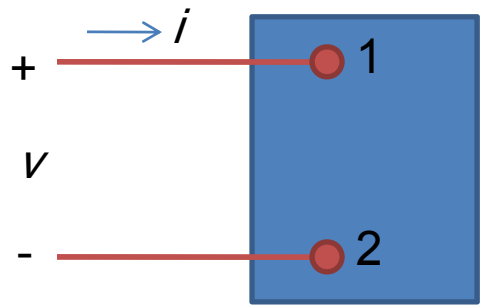
جامعة الأهرام الكندية
AHRAM CANADIAN UNIVERSITY

Lecture (01)
Ohm's and Kirchhoff's laws

Dr. Ahmed M. ElShafee

Ideal basic circuit element

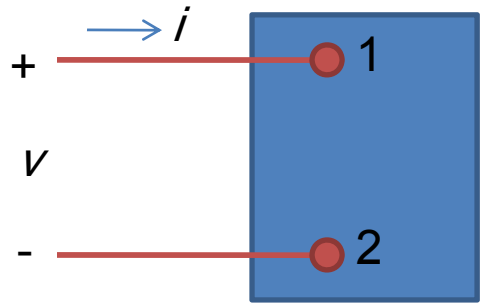
1. Has only 2 terminal
2. Described mathematically in terms of voltage and current
3. It can’ t be divided.



Passive sign convention theory

- Passive sign convention:

  if the current reference direction is in the direction of the voltage drop across the element, +ev sign in any expression relates voltage to the current, otherwise use a –ve sign.
- Note: polarity reference is independent on function of the basic element, or its interconnection.



Power and Energy

- Power and energy calculations are so important in electric circuit analysis because
  1. The useful output of these systems often nonelectrical (heat, light, movement, ….).
  2. All practical devices have limitations on the amount of power that can handle.

Power and Energy (2)

- Passive sign convention

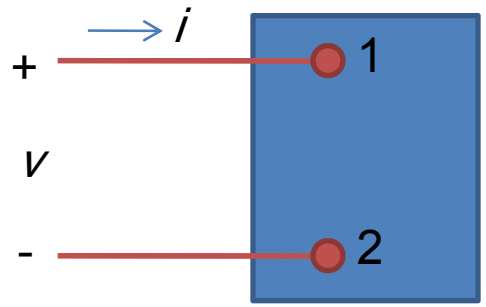
  if the current flow is in the same direction of voltage drop, then $P = i \times v$

  dissipating, absorbing power

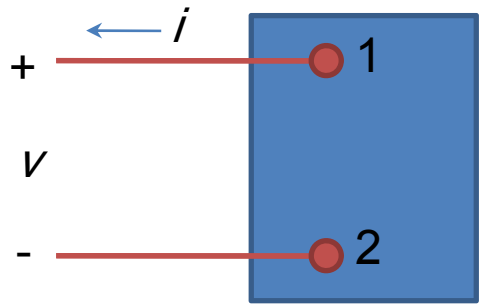
  if not $P = - i \times v$

  generating, losing power

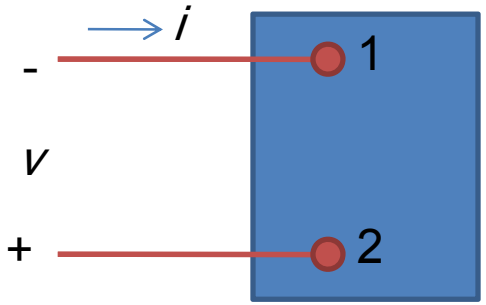
Power and Energy (3)



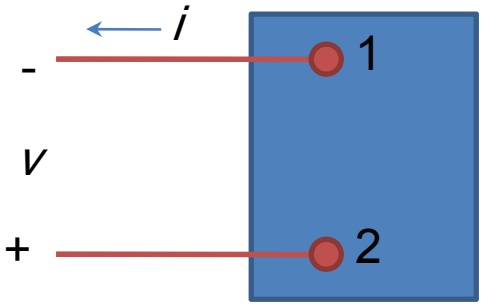
$P = vi$



$P = -vi$



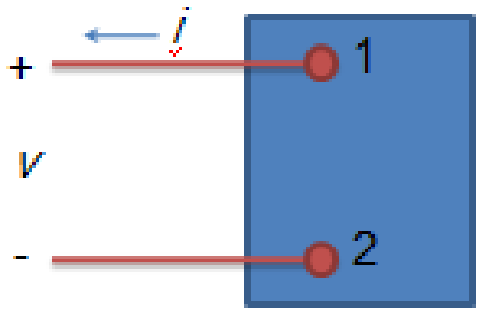
$P = -vi$



$P = vi$

Power and Energy (4)

- Example: in the following model



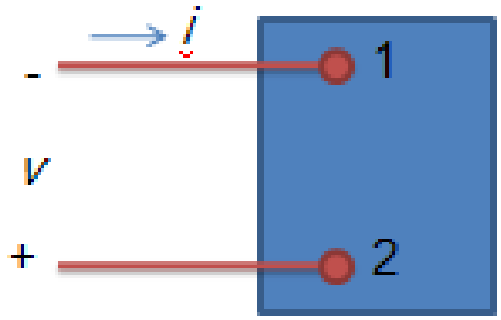
if i = 4 A and v = -10V

then P = - (-10)(4) = 40 W

The element is absorbing (dissipating) 40 watts

Power and Energy (5)

- Example: in the following model



if i = -4 A and v = 10V

then P = - (10)(-4) = 40 W

The element is absorbing (dissipating) 40 watts

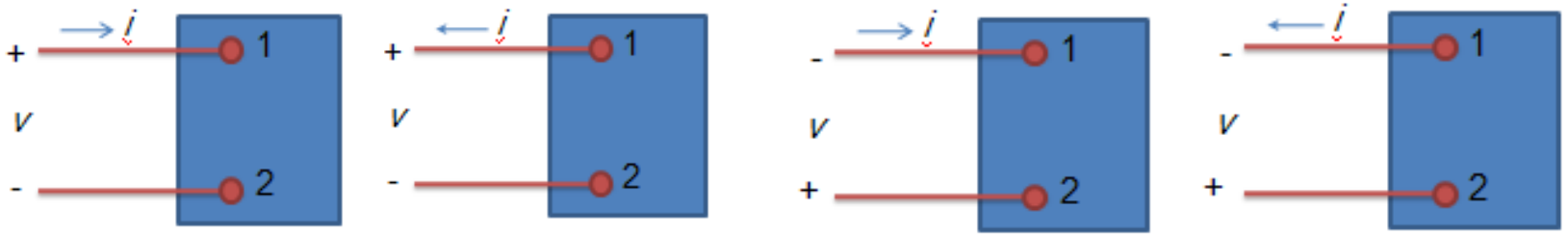
Example 01

Assume that a 10V drop occurs across an element from terminal 2 to terminal 1 and that a current of 4A enters terminal 2.

a) Specify the values of *v* and *i* for the polarity references shown in figures.

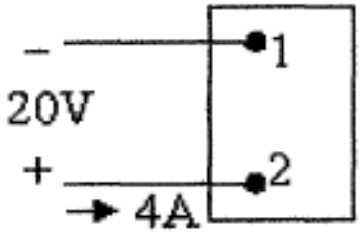
b) State whether the circuit inside the box is absorbing or delivering power.

c) How much power is the circuit absorbing?



Answer 01

- Start with sketching the circuit model



- For the first model

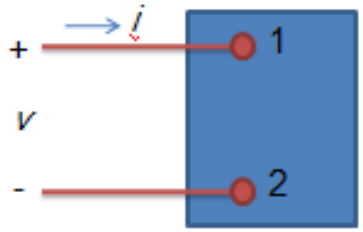
  v= -20v i=-4A;

  P=(-20)x(-40)=80W, absorbing

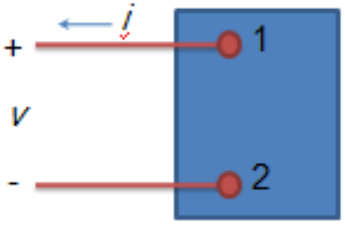
- For the second model

  v= -20v i=4A;

  P=-(-20)x(4)=80W, absorbing



$P = vi$



$P = -vi$

Answer 01(2)

- For the 3rd model

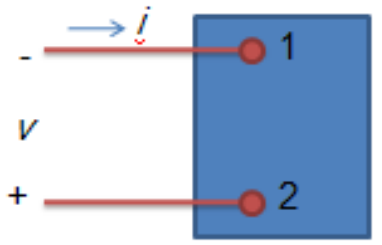
  v= 20v i=-4A;

  P=-(20)x(4)=80W, absorbing

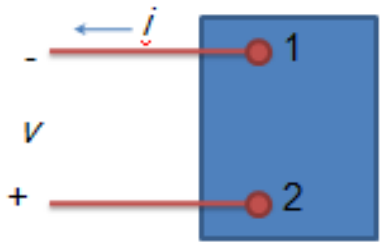
- For the 4th model

  v= 20v i=4A;

  P=(20)x(4)=80W, absorbing



$P = -vi$



$P = vi$

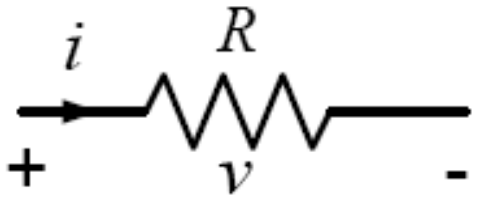
Ohm's law

The voltage *v* across a resistor is directly proportional to the current I flowing through the resistor.

1 Ohm :

$$v \propto i$$

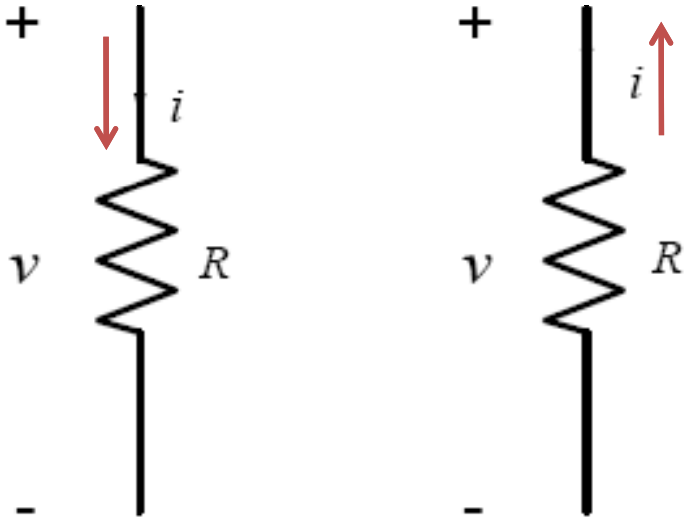
$$v = iR$$



Ohm's law (2)

Passive sign convention:

There are two possible reference choices for the current and voltage



$v=iR$ $v=-iR$

Ohm's law (3)

Conductance is the opposite of resistance:

$$G = 1/R = i/v$$

Symbol: G

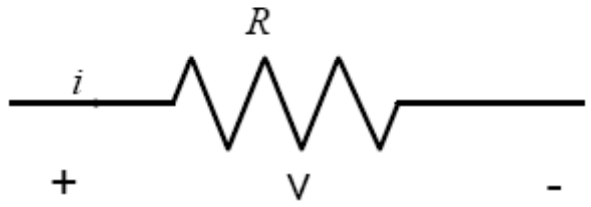
Units: Siemens (S) or mho ($\mho$)

Ohm's law (4)

Power dissipated by a resistor:

$$p = vi = v(\frac{v}{R}) = \frac{v^2}{R}$$

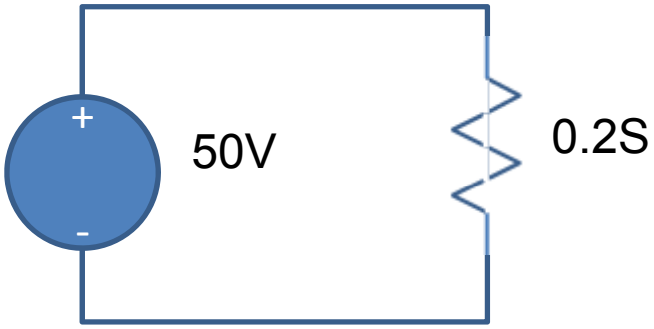
$$p = vi = (iR)i = i^2 R$$

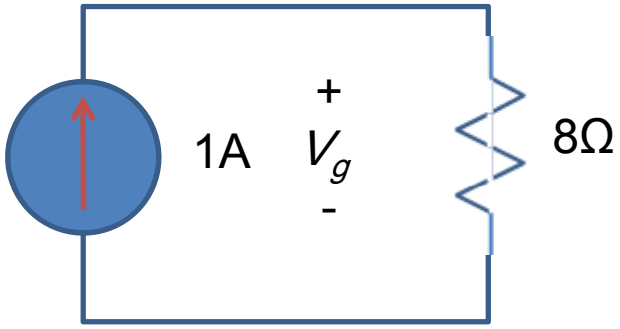


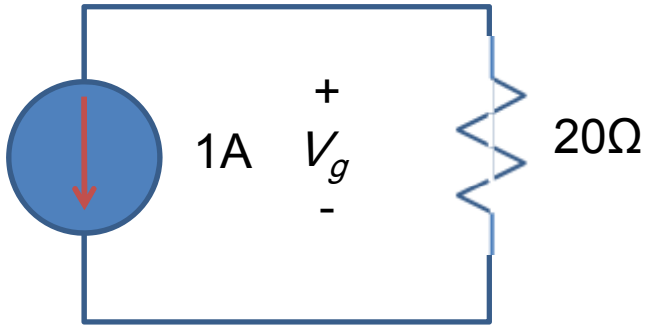
Example 09

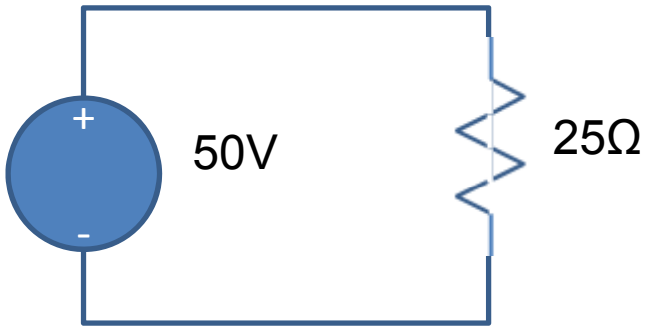
For each figure, calculate;

1. V, and I.
2. Power.







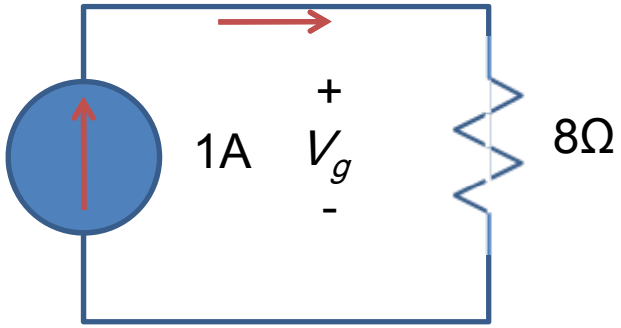


Answer 09

$I = 1A$

$V = I.R = 8V$

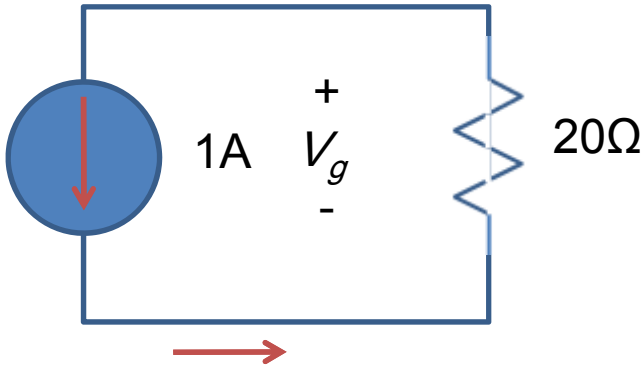
$P = V^2/R = 8W$



$I = 1A$

$V = -I.R = -20V$

$P = V^2/R = 20W$

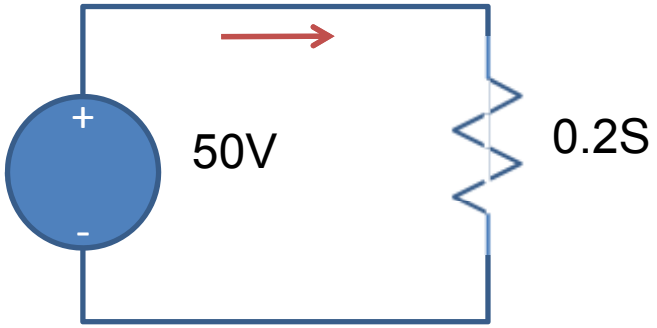


Answer 09 (2)

$V = 50V$

$I = V.G = 10A$

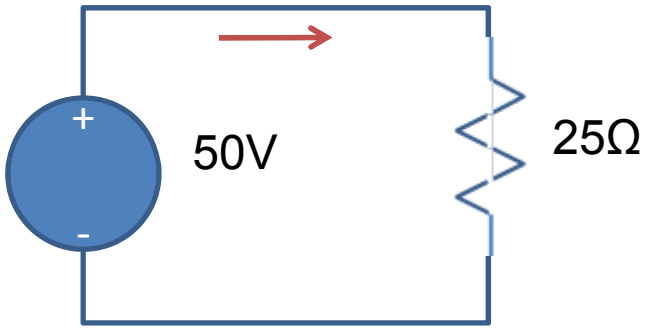
$P = I^2/G = 8W$



$V = 50V$

$I = V/R = 2A$

$P = I^2.R = 100W$

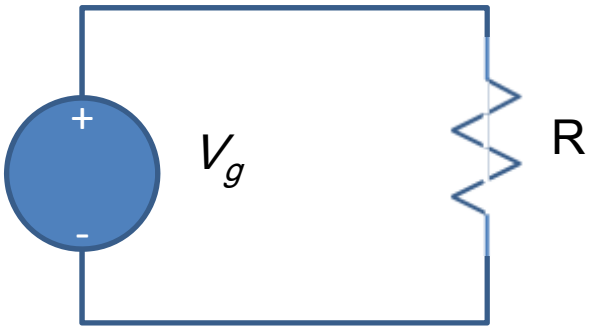


Example 10

a. V_g=1KV, I_g=5mA, find R&P_{resistor}.

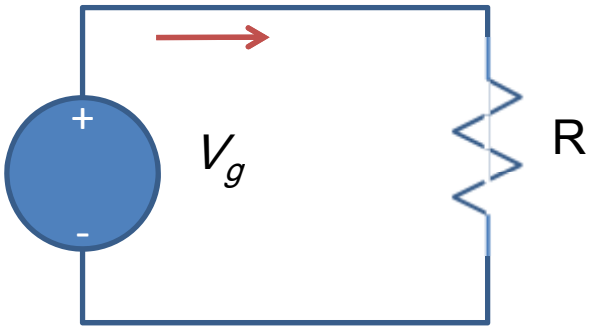
b. I_g=75mA, P_{source}=-3W, find V_g, R, P_{resistor}.

c. R=300Ω, P_{resistor}=480mW, find I_g, V_g.



Answer 10

a) V_g=1KV, I_g=5mA. find R&$P_{resistor}$.



$R= V_g/I_g = 10^3/5x10^{-3} = 0.2x10^6=$
200KΩ.

$P= V.I$ = 5W.

b) I_g=75mA, P_{source}=-3W. find V_g, R, $P_{resistor}$.

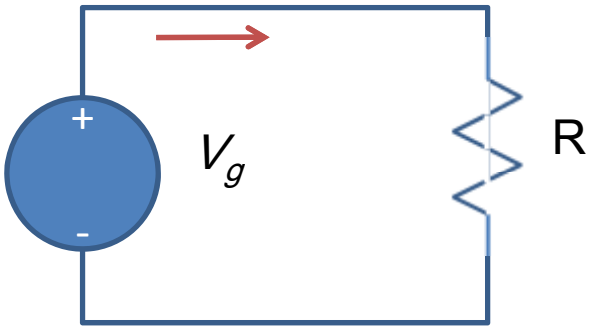
$V_g=-P/I_g = -(-3/(75x10^{-3})) = 40V.$

$R=V_g/I_g= 40/(75x10^{-3})=533.33Ω.$

$P_{resistor}$ = 3W.

Answer 10 (2)

R=300Ω, $P_{resistor}$=480mW, find I_g, V_g.



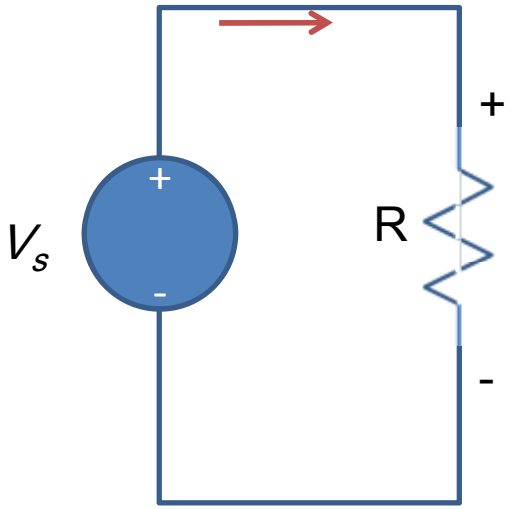
$I_g=(P/R)^{0.5}=((480x10^{-3})/300)^{0.5}=$

0.04A = 40mA.

$V_g=(PxR)^{0.5}=((480x10^{-3})x300)^{0.5}=12V.$

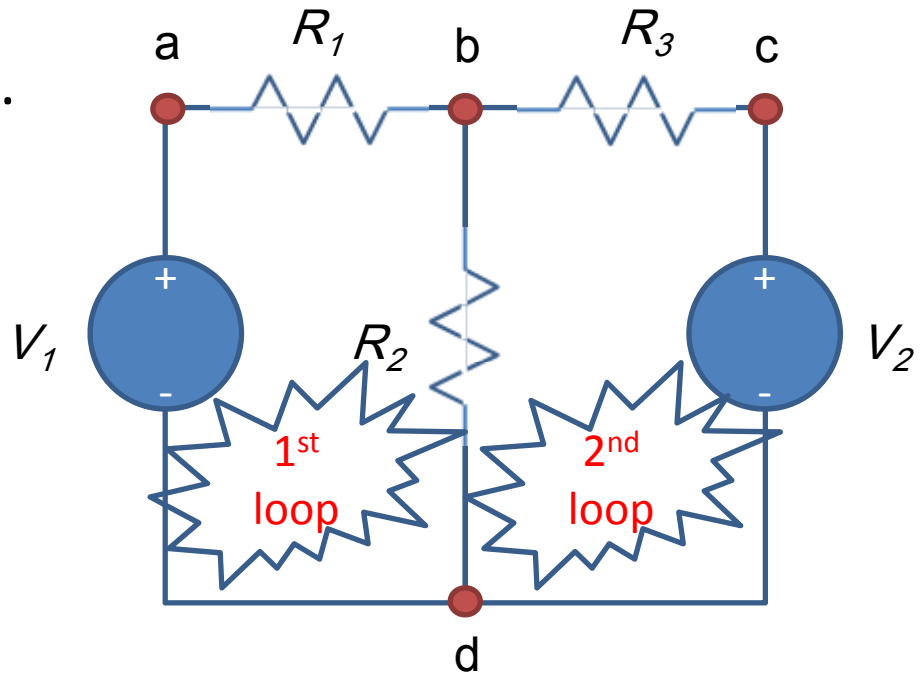
Kirchhoff's laws

- Simple circuit
  - Voltage
  - Current
  - Power



Kirchhoff's laws (2)

- More Complex circuit,
  - Circuit contains 2 loops 1, 2.
  - bd branch shared between the two loops.
  - Nodes b, d are shared between the two loops.



Kirchhoff's laws (3)

Kirchhoff's Voltage Law (KVL):

"The algebraic sum of all voltage drops around any closed loop is zero"

$$\sum_{m=1}^{M} v_m = 0$$

M: number of voltages in the loop

V_m: m^{th} element voltage.

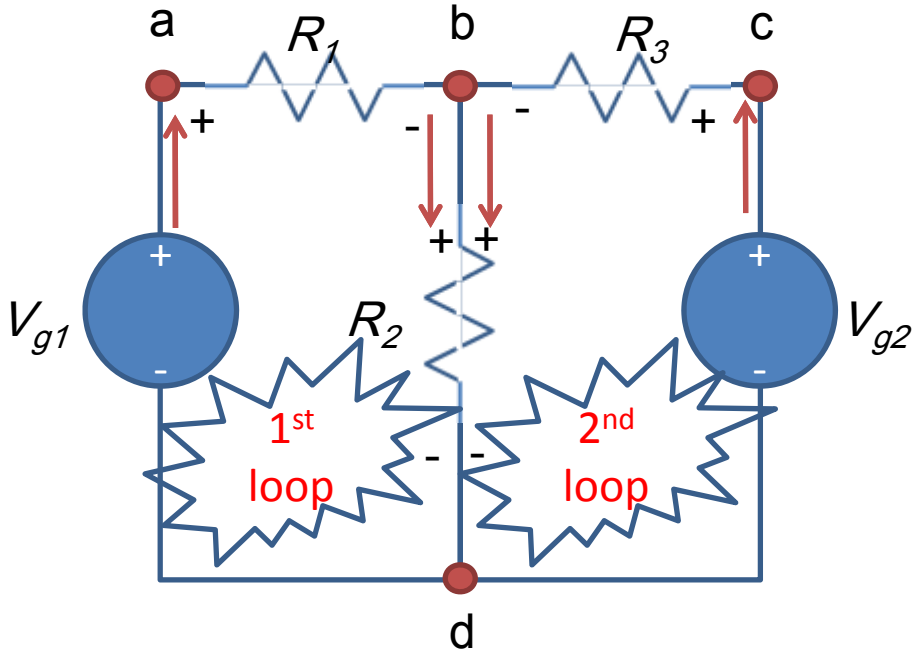
- Satisfied around all loops of a circuit.
- The law is about energy conservation

Kirchhoff's laws (4)

- KVL example:
- 1st loop:

  $-V_{g1} + V_1 + V_2 = 0$
- 2nd loop:

  $-V_{g2} + V_3 + V_2 = 0$



- Passive sign convention:

Voltage get +ve if the current flow in side component is in the same direction of voltage drop, otherwise voltage get –ve sign.

Kirchhoff’s laws (5)

- **Kirchhoff's current Law (KCL):**

“The algebraic sum of currents around a node is zero”

$$\sum_{n=1}^{N} i_n = 0$$

N: number of branches connected to the node

i_n: h current entering the node

- Satisfied at all nodes of a circuit
- The law is about charge conservation

Kirchhoff's laws (6)

- KCL example:

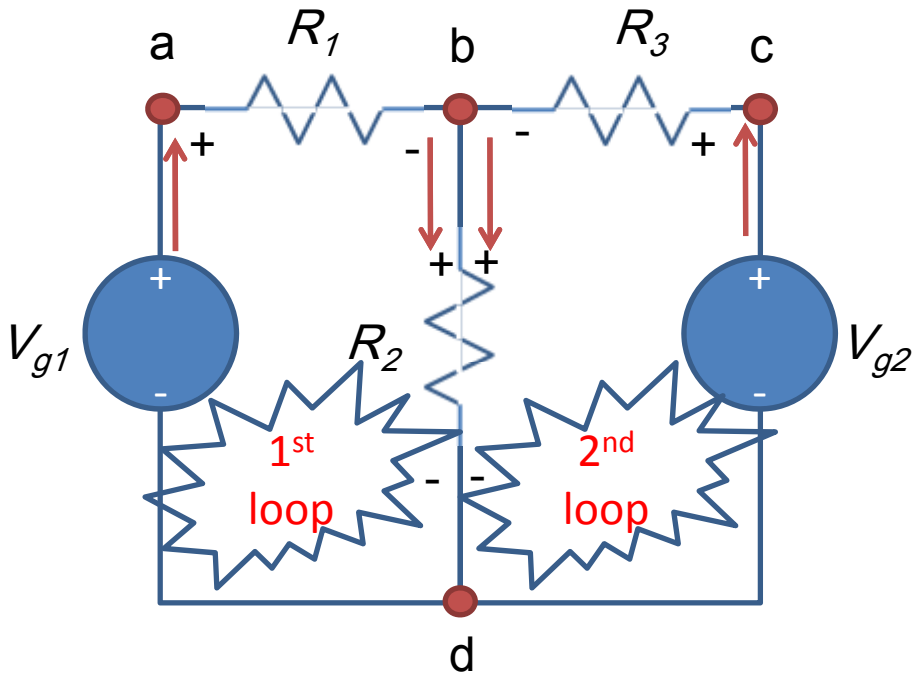
node a: $-I_{g1}+I_1 = 0$

Node b: $-I_1-I_3+I_2=0$

Node c: $-I_{g2}+I_3=0$

Node d: $-I_2+I_{g1}+I_{g2}=0$

So: $I_2=I_{g1}+I_{g2}$.



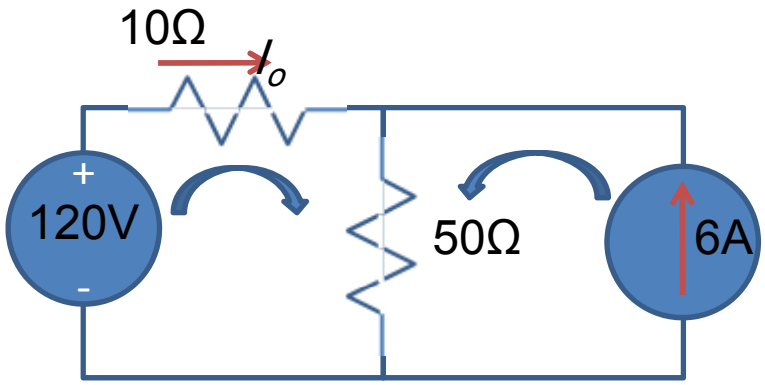
- Passive sign convention:

Current gets +ve if the current leave the node is while gets –ve sign if the current entering the node.

Example 3

use KL and Ohm's law to

1. find I_o
2. *Verify that total dissipated power – total generated power*



Example 3 solution

KCL:

$-I_o-6+I_{50}=0$

$I_{50}= I_o+6$ .....(1)

KVL:

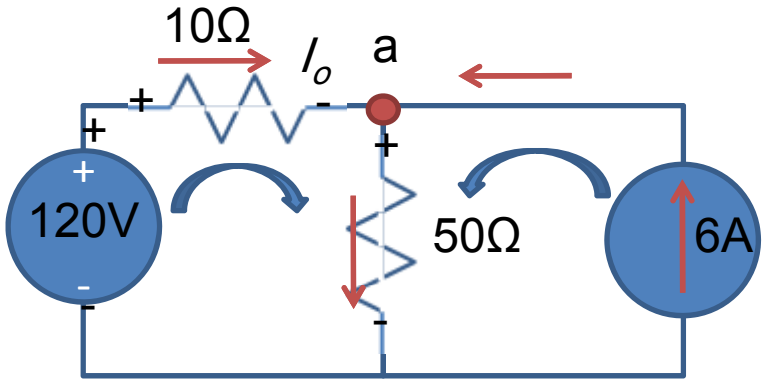
$-120 + (10xI_o)+ (50xI_{50}) =0$

.....(2)

Submit 2 in 1

$(10xI_o)+ (50x(I_o+6))=120$

$I_o=-3A$



Example 3 solution (2)

I_{50} = 3A

$P_{10}=(i_o)^2$x10=9x10=90W

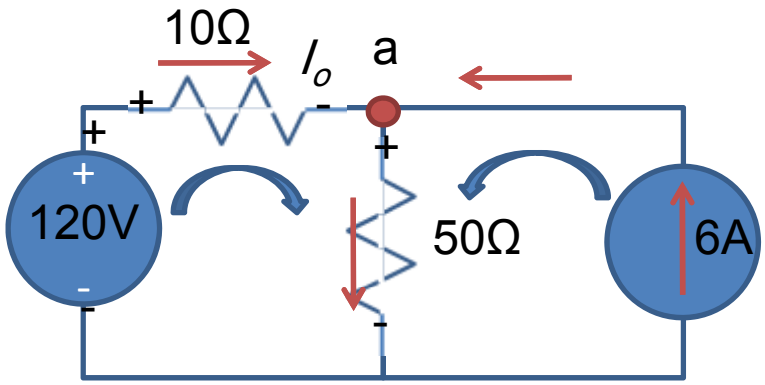
P_{50}=9x50=450W

P_{120V}=- 120 x $-i_{120V}$ =360W

Total dissipated power= 360+90+450= 900W

V_{50}=50x3=150V

$P_{6A}=-V_{50}$x6=-150x6=-900W (generated)



Example 4

For the shown circuit;

Find

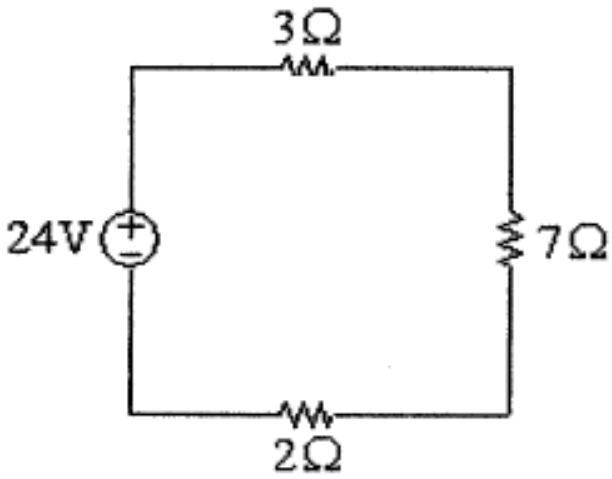
I_s.

V_3.

V_2.

V_7

Power delivered by source.



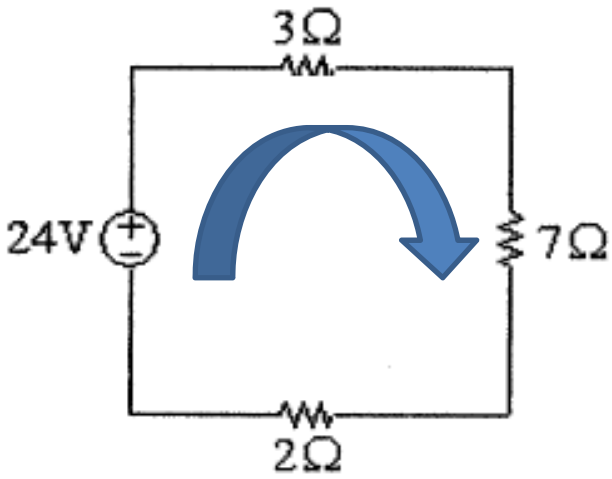
Example 4 solution

KVL:

$-24 + 3xI_s + 7xI_s + 2xI_s = 0$

$12xI_s = 24$

$I_s = 2A$ --->



Ohm:

$V_{3\Omega} = I_s \times 3 = 6v$

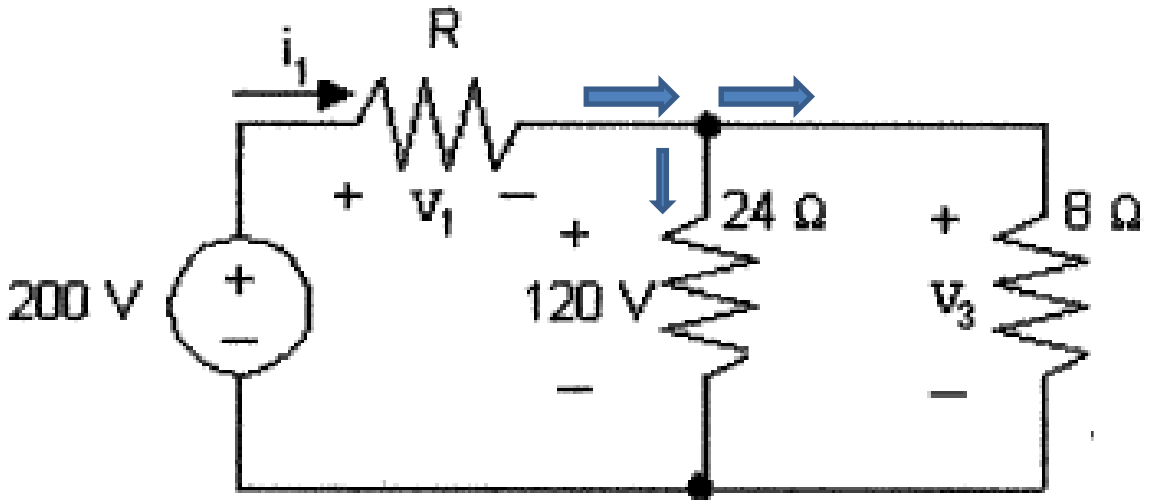
$V_{7\Omega} = I_s \times 7 = 14v$

$V_{2\Omega} = I_s \times 2 = 4V$

$P_s = -V_s \times I_s = -24 \times 2 = -48V$ (generated)

Example 5

Find R



Example 5 solution

KVL@1:

$-200 + V_R + 120 = 0$

$V_R = 80V$

KVL@2:

$-120 + 8xI_8 = 0$

$I_8 = 120/8 = 15A$

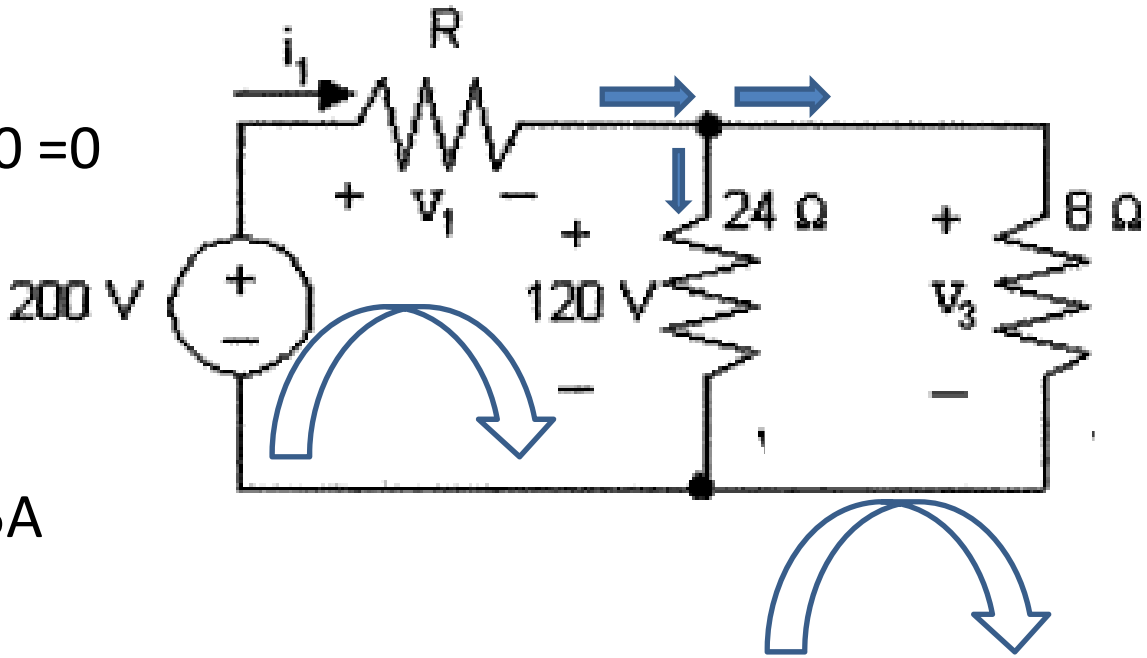
Ohm:

$I_{24} = 120/24 = 5A$

KCL:

$I_R = I_{24} + I_8$

$I_R = 20A$



Example 5 solution (2)

Ohm:

$$R = V_R / I_R = 80/20 = 4\Omega$$

Thanks,…

See you next week (ISA),…