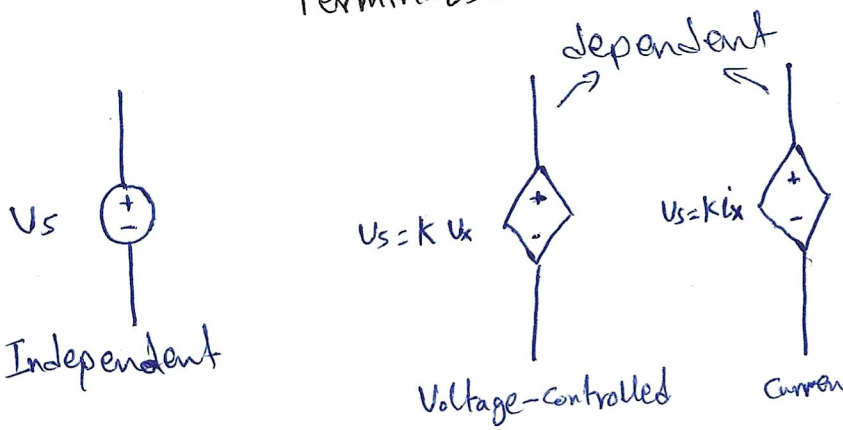
Chapter 2 :- Circuit elements

There are 5 ideal basic circuit elements

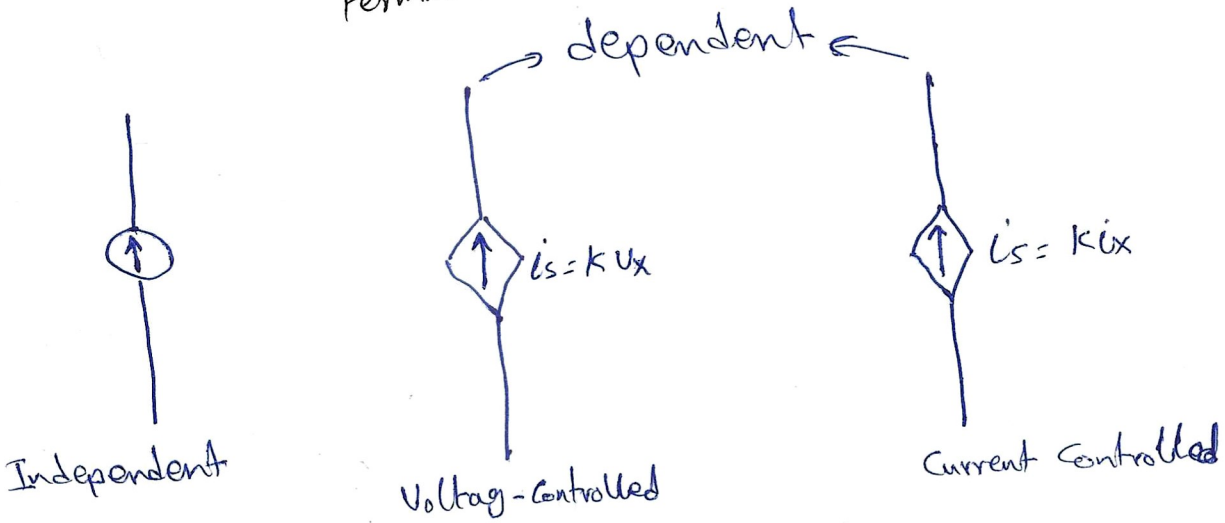
2.1 Voltage and Current source (active elements)

- dependent
- Independent

Voltage source :- circuit element that maintains a prescribed voltage across its terminals regardless of the current flowing in those terminals.



Current source :- Circuit element that maintain a prescribed current across its terminals regardless of the voltage across those terminals

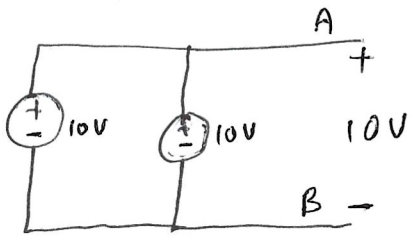


Connecting Voltage Sources

Ideal Voltage sources can be connected together in both parallel and series.

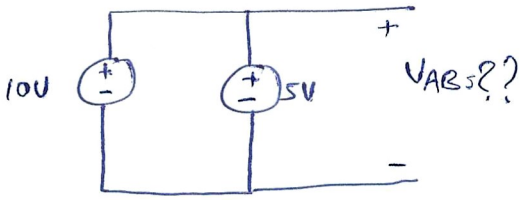
Series voltages add together while parallel voltages have the same value and polarity

unequal ideal Voltage sources cannot be connected directly together in parallel.



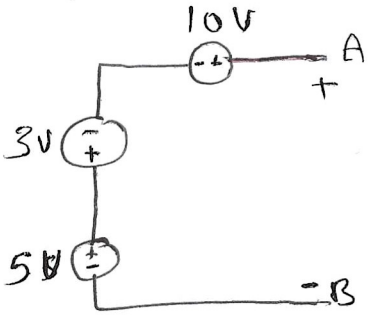
$V_{AB} = 10V$

Valid Connection



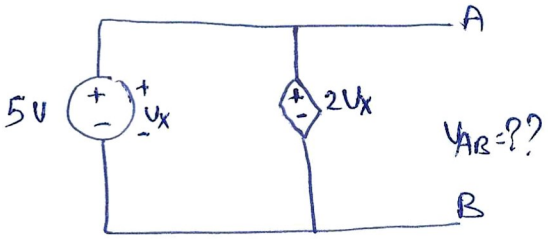
not permissible

not valid



$V_{AB} = 12\ V$

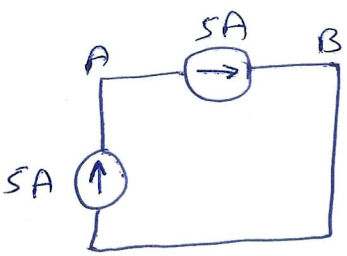
Valid Connection



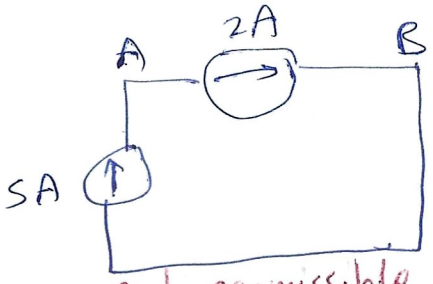
not permissible

Connecting Current Sources

parallel current sources add together while series current sources should have the same value and direction.



Valid Connection



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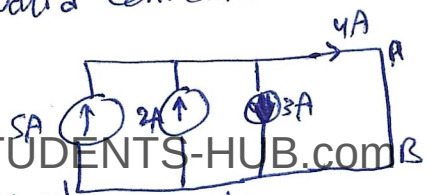
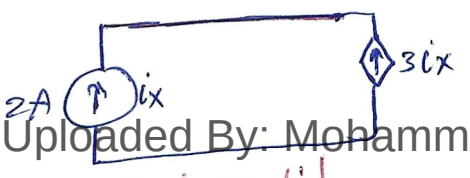
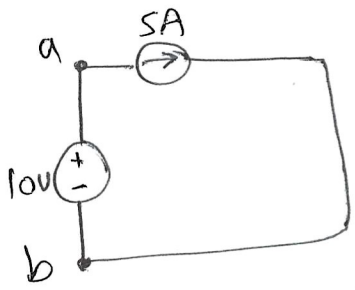
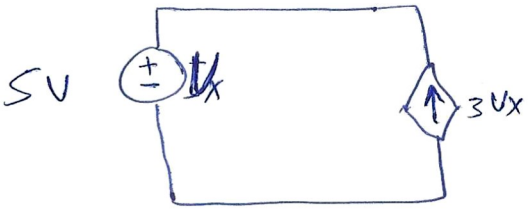






Valid Connection

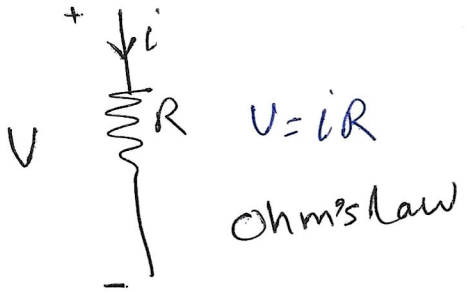


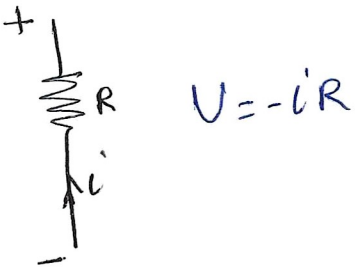
Valid Connection

2.2 Electrical Resistance

passive elements

- Resistor (R) in ohm (Ω)
- Inductor (L) in Henry (H)
- Capacitor (C) in Farad (F)

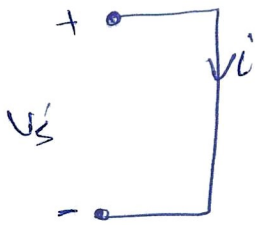




passive sign convention

$$G \text{ Conductance} = \frac{1}{R} \quad \begin{matrix} S \text{ (Siemens)} \\ \mho \text{ (mho)} \end{matrix}$$

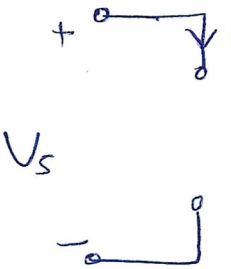
* Special Resistor Values



short Circuit

$R = 0$ $\quad i = \infty$

$G = \infty$



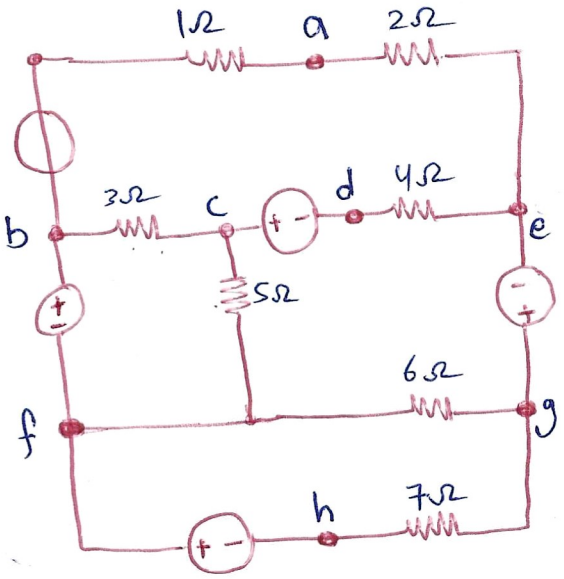
open Circuit

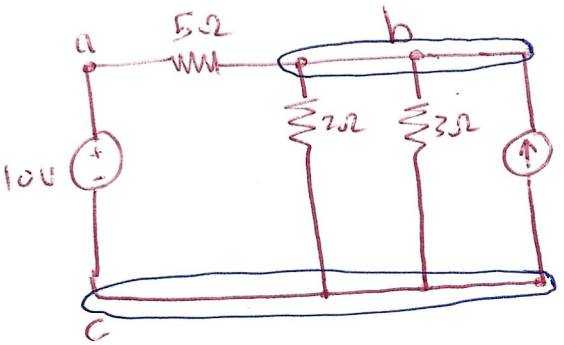
$R = \infty$ $\quad i = 0$

$G = 0$

2.4 Kirchhoff's Laws

Node	A point where two or more circuit element join (a, d, h, b, c, ---)
Essential node	A node where three or more circuit element join (b, c, e, g, f)
Path	A trace of adjoining basic elements with no element included more than once (bae)
Branch	a path that connects two nodes (ba, ae)
Essential branch	a path that connects two essintial nodes without passing through an essintial node (bc)
Loop	a path whose last node is the same as the starting node (b, a, e, d, c, b)
mesh	A loop that does not enclose any other loops (b, c, f, b)





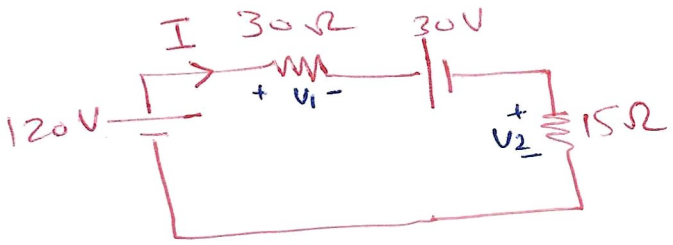
Kirchhoff's Voltage Law (KVL) :- The algebraic sum of all the voltages around any closed path in a circuit equals zero.

Kirchhoff's Current Law (KCL) :- The algebraic sum of the currents at any node in a circuit equals zero.

* Applying KVL :-

examples-

For the circuit shown, find I ?

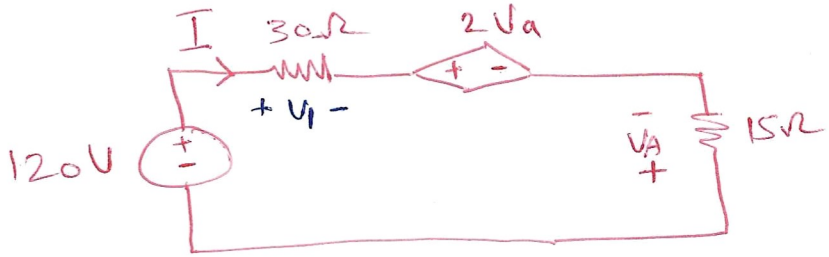


$$-120 + V_1 + 30 + V_2 = 0$$

$$-120 + (30)(I) + 30 + (15)I = 0$$

$$I = 2A$$

Example :- Find I and Calculate the power associated by each circuit element?



$$-120 + V_1 + 2V_a - V_a = 0$$

$$-120 + V_1 + V_a = 0$$

but $V_a = -15I$

and $V_1 = 30I$

$$\therefore -120 + 30I - 15I = 0$$

$$\Rightarrow I = 8A \qquad V_a = -15(8) = -120$$

$P_{120V} = -(V)(I) = -(120)(8) = -960$ W delivered

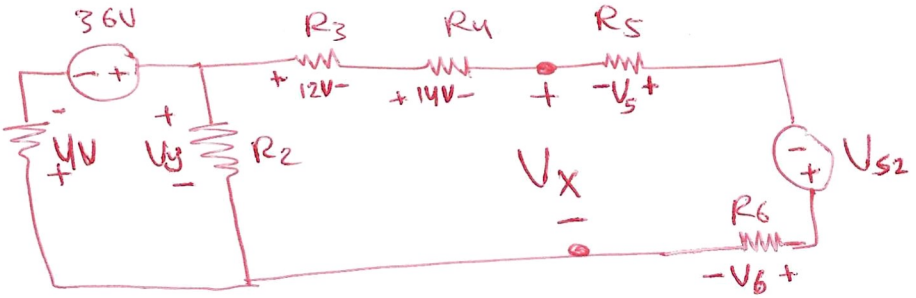
$P_{30\Omega} = VI = (30)(8)(8) = 1920$ W absorbed

$P_{2Va} = VI = (-240)(8) = -1920$ W delivered

$P_{15\Omega} = VI = (15)(8)(8) = 960$ W absorbed

} Law of Conservation of energy must be obeyed in any electric circuit

Example:- For the circuit shown, find V_y and V_x



To find V_y apply KVL for the first loop

$4V - 36V + V_y = 0$

$\Rightarrow V_y = 32\ V$

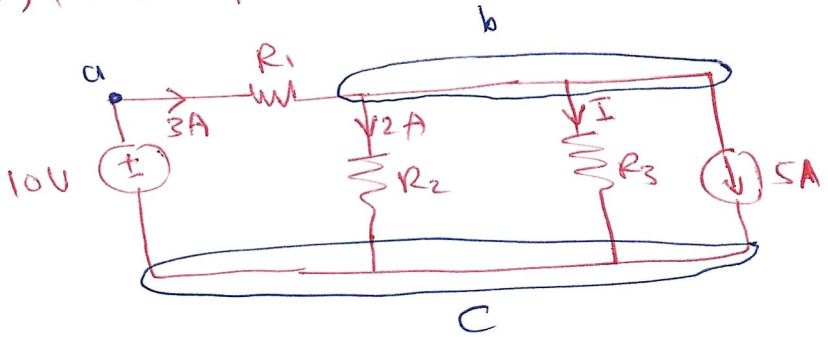
$-V_y + 12V + 14V + V_x = 0$

$-32 + 12 + 14 + V_x = 0$

$\Rightarrow V_x = 6V$

* applying KCL :-

Example:- for the circuit shown, find I?



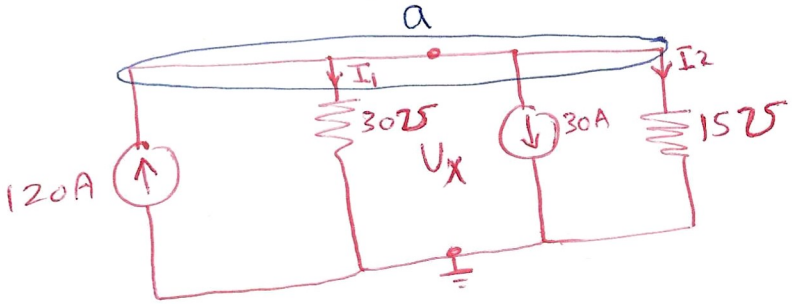
For node b

$3A = 2A + I + 5A$

$\therefore I = -4A$

Example:- for the circuit shown, find V_x?

$I = \frac{U}{R} = GV$

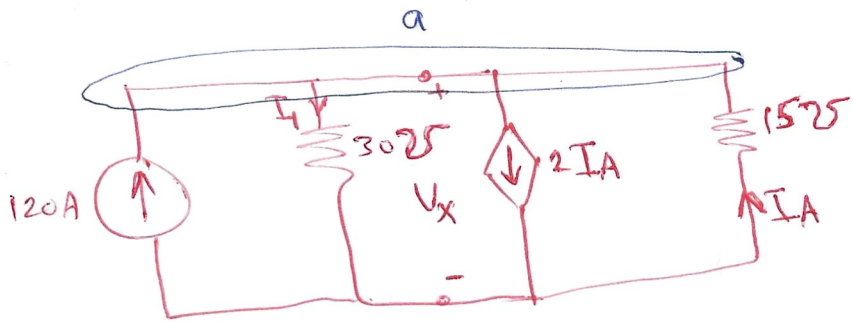


at node a

$120A = 30V_x + 30 + 15V_x$

$\therefore V_x = 2V$

Example- Find V_x ?



at node a

$$120 + I_A = I_1 + 2I_A$$

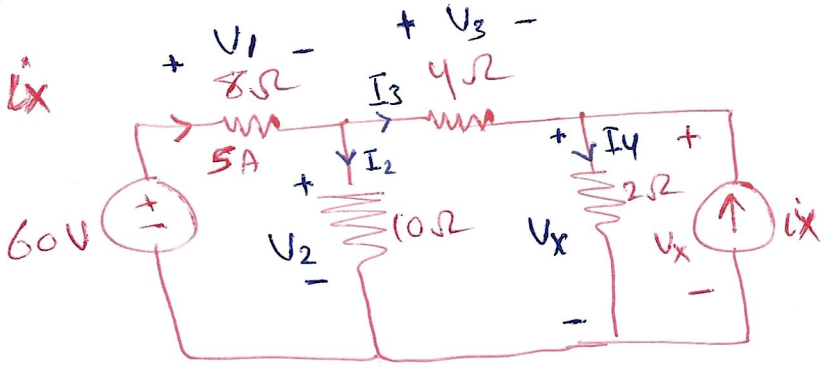
but $I_A = -15V_x$ and $I_1 = 30V_x$

$$120 + (-15V_x) = 30V_x + 2(-15V_x)$$

$$\Rightarrow V_x = 8V$$

* Applying KVL and KCL

Example solve for V_x and i_x



$V_1 = (8)(5) = 40\ V$

KVL

$$-60 + 40 + V_2 = 0$$

$$\Rightarrow V_2 = 20\ V$$

$$I_2 = \frac{V_2}{10} = \frac{20}{10} = 2\ A$$

KCL

$$5A = I_2 + I_3$$
$$= 2A + I_3 \Rightarrow I_3 = 3A$$

$$V_3 = (4)(3) = 12\ V$$

KVL

$$-20 + 12 + V_x = 0$$

$$\Rightarrow V_x = 8V \Rightarrow I_4 = \frac{8}{2} = 4\ A$$

KCL

$$I_3 + I_x = I_4$$

$$3 + I_x = 4$$

$$I_x = 1\ A$$