Unit - I

2.2 KVL, KCL and Problems

~~ed~~ Tool chest

- → Ohm's law
- → Reduction → Series/Parallel
- → Division → Series/Parallel
- → KVL, KCL.

Dr.Santhosh.T.K.

Syllabus

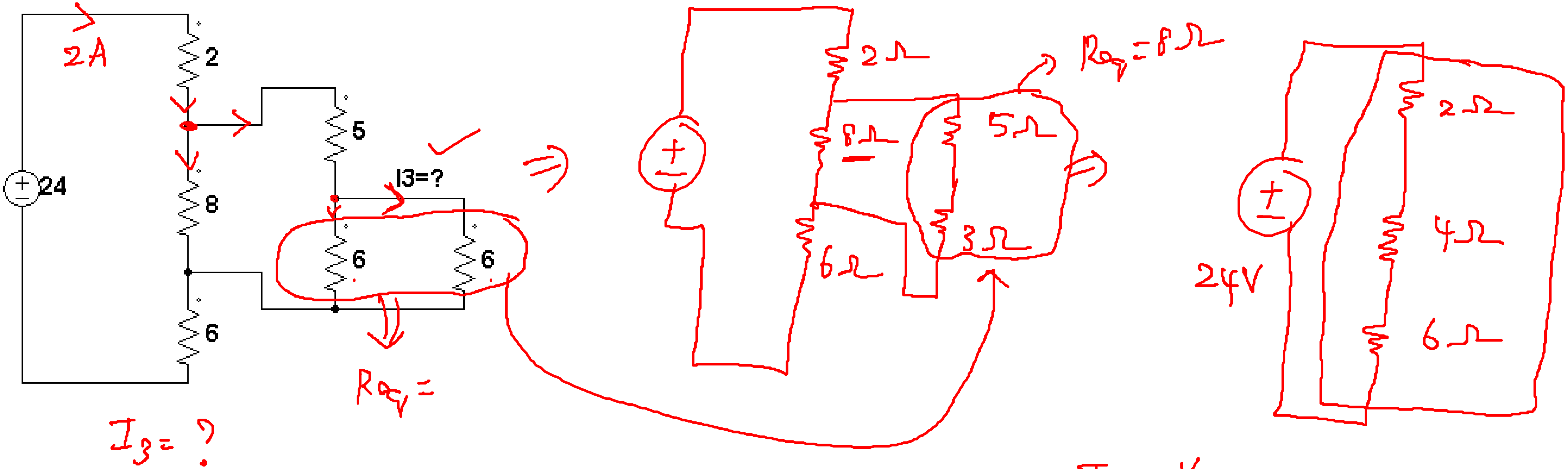
UNIT – II **14 Periods**

DC Circuit Analysis: Voltage source and current sources, ideal and practical, Kirchhoff's laws and applications to network solutions using mesh analysis, - Simplifications of networks using series- parallel, Star/Delta transformation, DC circuits-Current-voltage relations of electric network by mathematical equations to analyse the network (Superposition theorem, Thevenin's theorem, Maximum Power Transfer theorem), Transient analysis of R-L, R-C and R-L-C Circuits.

AC Steady-state Analysis: AC waveform definitions - Form factor - Peak factor - study of R-L - R-C -RLC series circuit - R-L-C parallel circuit - phasor representation in polar and rectangular form - concept of impedance - admittance - active - reactive - apparent and complex power - power factor, Resonance in R-L-C circuits - 3 phase balanced AC Circuits

Sample Problems

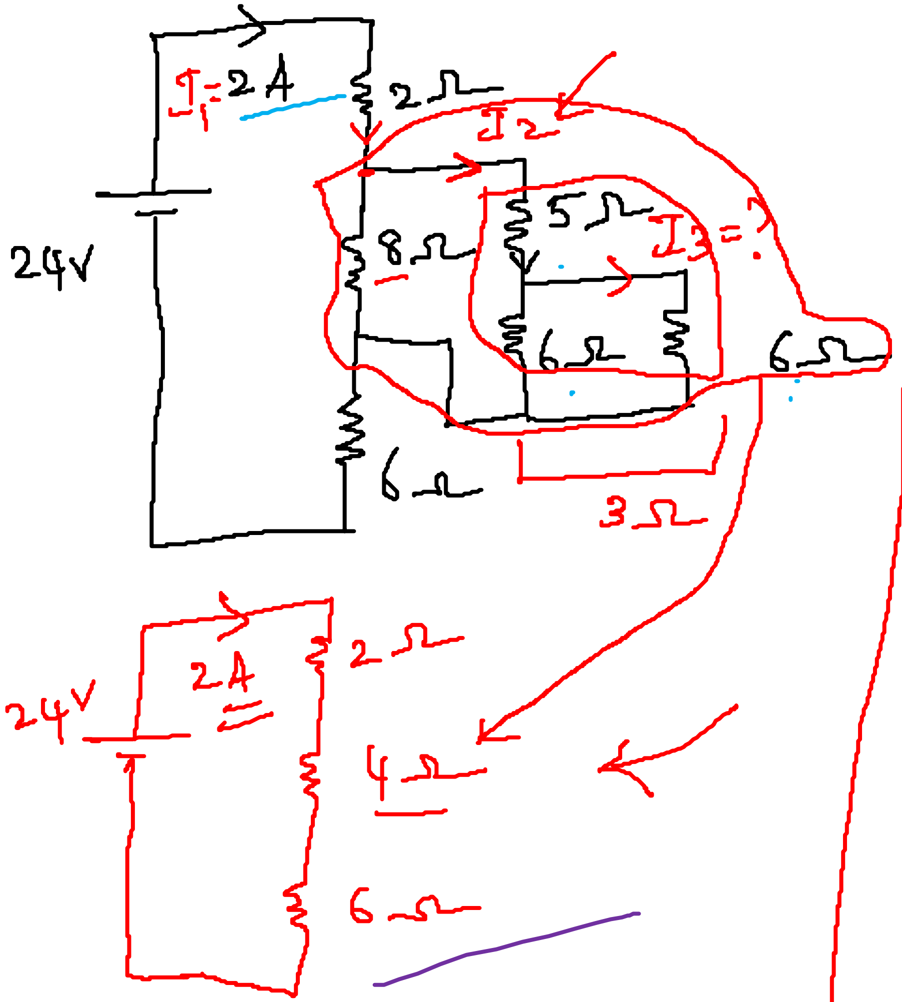
Determine the current I_3.



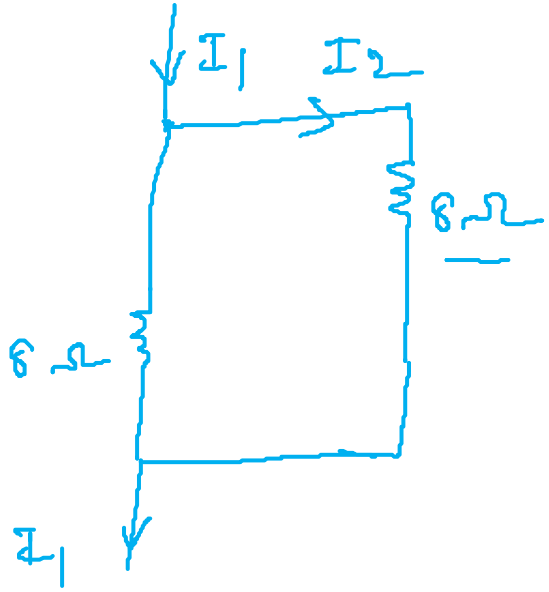
$$I = \frac{V}{R} = \frac{24}{12} = 2A$$

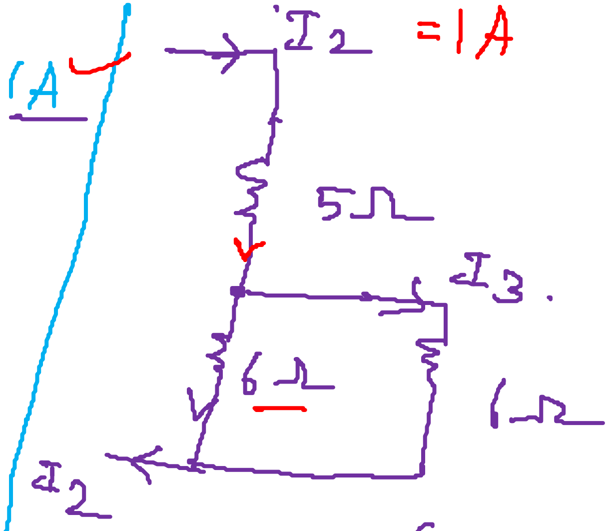
Sample Problems

7. Determine the current I_3.



$$I_2 = \left(\frac{8}{8+8}\right) 2 = 1A$$

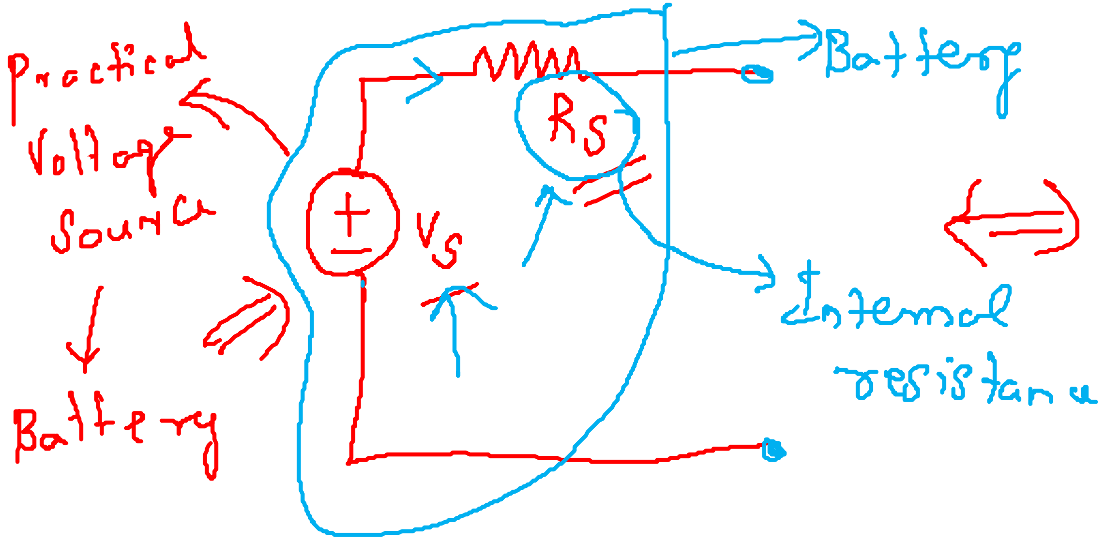


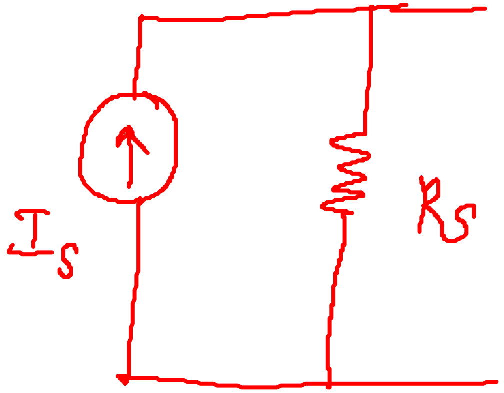


$$I_3 = \frac{6}{12} \cdot 1$$

$$\boxed{I_3 = 0.5A}$$

Source Transformation

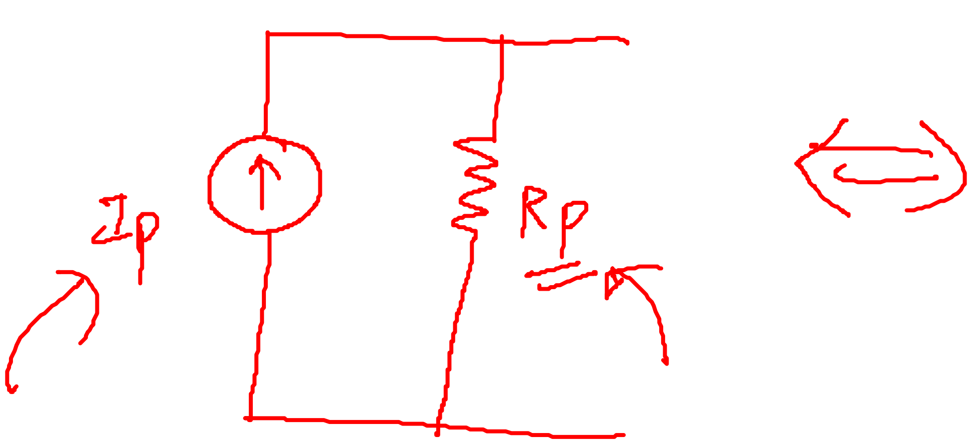


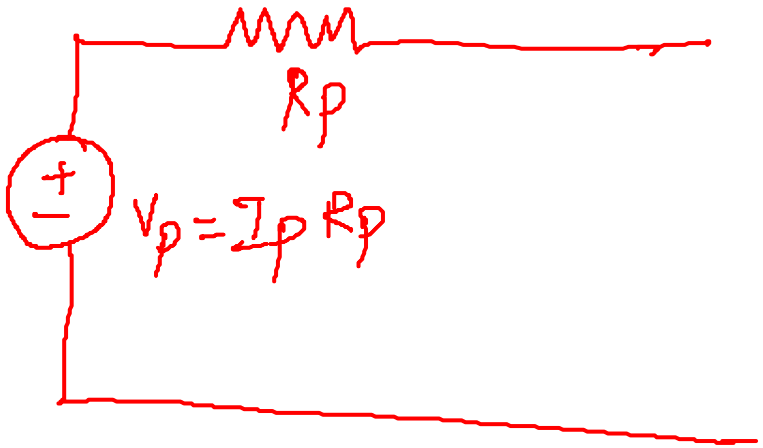


R_s

$V = IR$

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





Sample Problems

Two coils connected in series have a resistance of 18 Ω and when connected in parallel of 4 Ω. Find the value of resistance of the two coils.

$R_1 + R_2 = 18$

$R_1 \parallel R_2 = 4$

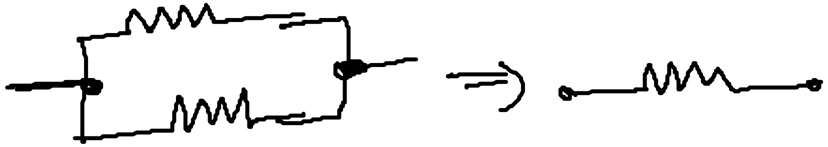
$\Downarrow$

$$\frac{R_1 R_2}{R_1 + R_2} = 4$$

$R_1 = 12\,\Omega$

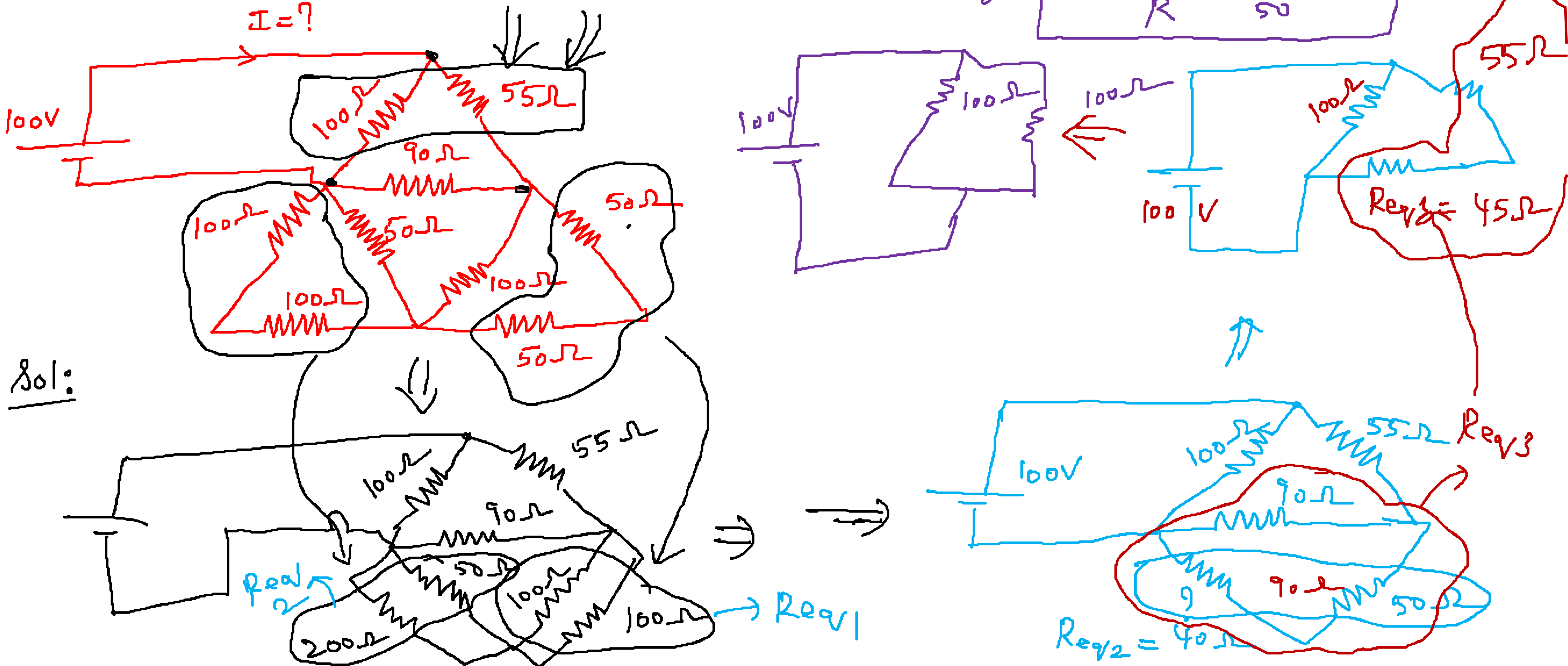
$R_2 = 6\,\Omega$

Sample Problems

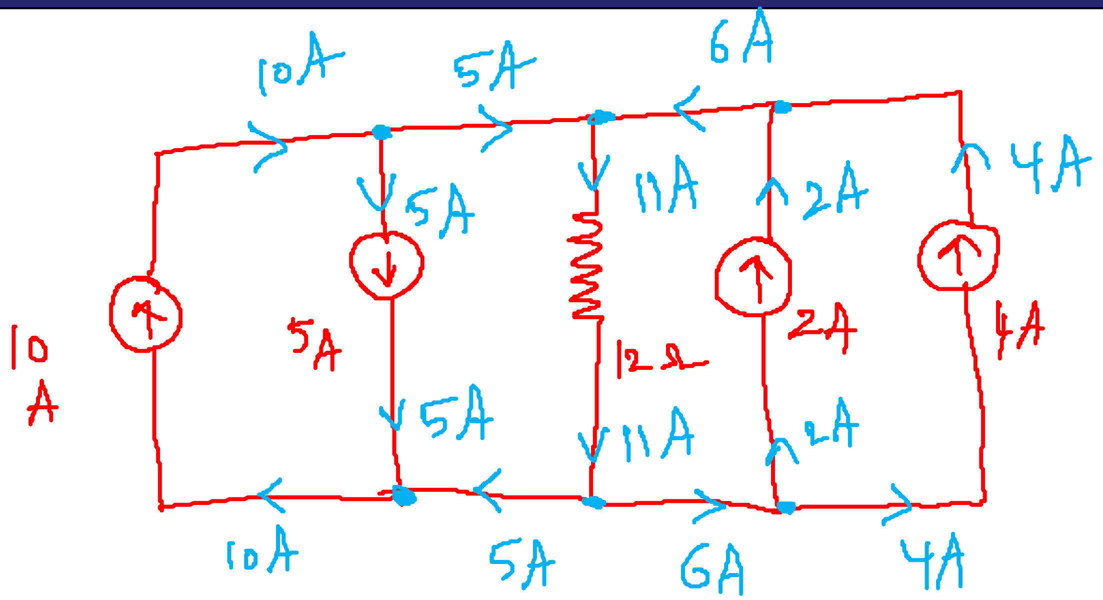


Determine the total current taken from the source.

$$\boxed{I = \frac{V}{R} = \frac{100}{50} = 2A}$$

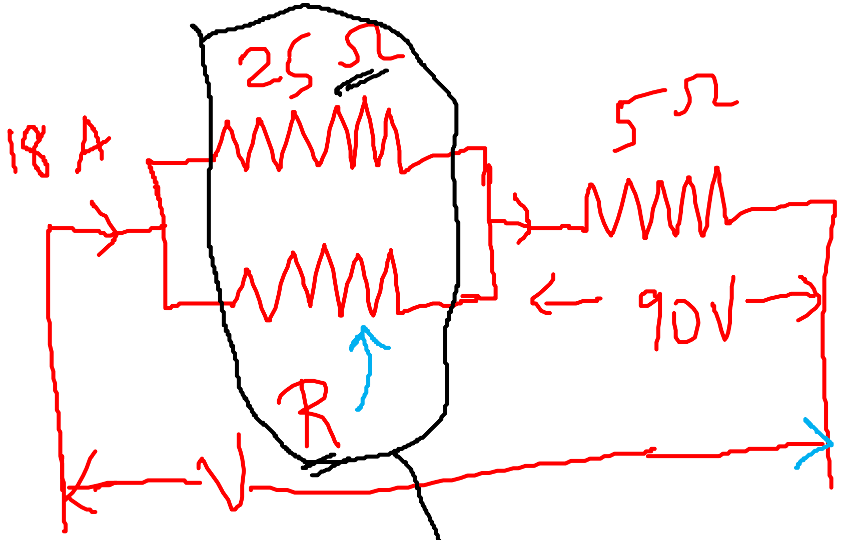


Current through 12 ohm resistor?



$$\boxed{I_{12\Omega} = 11A}$$

Find the R and V if the total power consumed is 4320 W.



Sol.

① Reduction

$25 \parallel R + 5$

$P = I^2 R$

$4320 = (18)^2 \cdot R_{eq}$

$\boxed{R_{eq} = 13.33\ \Omega}$

$(12.5 \parallel 25)$

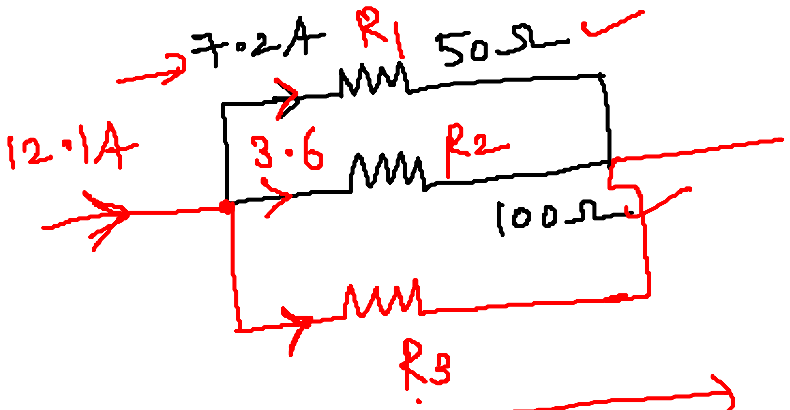
$V = \cancel{13.33} \times 18 + 90$

$\boxed{V = 240\text{V}.}$

$R_{eq} = \dfrac{25 \cdot R}{25 + R} + 5$

$\boxed{R = 12.5\ \Omega}$

A 50 Ω resistor is in parallel with a 100 Ω resistor. The current at 50 Ω resistor is 7.2 A. What is the value of third resistor to be added in parallel to make the total current as 12.1 A.



Sol:

$V_{R_1} = 7.2 \times 50 = 360V$

$V = IR$

$V_{R_2} = 360 = I_{R_2} \cdot 100$

$\boxed{I_{R_2} = 3.6A}$

KCL

$12.1 = 7.2 + 3.6 + I_{R_3}$

$\boxed{I_{R_3} = 1.3A}$

$R_3 = \frac{V_3}{I_{R_3}} = \frac{360}{1.3}$

$\boxed{R_3 = 276.92\ \Omega}$

Kirchhoff's Laws

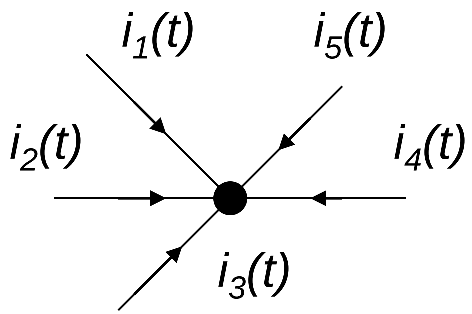
KCL:

"The sum of the currents flowing towards a junction is equal to the sum of current flowing away from it".

KVL:

Kirchhoffs Voltage Law or **KVL**, states that "in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop" which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero

KCL (Kirchhoff's Current Law)

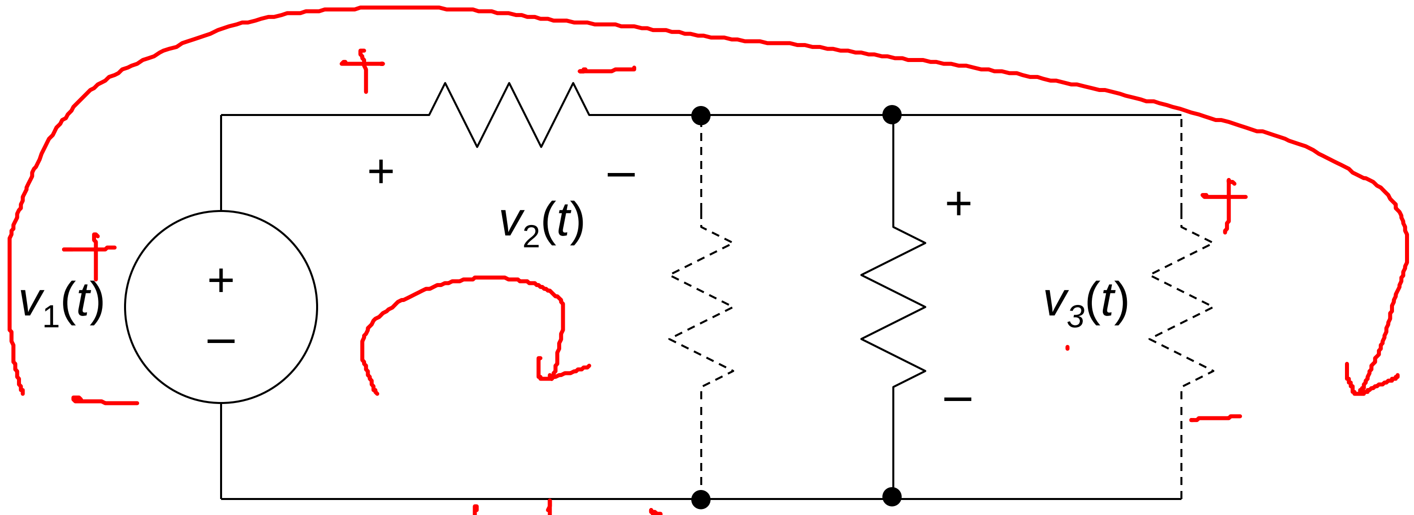


The sum of currents entering the node is zero:

$$\sum_{j=1}^{n} i_j(t) = 0$$

Analogy: mass flow at pipe junction

KVL (Kirchhoff's Voltage Law)



→ algebraic

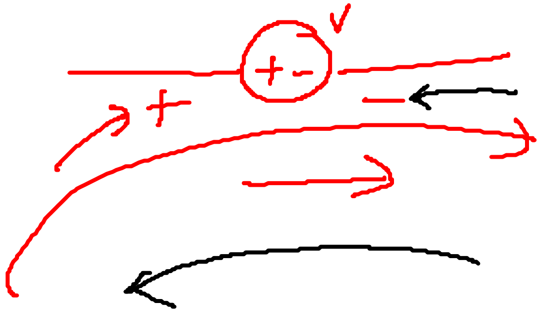
- The sum of voltages around a loop is zero:

$$\sum_{j=1}^{n} v_j(t) = 0$$

- *Analogy*: pressure drop thru pipe loop

KVL Polarity

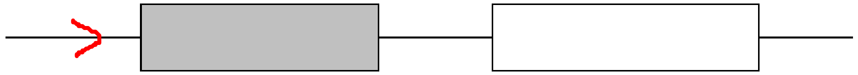
- A loop is any closed path through a circuit in which no node is encountered more than once



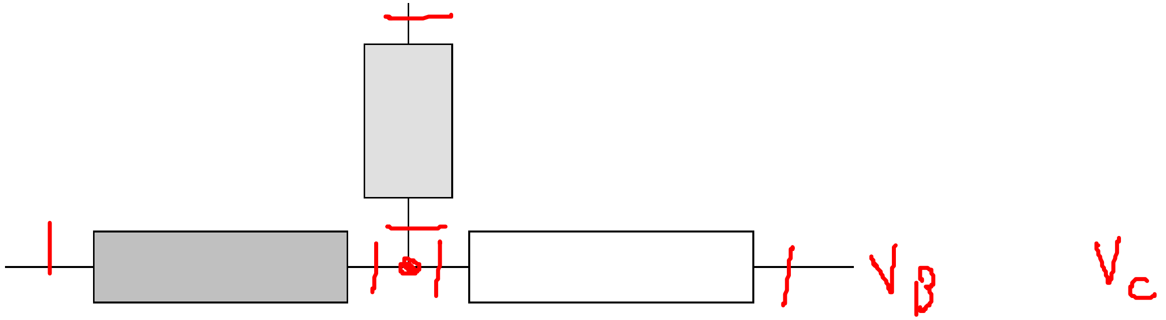
- Voltage Polarity Convention
  - A voltage encountered + to - is negative → −V
  - A voltage encountered - to + is positive → Rise → +V

BRANCHES AND NODES

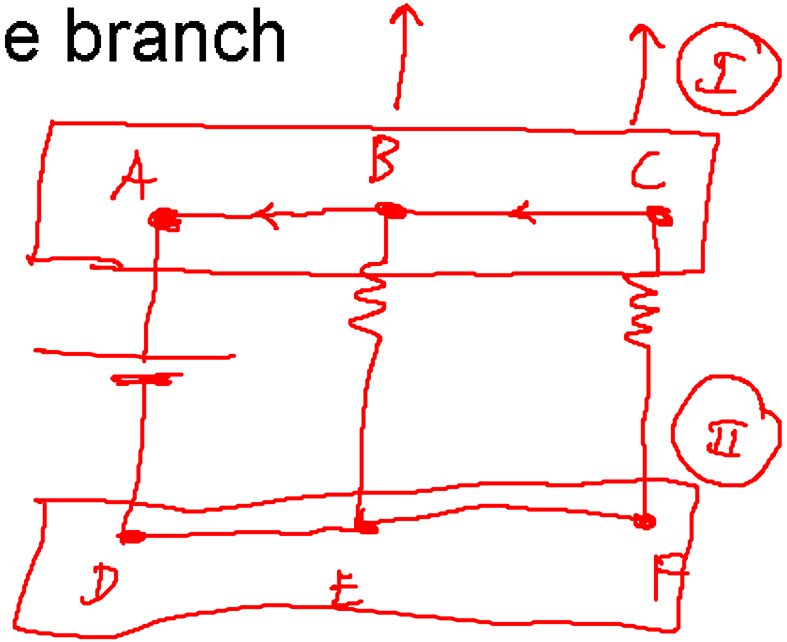
Branch: elements connected end-to-end, nothing coming off in between (in series)



A single branch

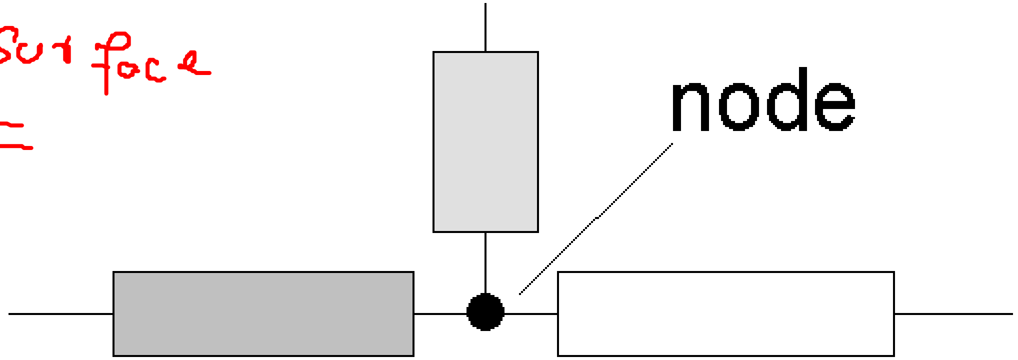


NOT a single branch



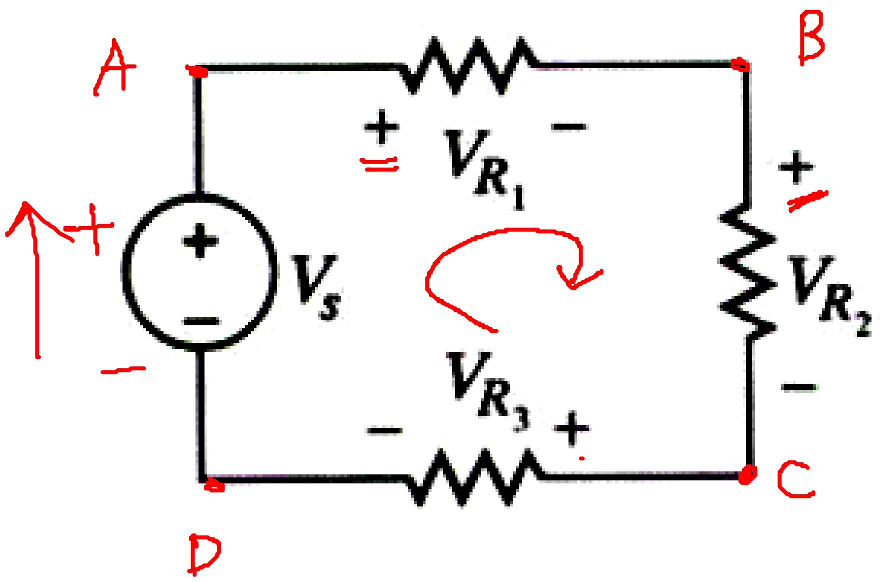
Node: place where elements are joined—entire wire

→ equipotential surface



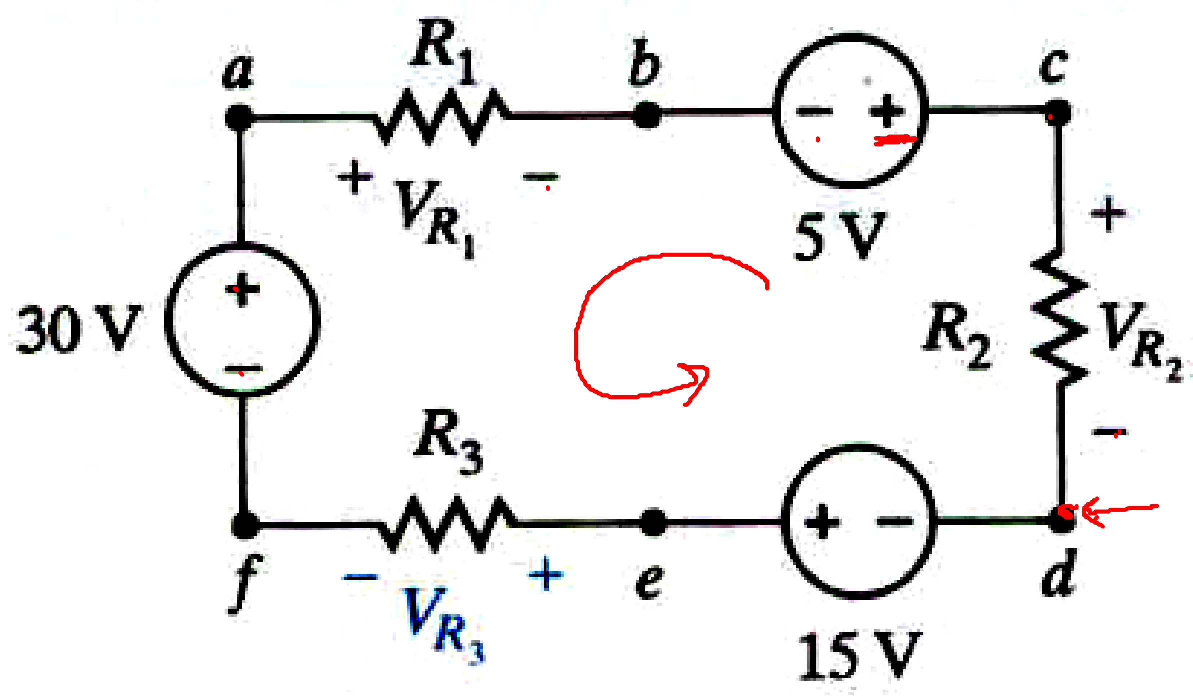
KVL, KCL

Write the KVL equation for the following loop, traveling clockwise:



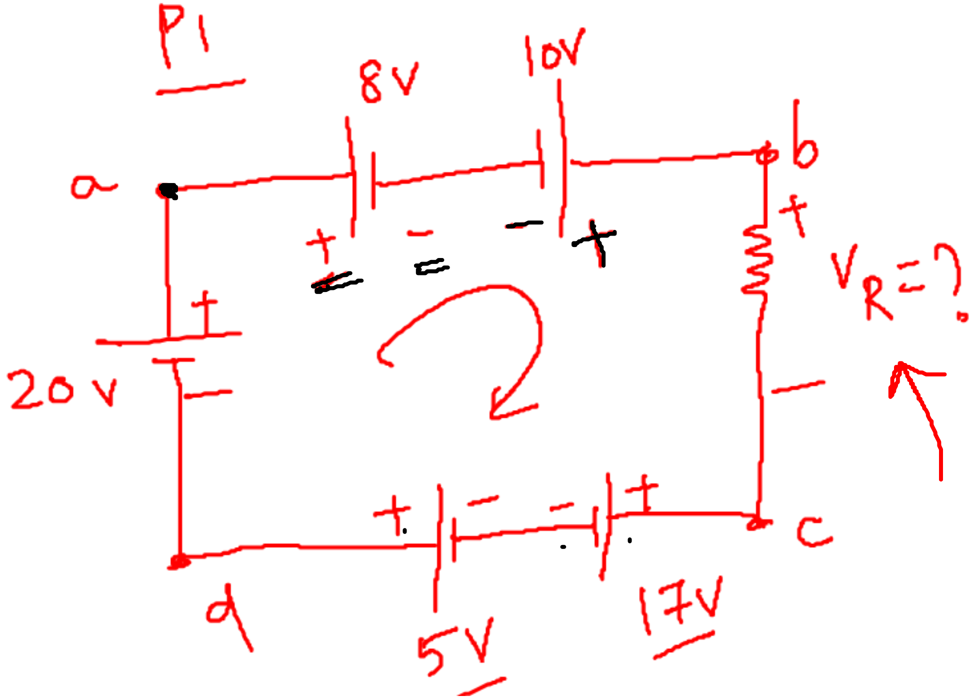
clockwise

$$-V_{R_1} - V_{R_2} - V_{R_3} + V_S = 0$$



$+V_{R_2} - 5 + V_{R_1} - 30 + V_{R_3} - 15 = 0$

P1



Sol:

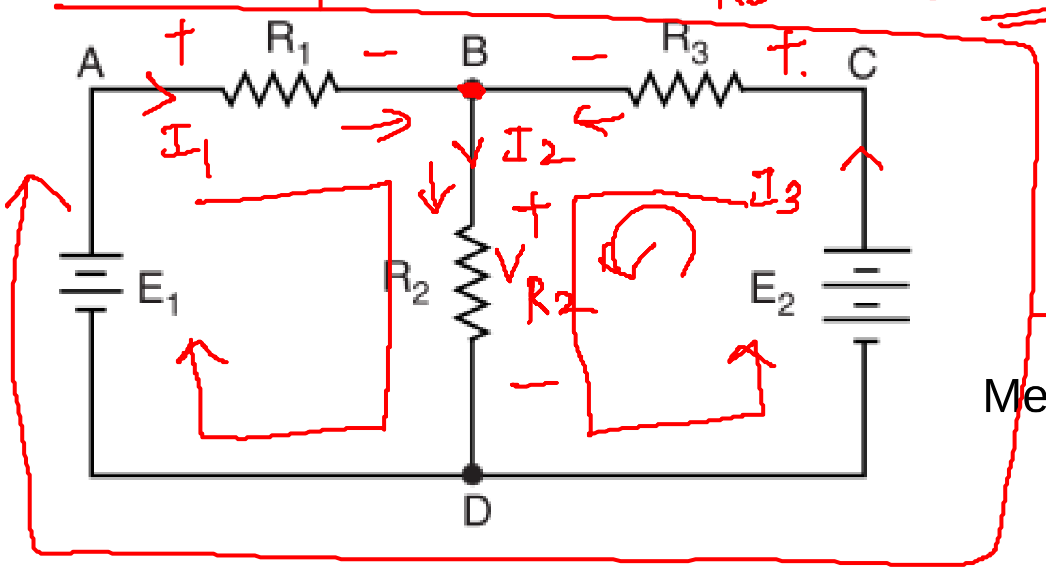
$$-8 + 10 - V_R - 17 + 5 + 20 = 0$$

$$\boxed{V_R = 10V}$$

$$\boxed{V_R = 10\,V}$$

Network Terminologies

V_{R_1} V_{R_3}



→ **Loop** → Any closed path

① A – B – D – A

② B – C – D – A (B)

③ A – B – C – D – A ×

Mesh → ① & ② → Mesh

→ Elementary loop

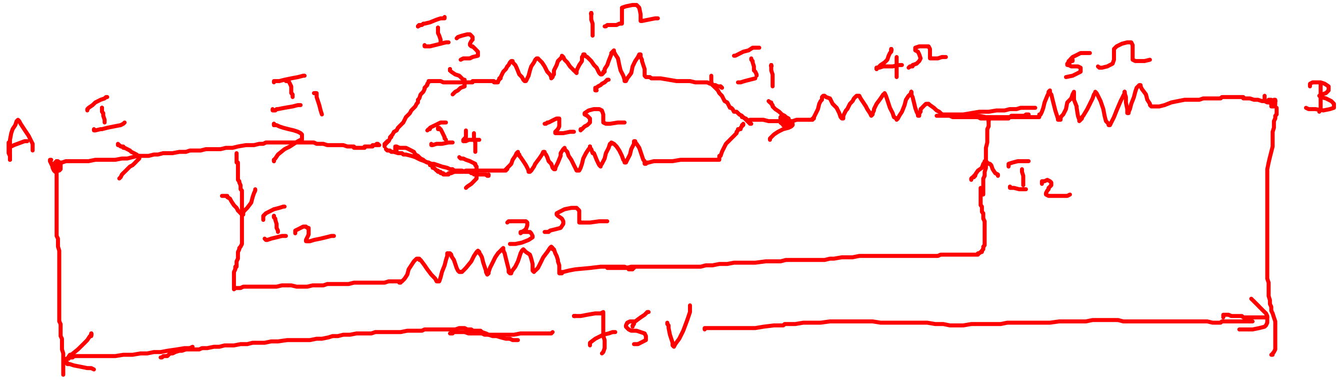
KVL, KCL

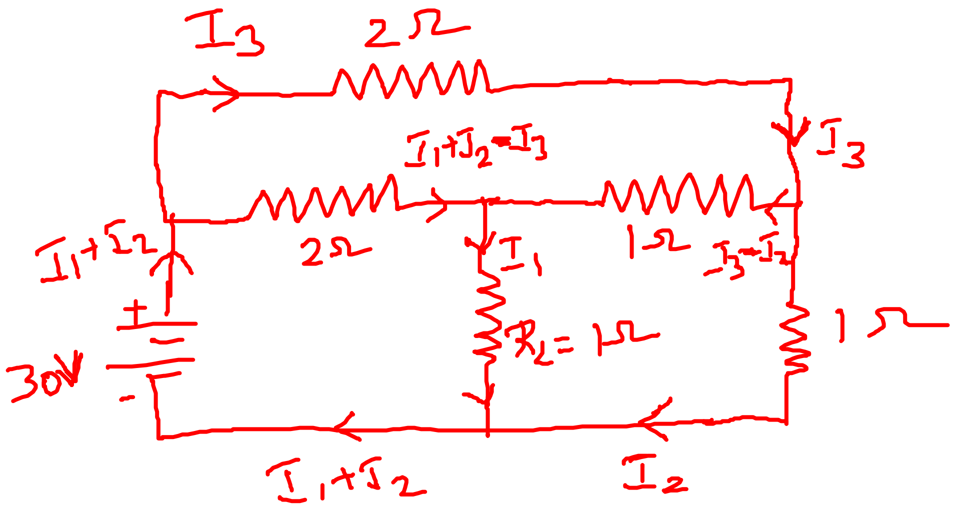
→ branch voltage & current

→ KVL, KCL → $I_1 + I_3 = I_2$

Practice Problem

- Determine the effective resistance of the series-parallel combination shown in the figure. Also, find the current, voltage and power dissipated in each of the resistor in the given circuit.





- Find the load current in the given circuit (Use KVL).

Summary

Reduction

- ↳ problems.

Tool chest

- → Division
- → Reduction
- → ohm's law
- → ~~kt~~ KVL, KCL
  - ↳ branch Voltage & currents
    - ↓ KVL, KCL.

↓

Mesh