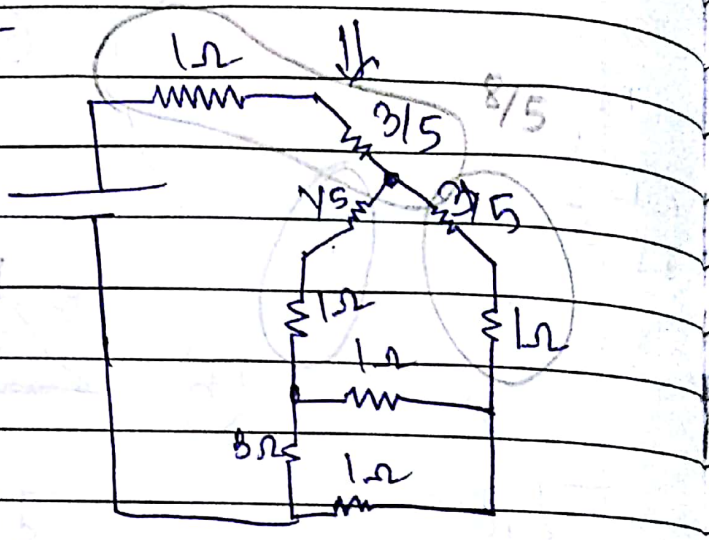
(5)

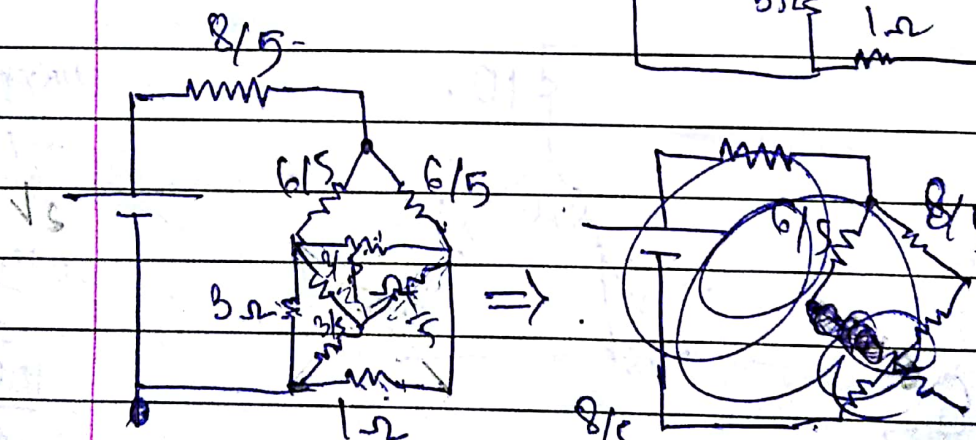


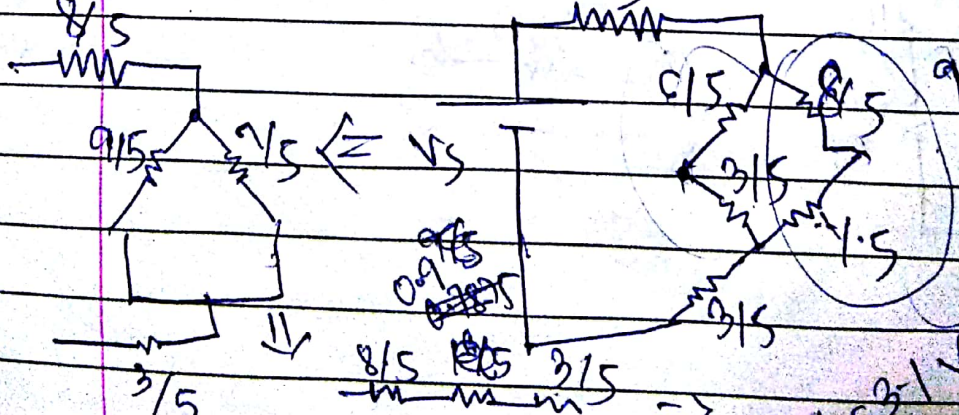
$z_a = 3/5$

$z_b = 1/5$

$z_c = 9/5$.







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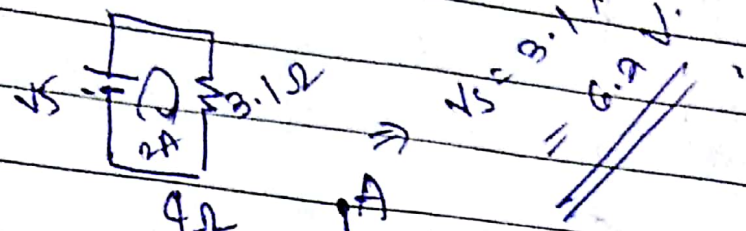
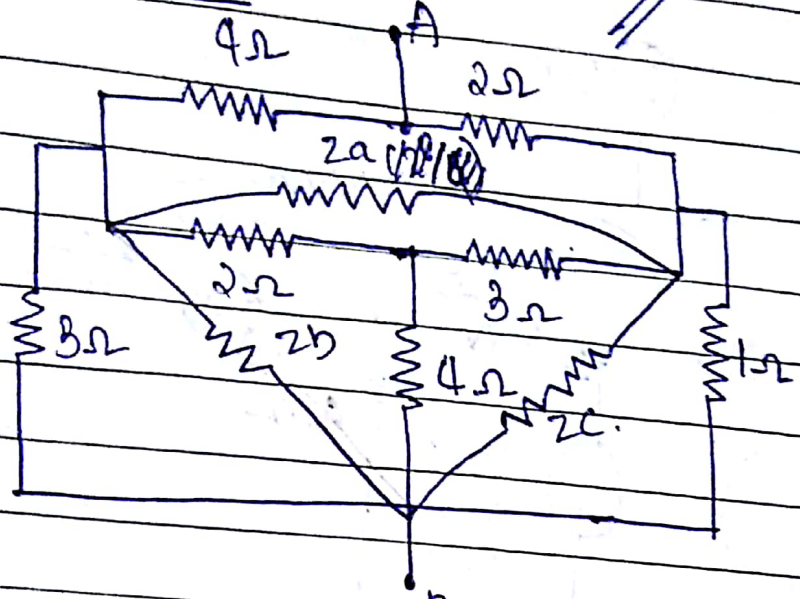


⑥.



$Z_a = 2\frac{6}{4} = 6.5$

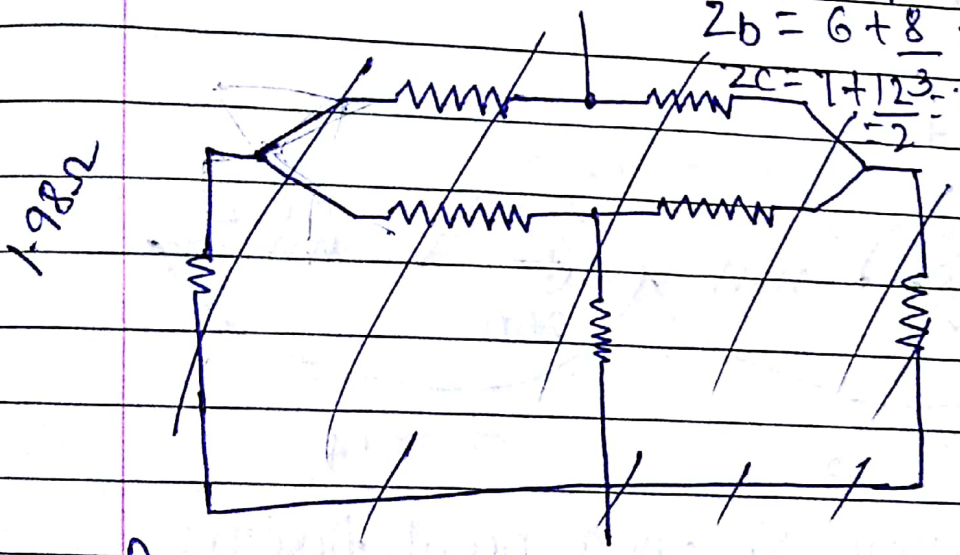
$Z_b = 6 + \frac{8}{4} = 8.6\Omega$

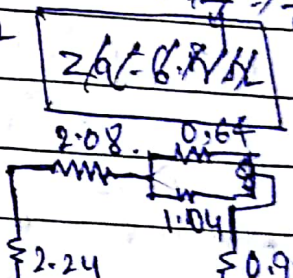
$Z_c = 1 + \frac{12}{3} = 13\Omega$

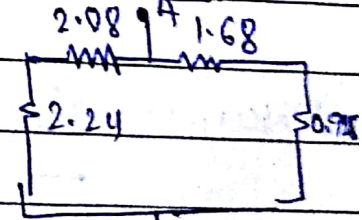
$Z_a = \frac{8 \times 8 \times 6}{4}$

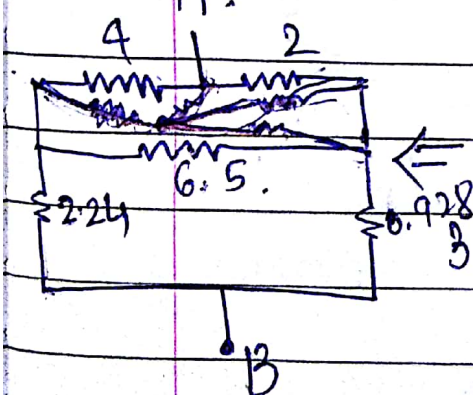
$= \frac{8 + 6}{4} = \frac{26}{4}$

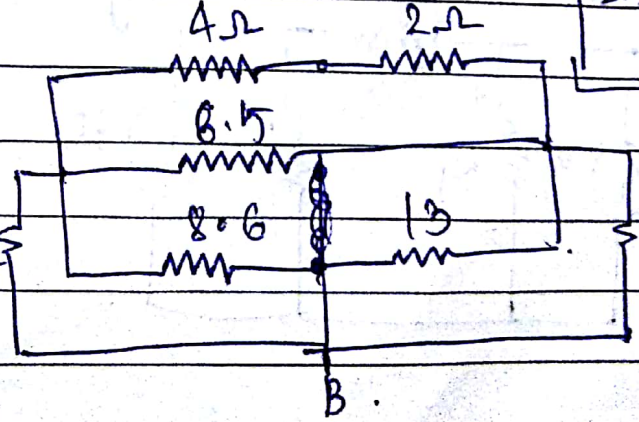
$Z_a = 6.5\Omega$

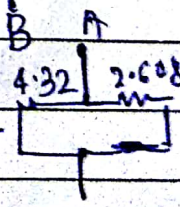












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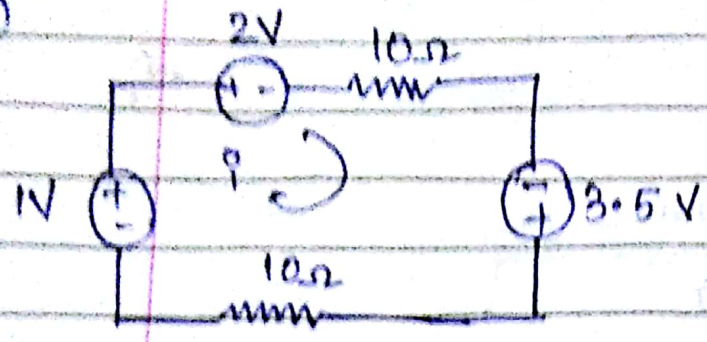
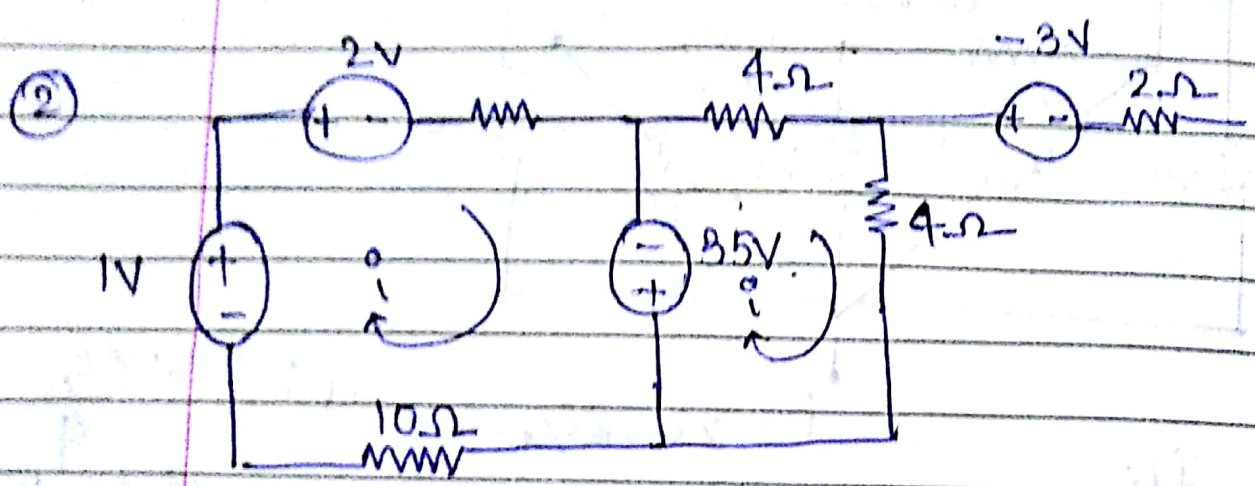
11/10:

Find current i in foll^{n} ckt:

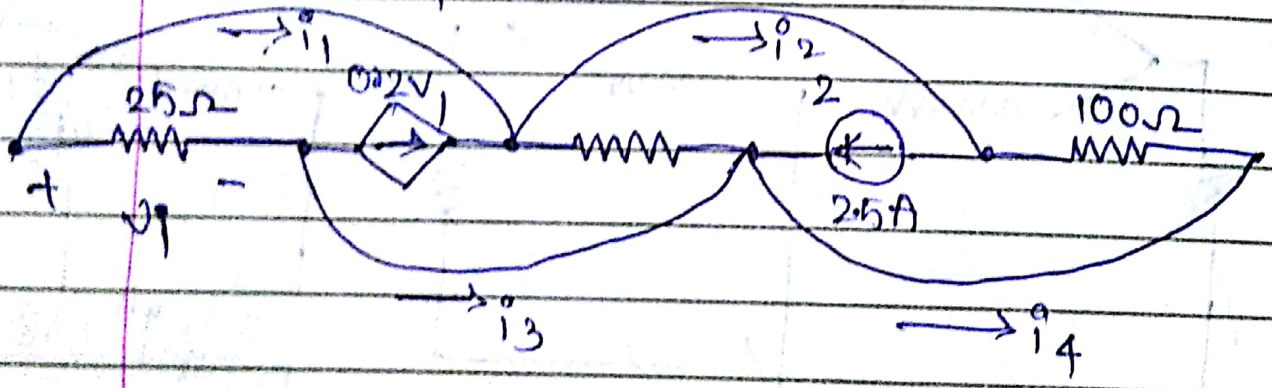
(1)



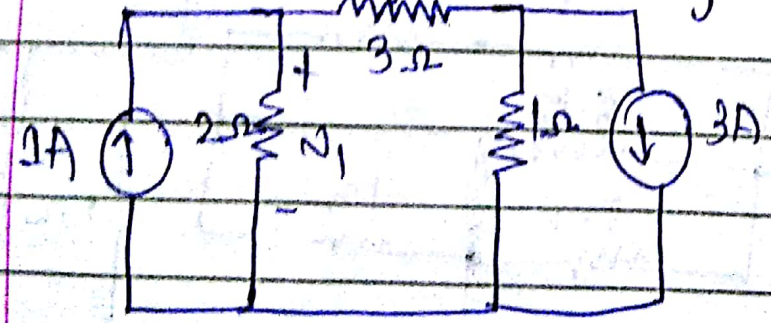
(2)



(3) Find $i_1\ i_2\ i_3\ i_4$



Determine the voltage V_1 using nodal Analysis



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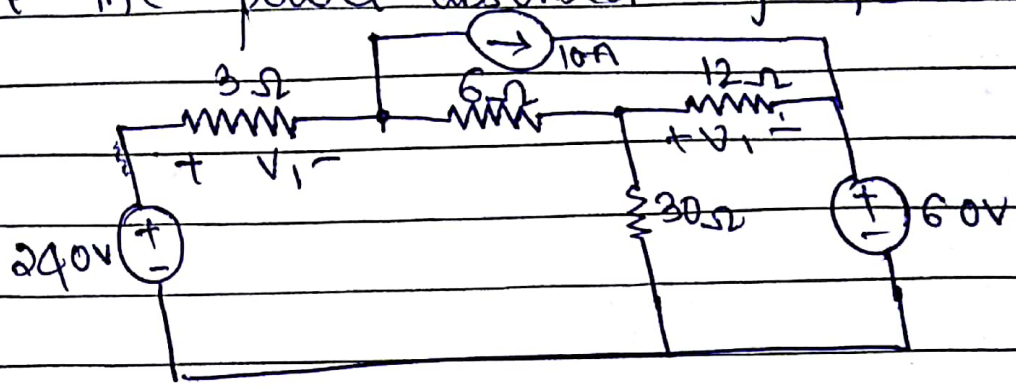
For the ckt

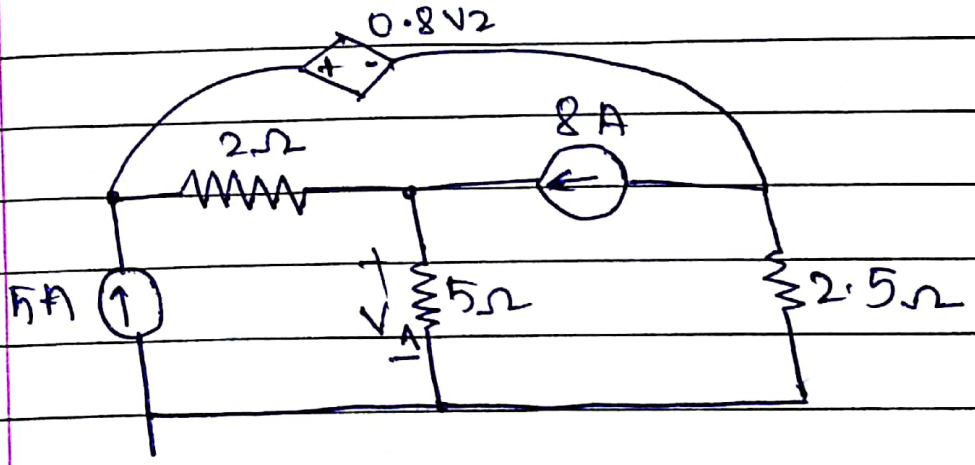
(i) Use nodal Analysis to find V_1 and V_2

(ii) Compute the power absorbed by the 6Ω resistor

Solution



(B)



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