DAY 4

Fundamentals of Electrical & Electronics Engg.

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KIRCHHOFF'S LAW

→ KVL → Conservation of Energy $\Sigma V = 0$

→ KCL → Based on conservation of electric charge

$$\Sigma i = 0$$
$$(i_{in} = i_{out})$$

Kirchhoff's Voltage Law

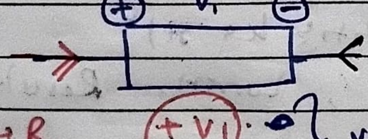
→ how to handle voltages in an electric circuit

→ algebraic sum of the voltages around any closed path = 0

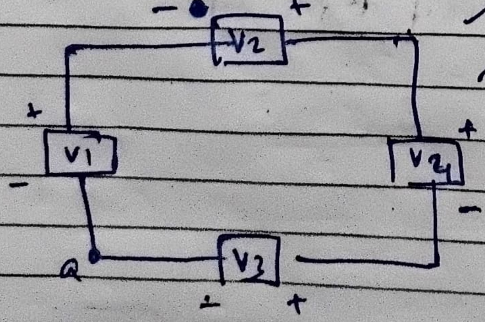
→ 3 ways - we can interpret the algebraic sum of voltages in a closed path = 0.

Consideration 1: The sum of the voltage drops around a circuit is equal to zero.

We define a voltage drop as +ve if we enter the +ve terminal and leave -ve terminal



L → R $+V_1$
R → L $-V_1$
} voltage drop

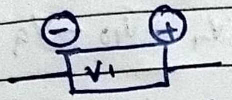


CW → $-V_1 - V_2 + V_4 + V_3 = 0$

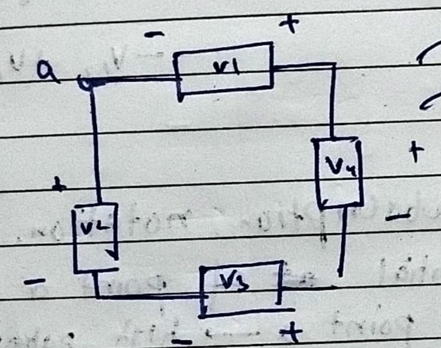
CCW → $-V_3 - V_4 + V_2 + V_1 = 0$

Consideration 2: The sum of voltages around circuit = 0.

We define a voltage rise

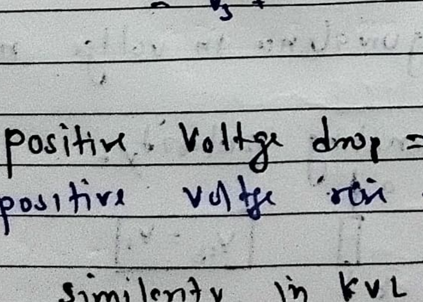


$L \to R \Rightarrow +V_1$ } voltage Rise
$R \to L \Rightarrow -V_1$ }



voltage rise
CW → $+V_1 - V_4 - V_3 + V_2 = 0$
CCW → $-V_2 + V_3 + V_4 - V_1 = 0$

Consideration 3: Sum of voltage rises = sum of voltage drop around the circuit



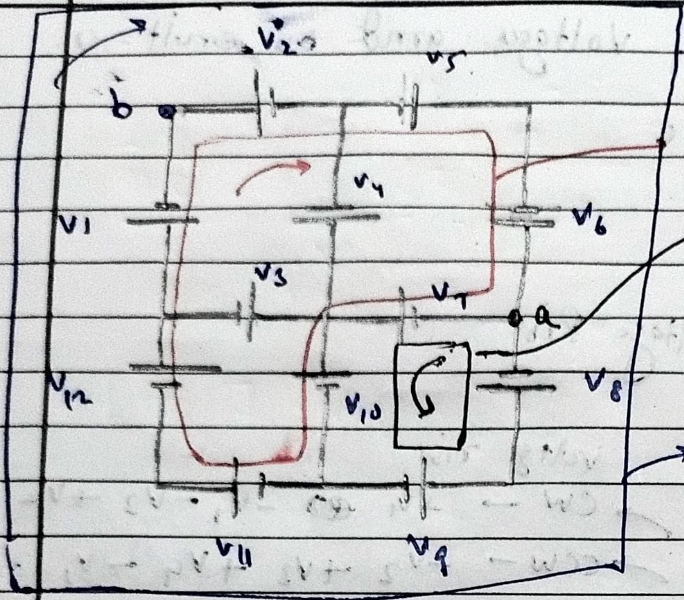
while crossing 1 & 2 → voltage rise (used)
while crossing 3 & 4 → use voltage drop

$+V_1 + V_2 = +V_4 + V_3$

→ positive voltage drop = negative voltage rise
positive voltage rise = negative voltage drop

similarity in KVL & KCL : sums - - -

Never! sum of voltages enter = 0 at junction point
sum of currents around closed path = 0.



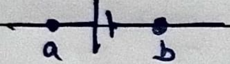
using sum of drops = 0

$V_2 - V_5 - V_6 - V_7 + V_{10} - V_{11} - V_{12} + V_1 = 0$

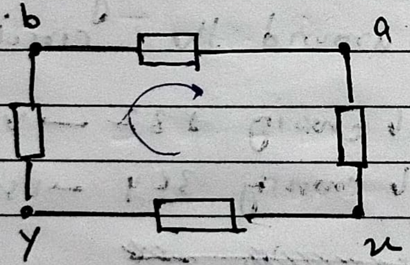
$-V_7 + V_{10} - V_9 + V_8 = 0$

$+V_2 - V_5 - V_6 - V_8 + V_9 - V_{11} - V_{12} + V_1 = 0$

KVL: Double subscription notation.



V_{ab} → potential of point a wrt point b
with point a → high potential (+)
point b → low potential (−)

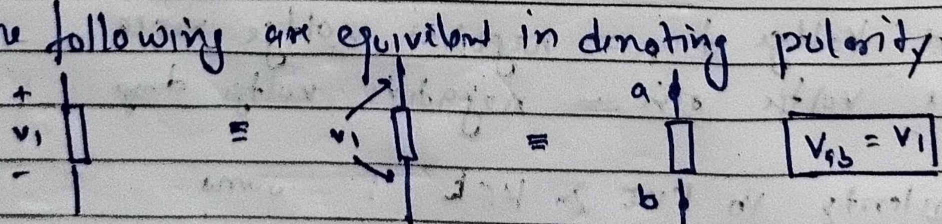


CW: $V_{ab} + V_{xa} + V_{yx} + V_{by} = 0$
(using Rises)

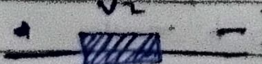
Kirchoff's Voltage Law : Equivalence in voltage notations

The following are equivalent in denoting polarity:

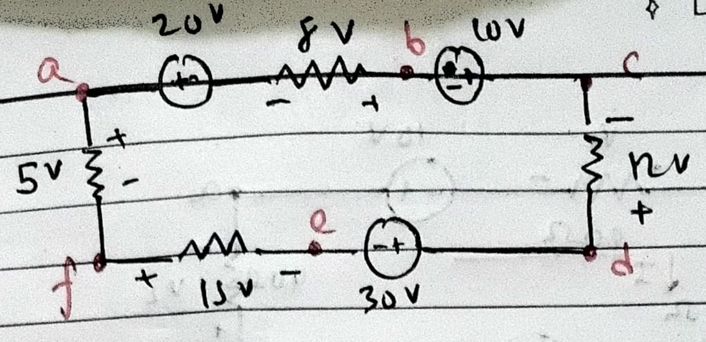
polarity



[Assumed the upper terminal +ve in all scans]



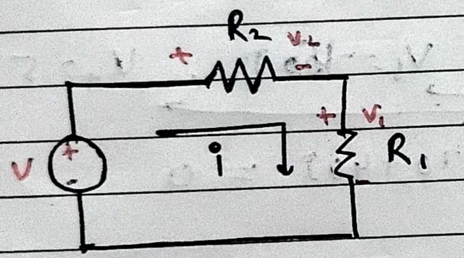
$V_2 = -9$ V → RHS of element → (+ve)



using drops = 0 find V_{ad} & V_{fc}

Single loop circuits

→ Voltage Divider ~~Recognition~~ Rule



$V = V_1 + V_2$

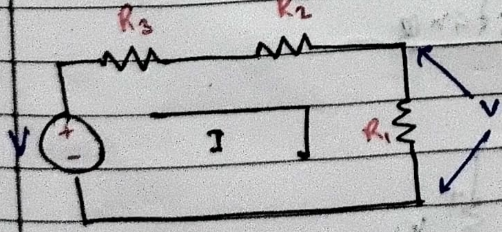
$V_1 = iR_1$, $V_2 = iR_2$

then,

$V = i_1(R_1 + R_2)$ and

$i_1 = \dfrac{V}{(R_1 + R_2)}$

$$\boxed{V_1 = \frac{VR_1}{(R_1 + R_2)}} \; *$$



$I = \dfrac{V}{(R_1 + R_2 + R_3)}$ > $\boxed{V_1 = \dfrac{VR_1}{(R_1 + R_2 + R_3)}}$

$V_1 = IR_1$

Eg. $R_1 = 4\Omega$ $V = 50\,V$ $P_1 = 16\,W = I^2 R_1$

$R_2 = 11\Omega$ $P_1 = 16\,W$ $\Rightarrow I = 2\,A$

$R_3 = ?$

$V = I(R_1 + R_2 + R_3)$

$R_1 + R_2 + R_3 = 25 \longrightarrow R_3 = 25 - 15 = 10\,\Omega$

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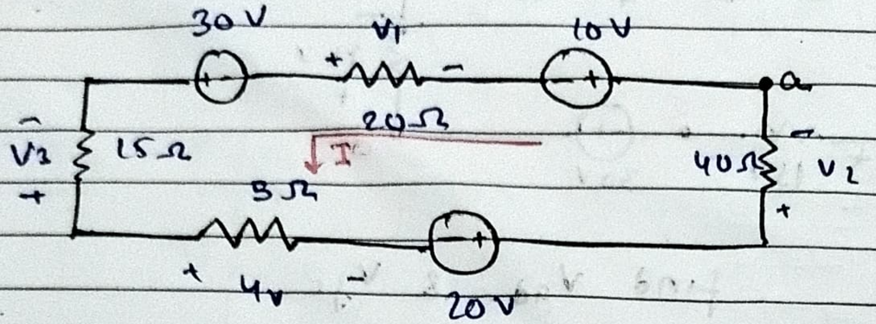


find I, V_1, V_2, V_3, V_4 and Power supplied by 10 V source

start from pt. a, sum of voltage drops = 0 in dir^n of current I

$$+10 - V_1 - 30 - V_3 + V_4 - 20 + V_2 = 0$$

$V_1 = -20I$, $V_2 = 40I$, $V_3 = -15I$, $V_4 = 5I$

$$10 + 20I - 30 + 15I + 5I - 20 + 40I = 0$$

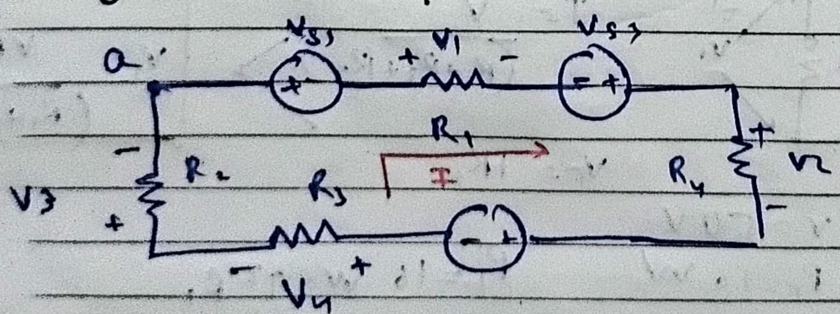
$I = 0.5\,A$

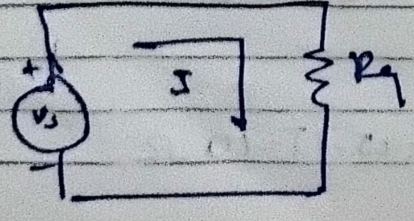
$V_1 = -10V$ $\quad V_3 = -7.5V$

$V_2 = 20V$ $\quad V_4 = 2.5V$

$$P_{10(\text{supplied})} = -10I = -5W$$

Single loop, Equivalent Resistance





KVL →

$\boxed{V_s = I R_{eq}}$ —— (1)

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apply KVL start from 'a' using drops = 0 (cw)

$$V_{s1} + v_1 - V_{s3} + V_2 + V_{s2} + V_4 + V_3 = 0$$

OR

$$-V_{s1} - V_{s2} + V_{s3} = I(R_1 + R_2 + R_3 + R_4) \quad \text{--- (II)}$$

comparing with (I)

$$V_s = V_{s1} - V_{s2} + V_{s3}$$

$$R_{eq} = R_1 + R_2 + R_3 + R_4$$

Kirchoff's Current Law

At any junction (node) ; total current flowing in = total current flowing out

→ ~~ect~~ charge can't pile up or dissapear at a pt.

$$\sum i_{in} - \sum i_{out} = 0.$$

$$\sum i_{in} = \sum i_{out}$$