Welcome to

# ENEE2301
# Network Analysis 1

**Instructor**
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**(Office Masri216)**

**Text Book:** ***Electric Circuits, 10th Edition*** **by Nilsson/Riedel**

# Course Objectives

- Analysis of DC circuits with different techniques.
- Analysis of transient circuits using:

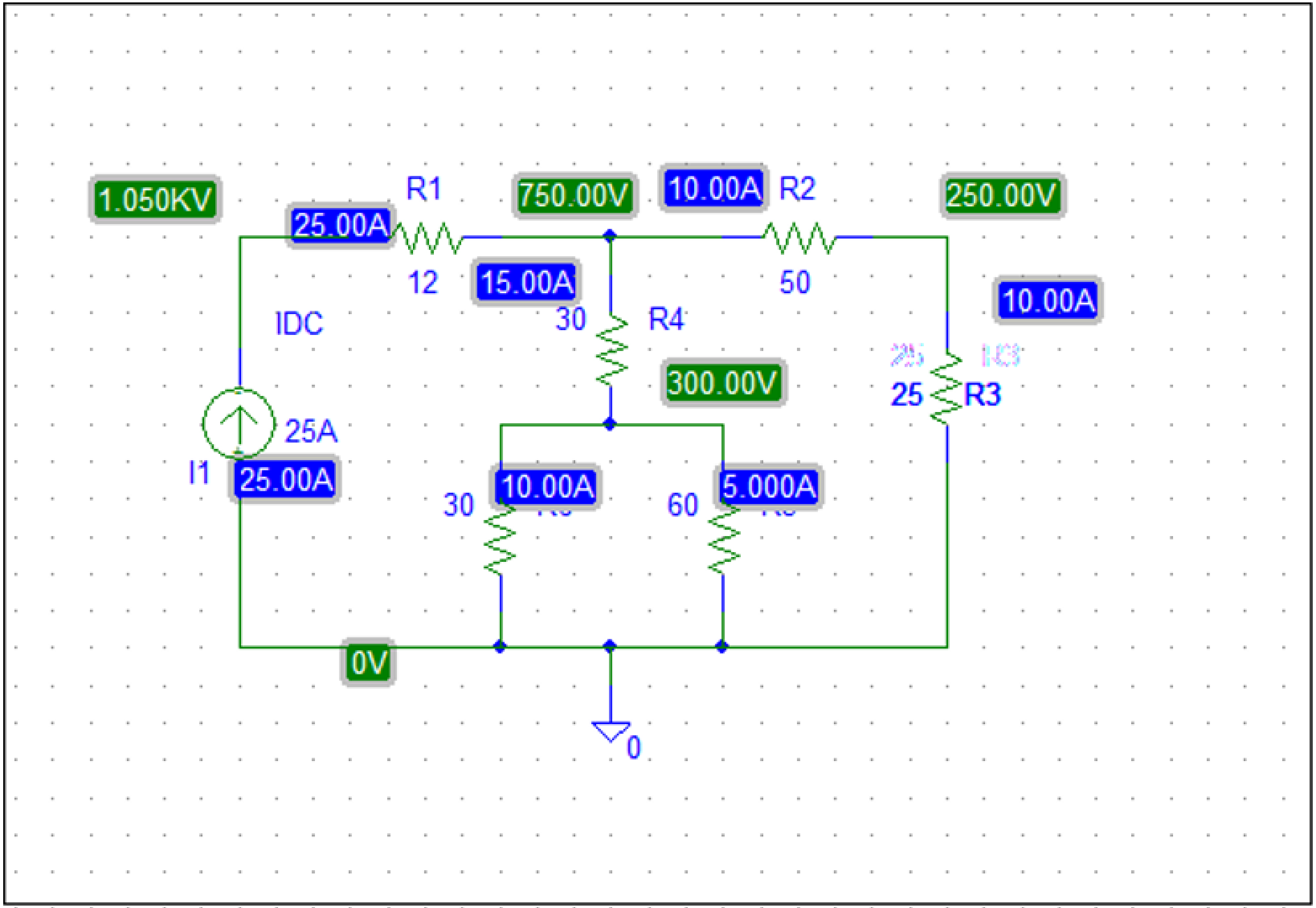
1st, 2nd order DE.

- Analysis of AC circuits using phasors.
- Sinusoidal Steady state Power analysis.
- Analysis of three phase circuits.
- Analysis of linear and ideal transformer circuits
- Using software tools (Pspice) to analyze various types of circuits.

| Chapters | Topic | Sections |
|---|---|---|
| 1 | Circuit Variables (self reading) | 1.1 – 1.6 |
| 2 | Circuit Elements | 2.1 – 2.5 |
| 3 | Simple resistive circuits | 3.1 – 3.7 |
| 4 | Techniques of circuit analysis. | 4.1 – 4.13 |
| 6 | Inductance , Capacitance (self reading)<br>and Mutual inductance | 6.1 – 6.3 |
| 7 | Response of first order RL and RC circuits | 7.1 – 7.6 |
| 8 | Natural and step responses of RLC circuits | 8.1 – 8.4 |
| 9 | Sinusoidal steady-state analysis | 9.1 – 9.12 |
| 10 | Sinusoidal steady state power calculations | 10.1 – 10.6 |
| 11 | Balance three-phase circuits | 11.1 – 11.6 |
| Ch A | Magnetically coupled networks | 6.4, 6.5, 9.10, 9.11 |

## Grading Policy

| | |
|---|---|
| Quizzes , PSPICE Simulation, and Participation: | 25% |
| Midterm Exam: | 30% |
| Final Exam: | 45% |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R1
12
750.00V
10.00A
R2
50
250.00V
15.00A
10.00A
IDC
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R4
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R3
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60
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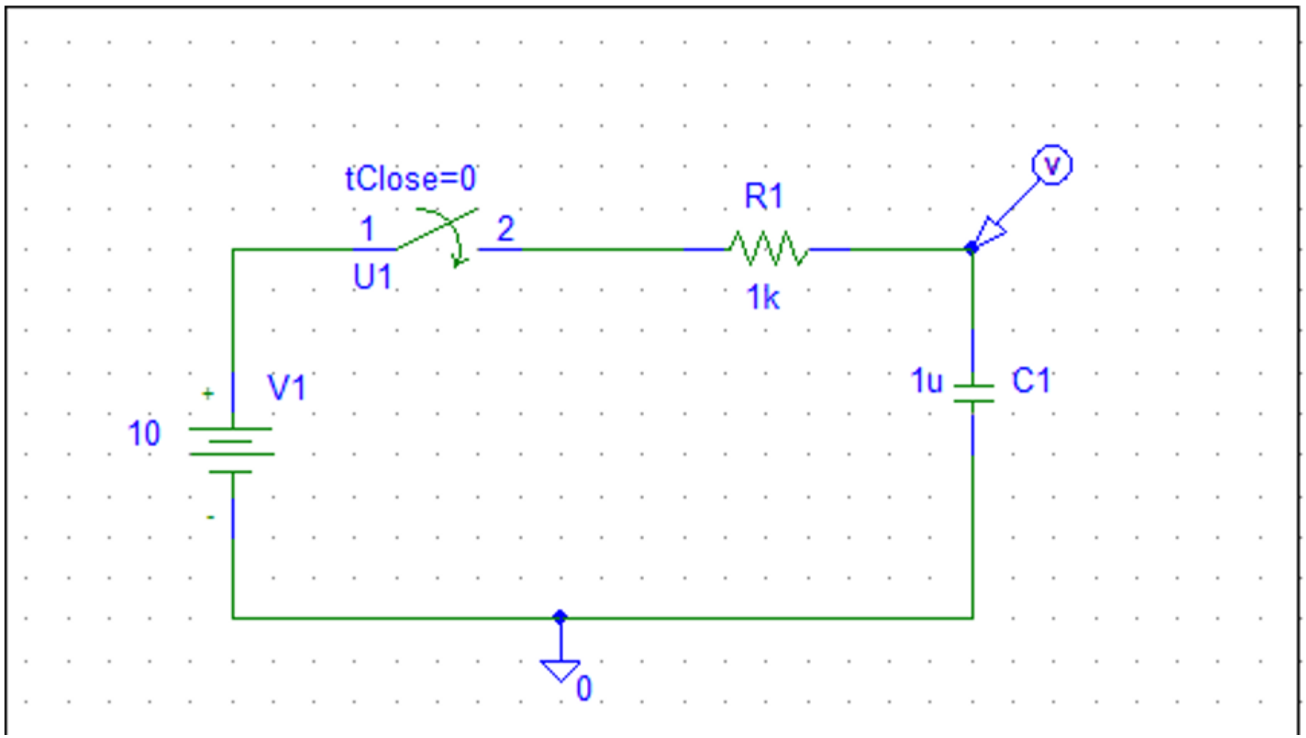
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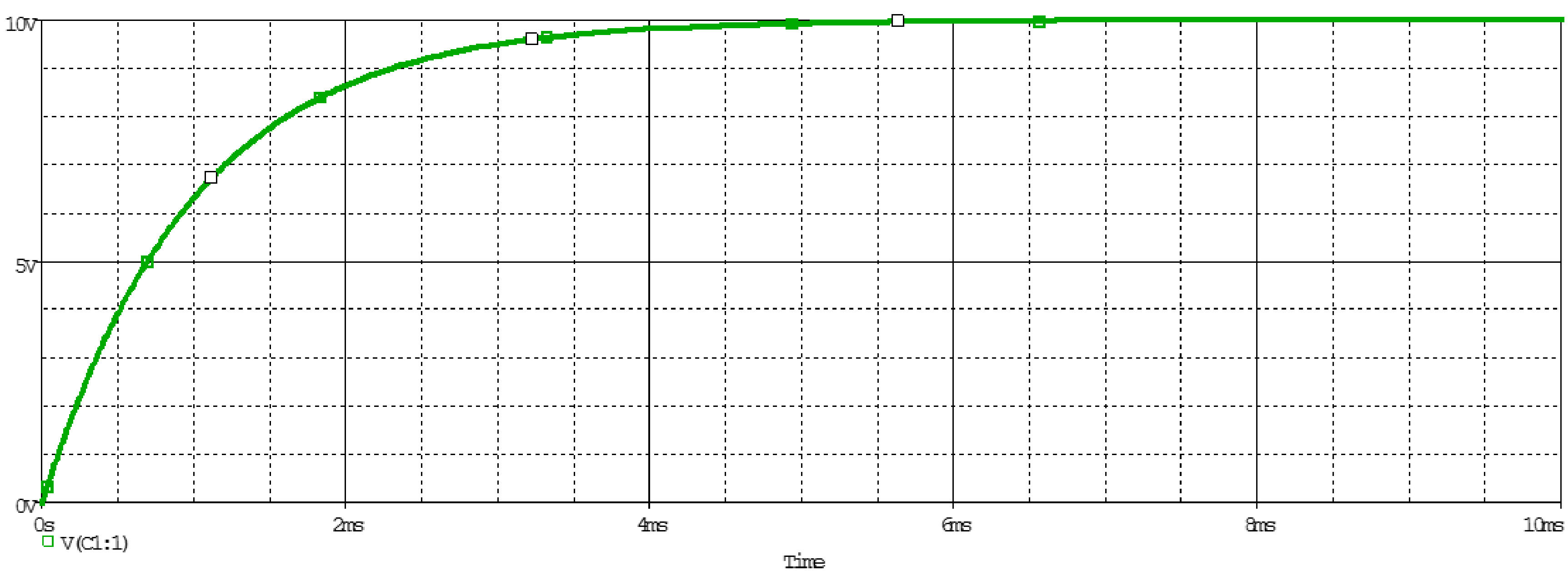
10V
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10ms
V(C1:1)
Time

**Reading Assignment:** **Chapter 2 in *Electric Circuits, 10th Edition* by Nilsson**

## Chapter 2: Circuit Elements

Several types of electrical devices are introduced in this chapter, including independent sources, dependent sources, and resistors.

**Reading Assignment: Chapter 2 in *Electric Circuits, 9th Edition* by Nilsson**

# Chapter 2: Circuit Elements

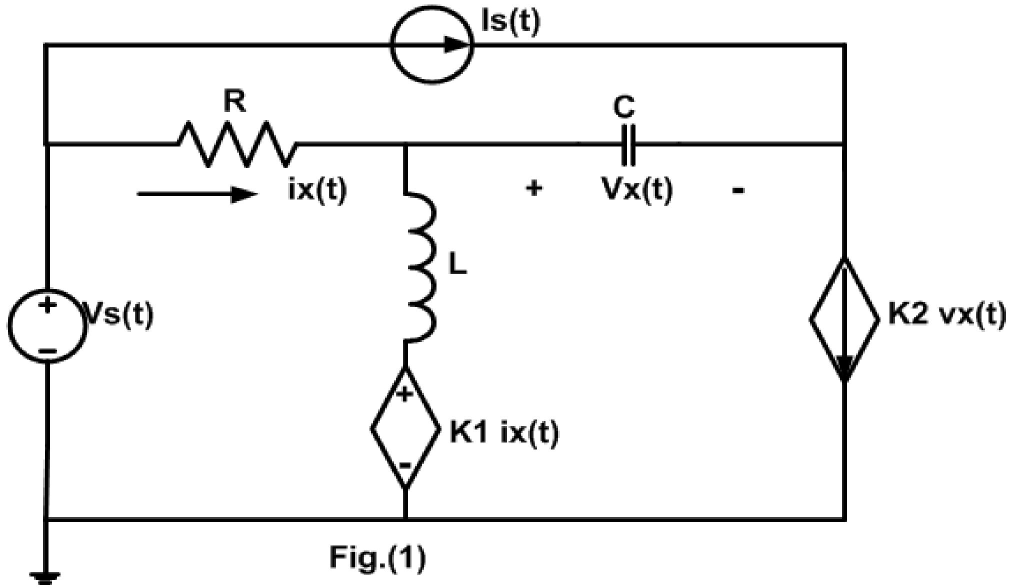



Fig.(1)

- Network : the interconnection of two or more simple circuit element is called electrical network.
- Circuit : if the network contains at least one closed path ,it is called electric circuit .
- Circuit analysis : given a circuit in which all the components are specified , **analysis involves finding such things as the voltage across some elements or the current through another**. **The solution is unique**.
- Circuit design involves determining the circuit configuration that will meet certain specifications . **The solution is not unique**.

# Circuit Elements

1) Active element : capable of delivering power to some external elements (sources).

2)Passive element : capable only of receiving power (R,L,C,…).

Circuit element can be classified according to the relationship of the current through the element to the voltage a cross the element .

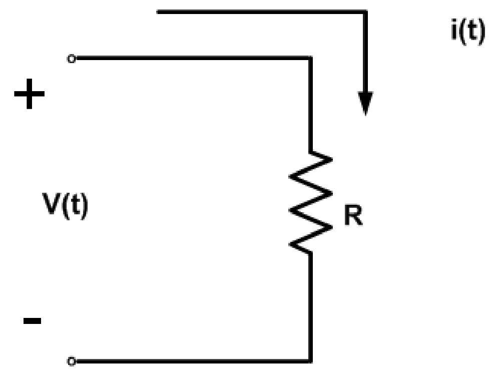
# Chapter 2: Circuit Elements

1) Resistor

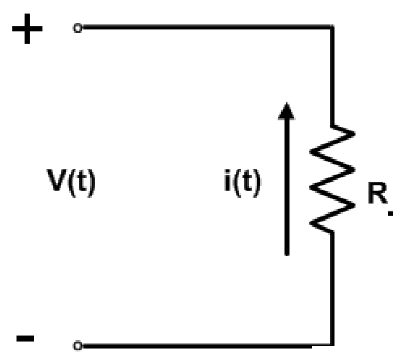
$$V(t) = R\,.\,i(t)$$

$$i(t) = \frac{1}{R}.V(t)$$

$$= \text{G}.\,V(t)$$




$$V(t) = -\,R.\,i(t)$$




- ➢ R is called the resistance of the the component and is measured in units of ohm (Ω )
- ➢ G is called the conductance of the component and is measured in units of Siemens (ʊ )

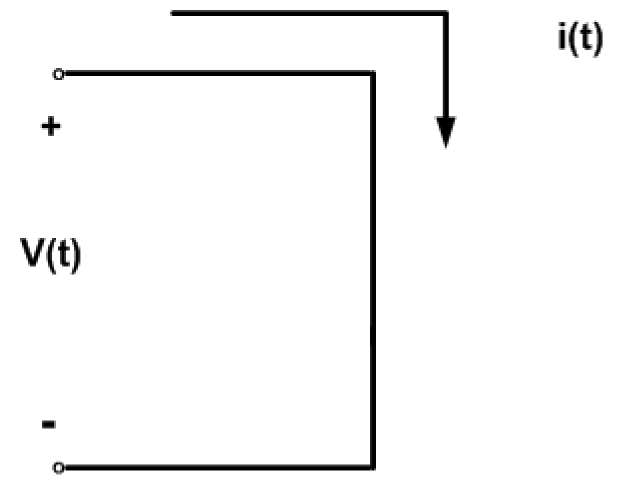
## ** two special resistor values

First : short circuit

$R=0\ \Omega$

$V(t)=0\text{V}$ $i(t)=\ ???$

$G=\infty\mho$

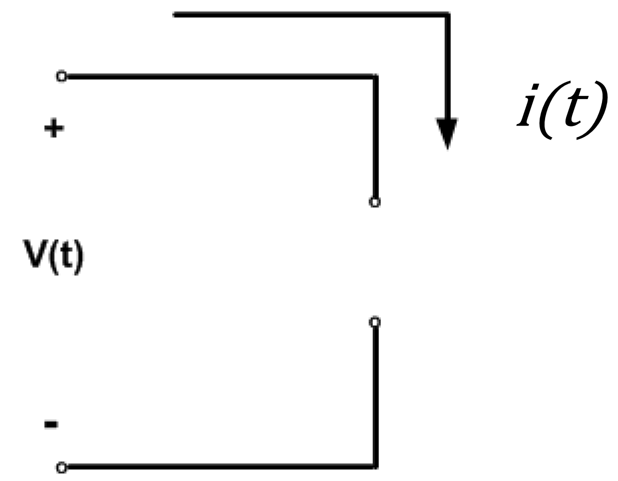



Second: Open Circuit

$R=\infty\Omega$

$i(t)=\ 0\ A$ $V(t)=???$

$G=\ 0\mho$



# Resistors and electric Power

## Resistors are passive elements that can only absorb energy

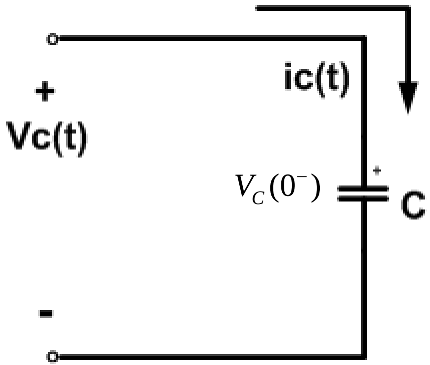
$$P(t) = V(t).i(t)$$

$$V(t) = R.i(t)$$

$$P(t) = \frac{V^2(t)}{R}$$

$$P(t) = R.i^2(t)$$

## 2. Capacitors




$$V_C(t) = \frac{1}{C}\int_{-\infty}^{t} i_C(t)dt$$

$$V_C(t) = V_C(0^-) + \frac{1}{C}\int_{0^-}^{t} i_C(t)dt \quad \text{for } t \ge 0$$

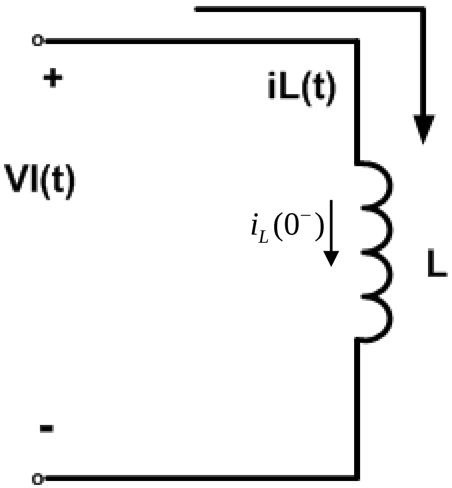
$$i_C(t) = C\frac{dv_C(t)}{dt}$$

C is called the capacitance of the capacitor and is measured in units of farad (F)

## 3. Inductors

$$V_L(t) = L\frac{di_L(t)}{dt}$$

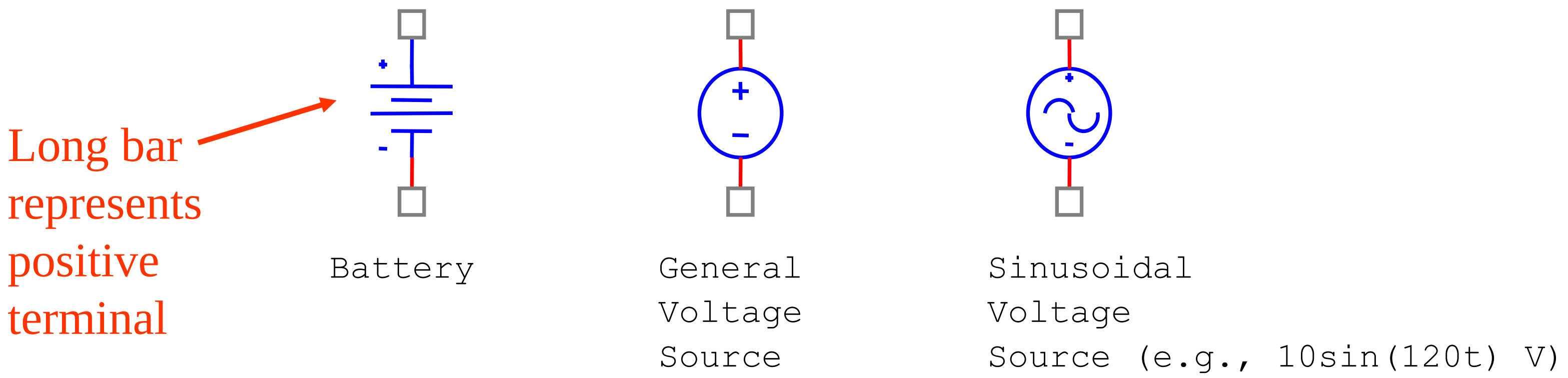
$$i_L(t) = i_L(0^-) + \frac{1}{L}\int_{0^-}^{t} V_L(t)dt \quad \text{for } t \geq 0$$




L is called the inductance of the coil and is measured in units of the henry (H)

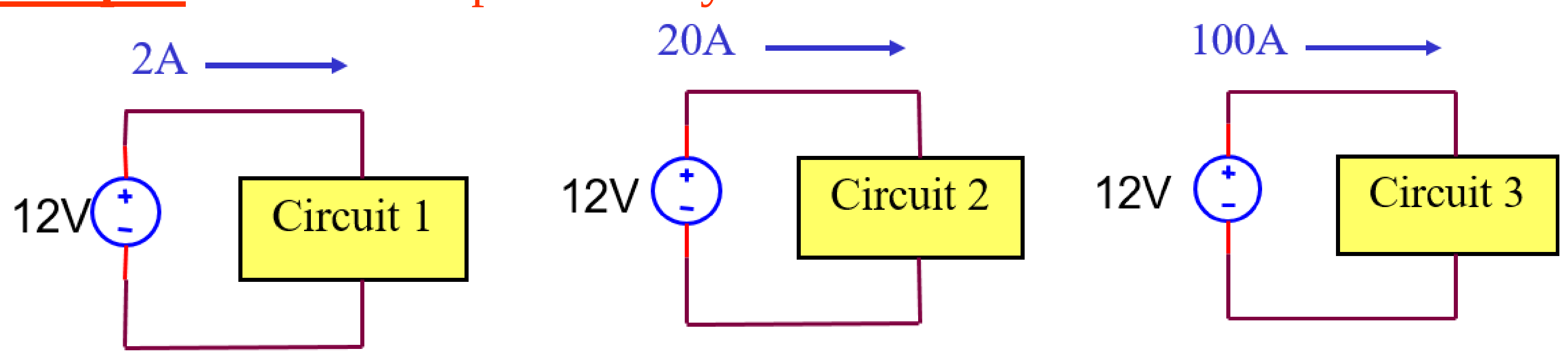
**Independent voltage source** – A circuit element in which the voltage across its terminals is completely independent of the current through it .

Symbols:




- The symbols shown above are from PSPICE. The boxes on the ends of the wires are simply for connecting wires or other components to the sources.
- Voltages sources have a specified voltage, but the current depends on the circuit and is determined through analysis.

**Example:** The current provided by the 12V source below varies in each case.

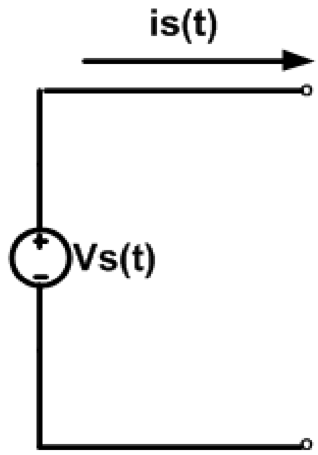


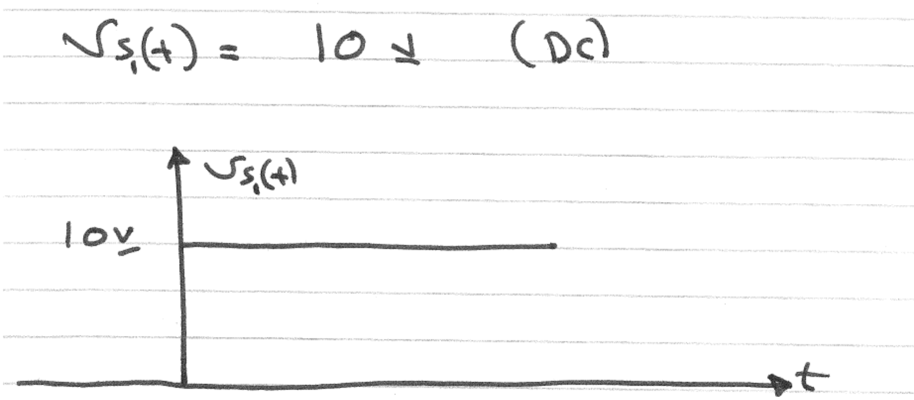
## Voltage Source

$$Vs1(t) = 10\,V\ (DC)$$

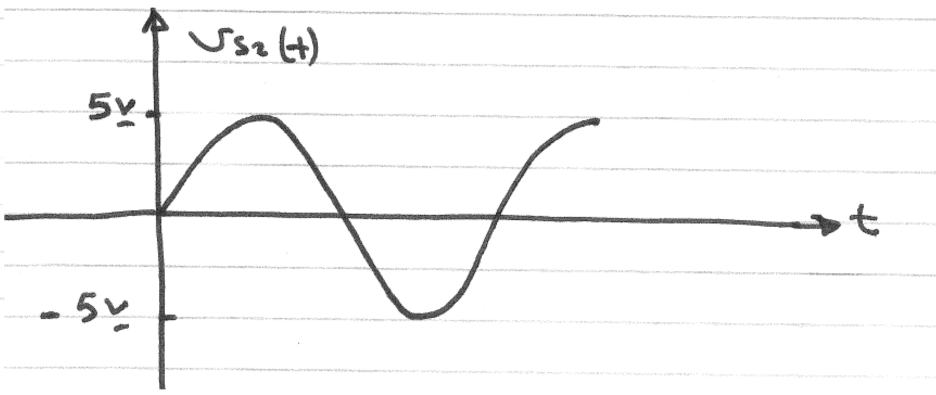
$$Vs2(t) = 5\sin\omega t\ \ V\ (ac)$$

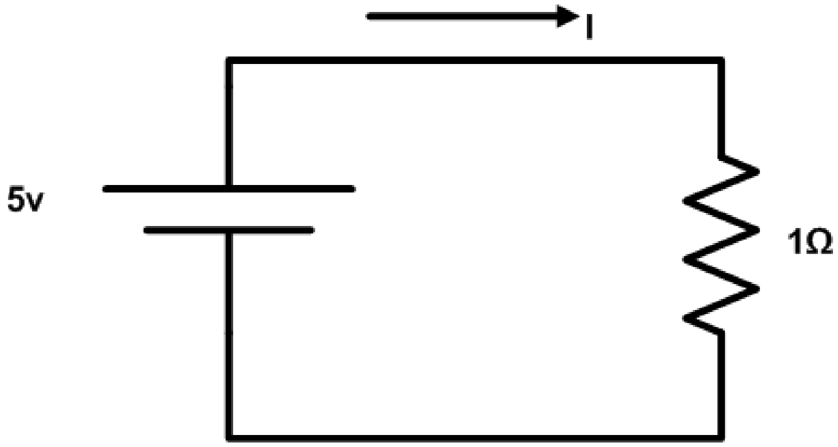
$$Vs3(t) = 10\,e^{-t}\,V$$

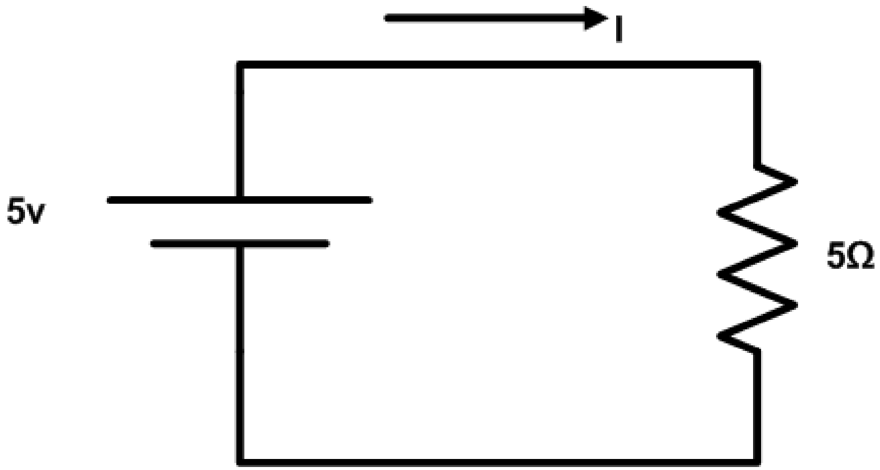



$$Vs2(t) = 5\sin\omega t\ \ V\ (ac)$$





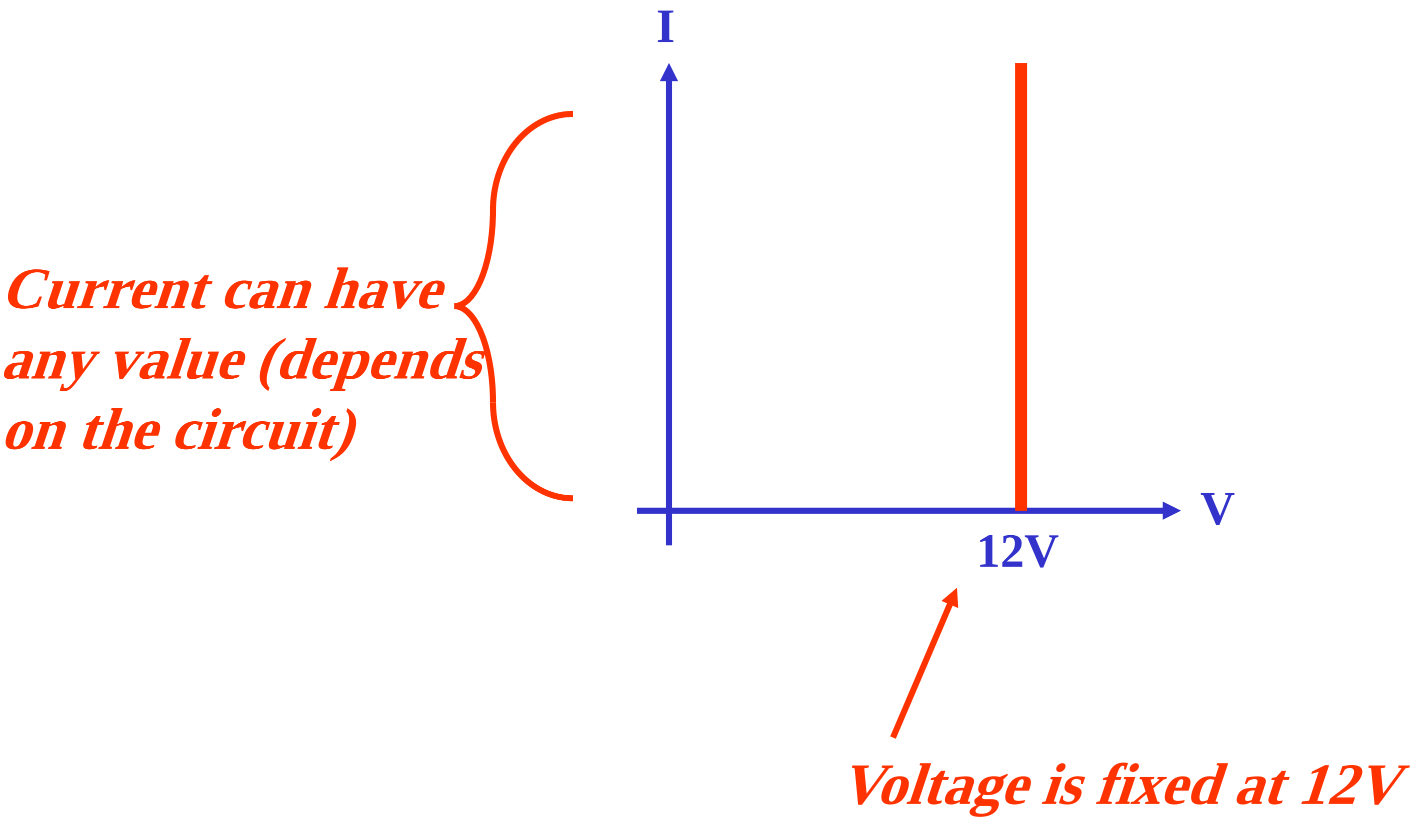

$$I = \frac{5v}{1\,\Omega} = 5A$$

$$I = \frac{5v}{5\Omega} = 1A$$

## Independent voltage source characteristics

The “characteristics” of a device typically refers to a graph of I versus V which illustrates the behavior of the device.

The characteristics of an ideal independent 12 V voltage source are shown below.

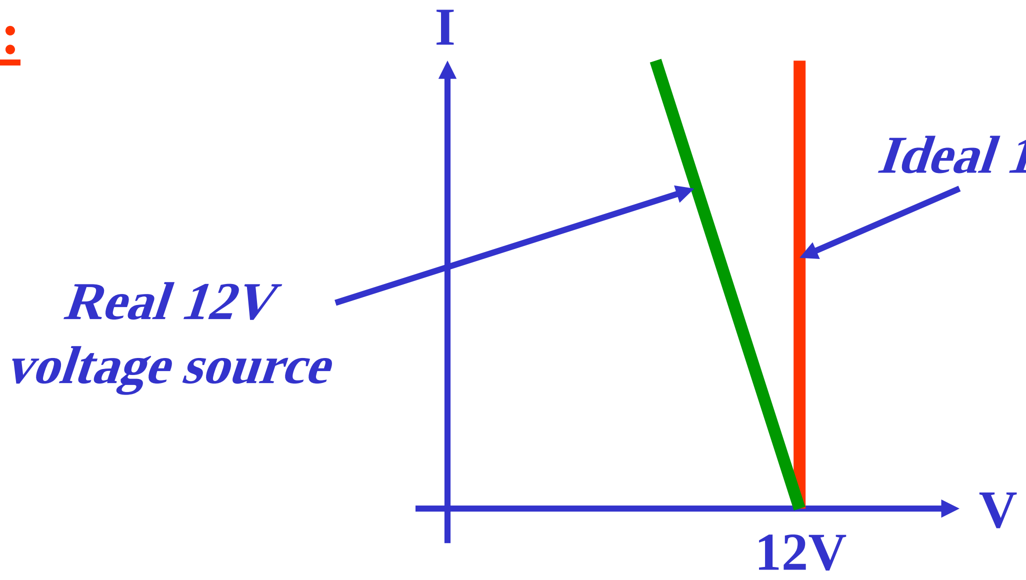


## Real versus ideal independent voltage sources

The voltage delivered by an **real voltage source** (or practical voltage source) will typically drop as the current required by the source increases. For example:

- The 1.5V across a D-cell in a flashlight drops when the light is turned on.
- The 12V across a car battery drops when the car is started.
- The voltage from a power company drops during peak load hours (the voltage typically ranges from 115V - 130V in North America).

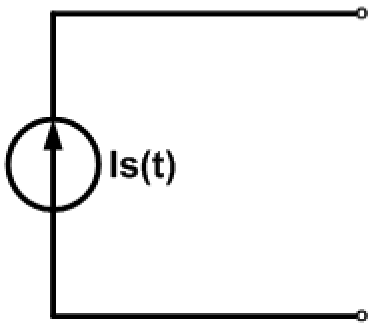
**Example:**




Note: Any voltage source shown in the text is assumed to be ideal.

**Independent current source** – A circuit element in which the current through it is completely independent of the voltage a cross its terminals. (This device is not as common in everyday use as the independent voltage source.)

Symbol:

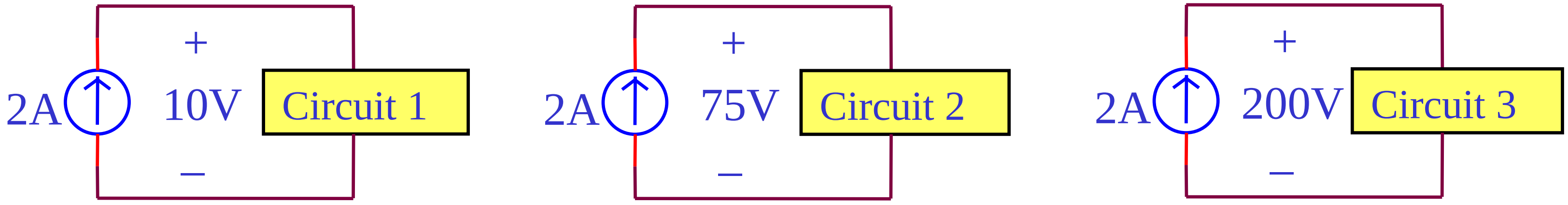


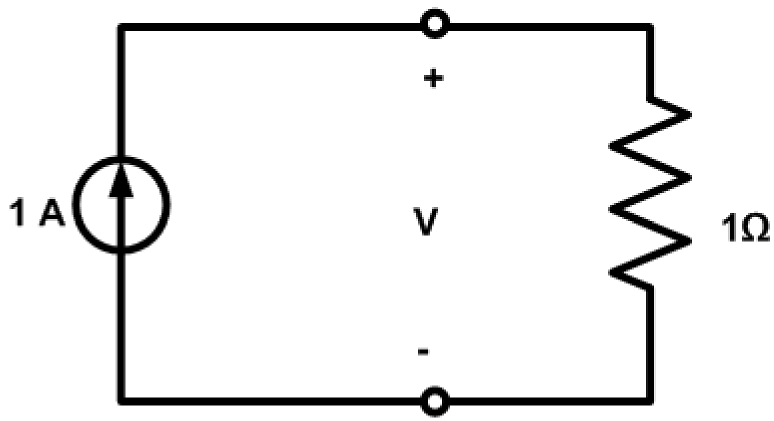

$$is(t) = 10\ \sin wt\ \ A$$

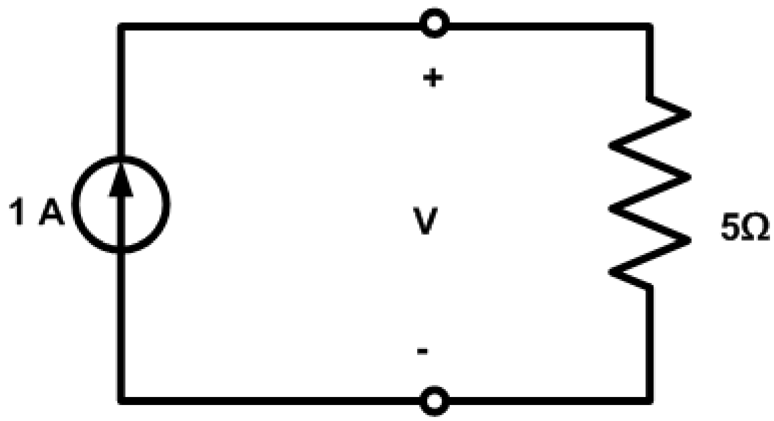
$$is(t) = \ 20\ A$$

- Current sources have a specified current, but the voltage depends on the circuit and is determined through analysis.

**Example:** The voltage provided by the 2A source below varies in each case.





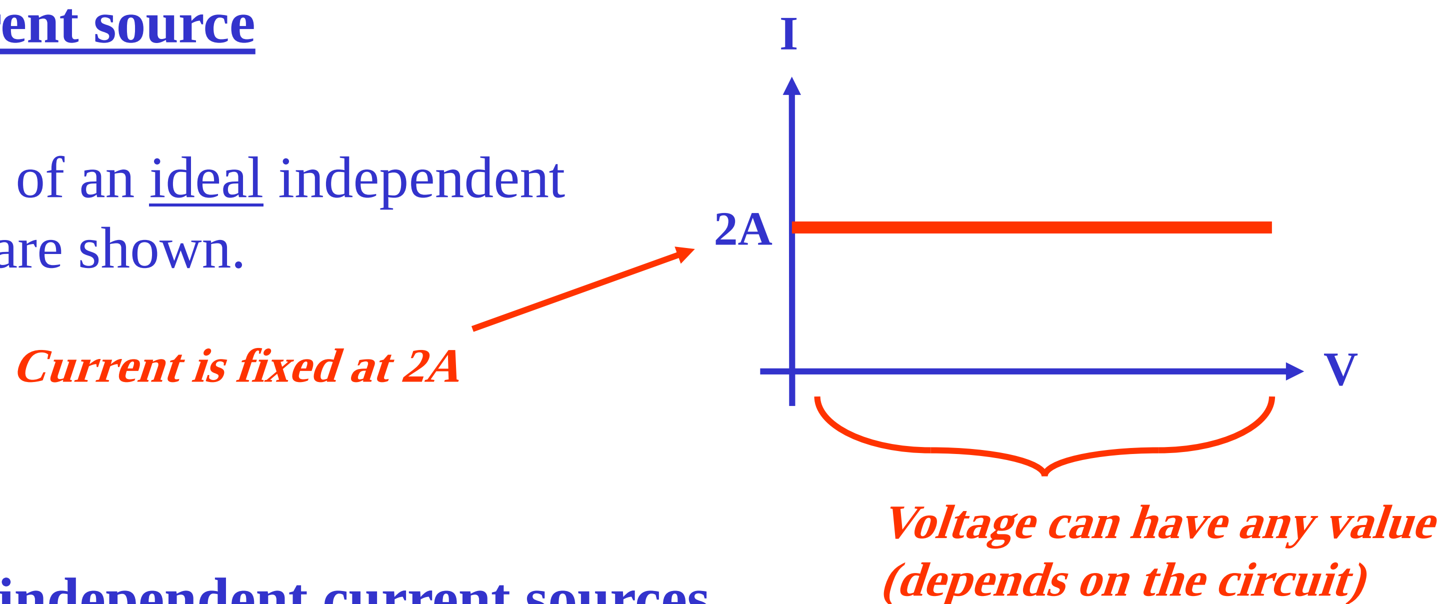




$$V = (1\,A).\,(1\,ohm) = 1\,V$$

$$V = (1\,A).\,(5\,ohm) = 5\,V$$

## Independent current source characteristics

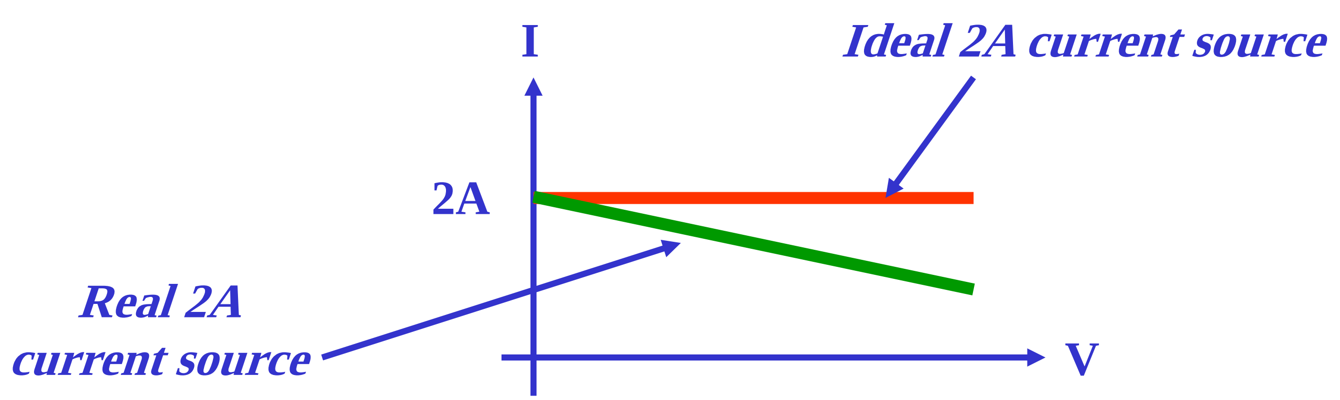
The characteristics of an ideal independent 2A current source are shown.




## Real versus ideal independent current sources

The current delivered by an **real current source** (or practical current source) will typically drop as the voltage required by the source increases.

**Example:**



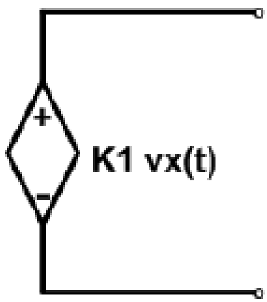

Note: Any current source shown in the text is assumed to be ideal.

# Dependent Sources

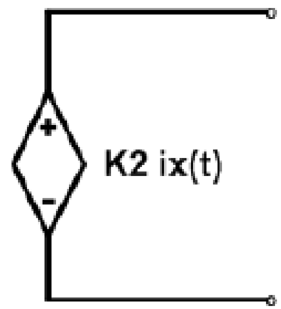
- Are sources in which the source voltage (or current ) depend upon a current or voltage else where in the circuit .

Voltage Controlled Voltage Source

VCVS



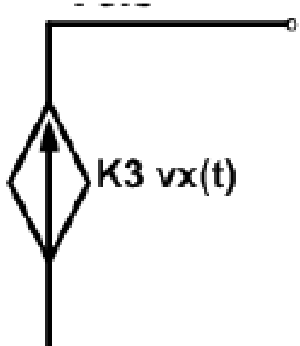

CCVS



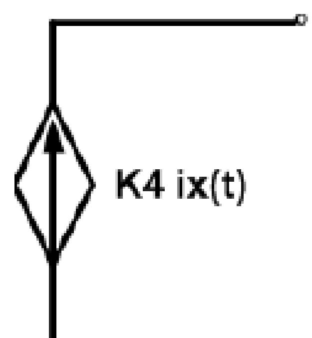

Current Controlled Voltage Source

Voltage Controlled Current Source

VCCS

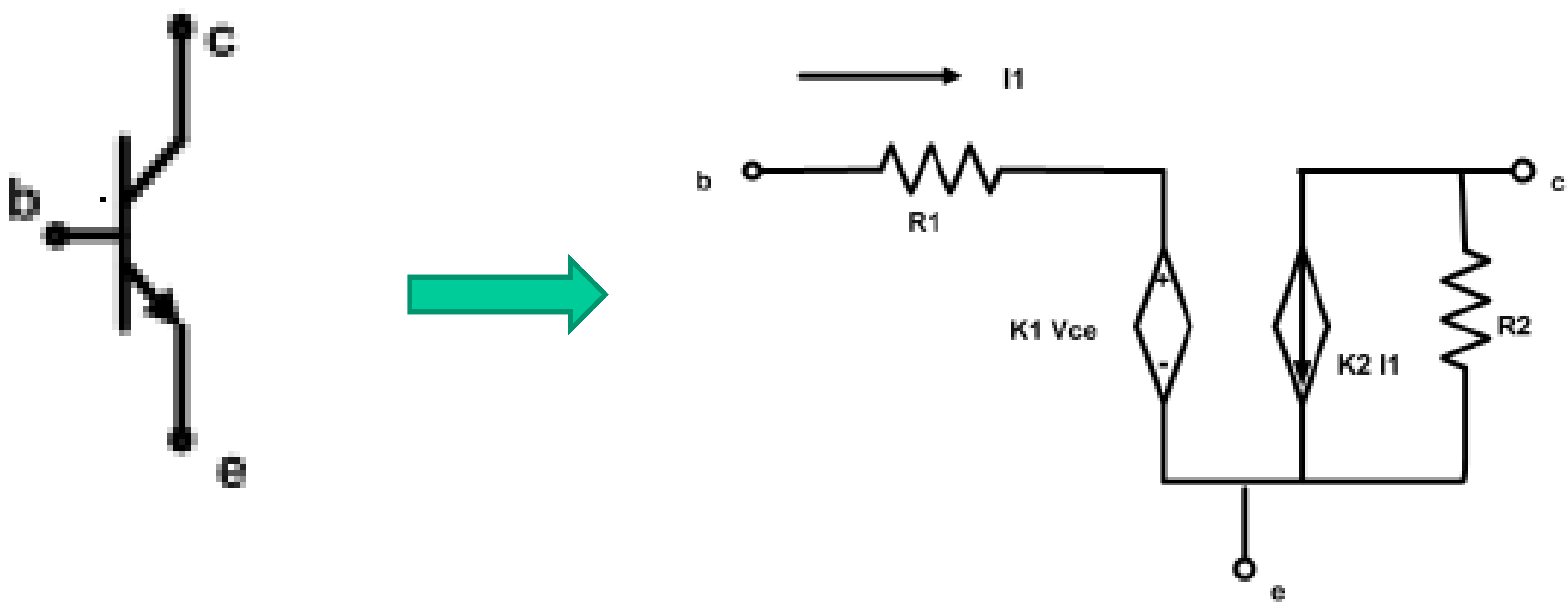



CCCS




Current Controlled Current Source

# Transistor Model example

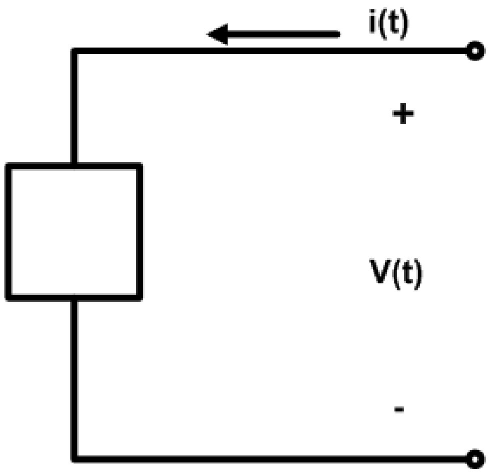


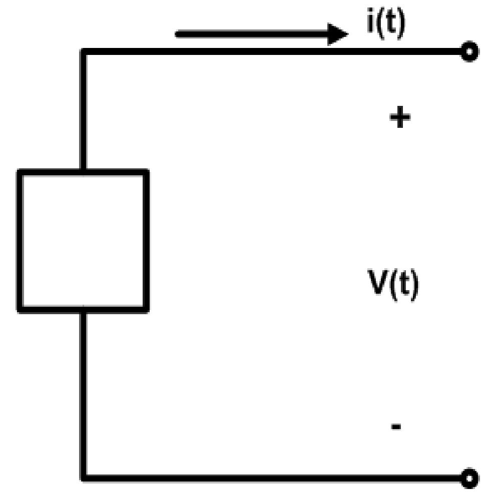
# Power and Energy

- Why Power & Energy are important in circuit analysis?
  - Although current and voltage are useful in analysis & design of electrical systems, the useful **output of the system often is non-electric**, & this output is usually expressed in terms of power & Energy.
  - Also, all **practical devices have limitations** on the amount of power that they can handle.

# Power and Energy

$$p(t) = \frac{dw(t)}{dt}$$




$$p(t) = \ +v(t)i(t)\ absorbing \qquad p(t) = -v(t)i(t)\ supplying$$

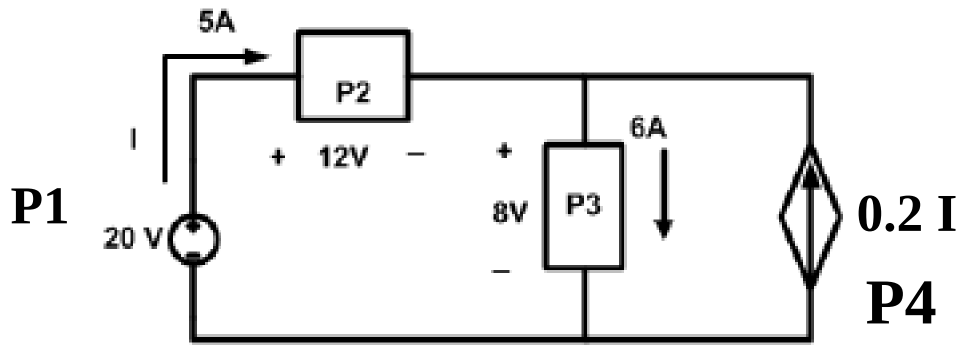
**Power**: is defined as the time rate of supplying or absorbing energy.
"a water pump rated 75 kW can deliver more litters per second than one rated 7.5 kW"

# Conservation of Energy

- The law of conservation of energy must be obeyed in any electric circuit .
- The algebraic sum of power in a circuit at any instant of time ,must be zero.

$$\sum p(t) = 0$$

- Calculate power supplied or absorbed by each element




$p1 = (20)(-5) = -100\,w$ *supplied power*

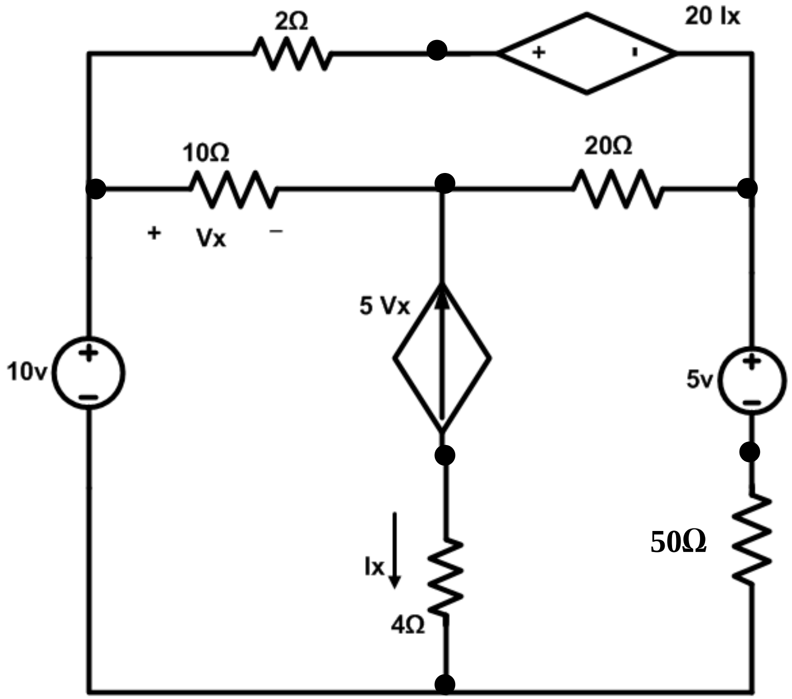
$p2 = (12)(5) = 60w$ *absorbed power*

$p3 = (8)(+6) = 48w$ *absorbed power*

$p4 = (8)(-0.2 \times 5) = -8w$ *supplied power*

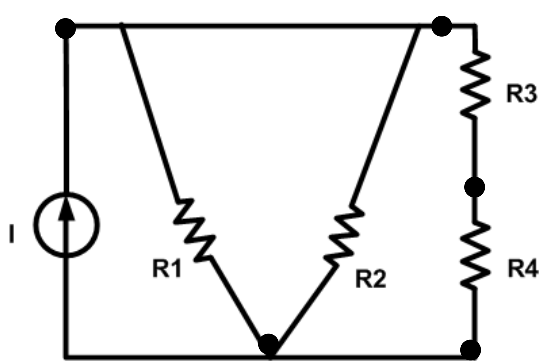
$$p\ absorbed = p\ supplied$$

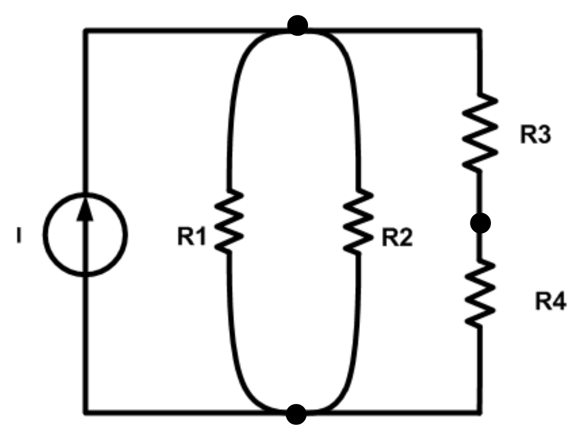
$$60 + 48 = 100 + 8$$




# Definitions

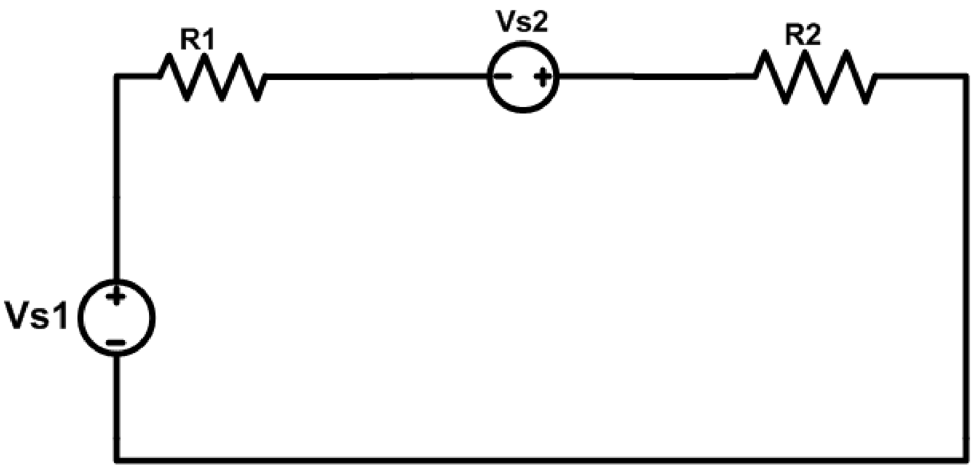
- Node : A point of connection of two or more circuit elements.
- Loop: Any closed path through the circuit in which no node is crossed more than once.
- Mesh : Any loop that doesn't contain within it another loop.



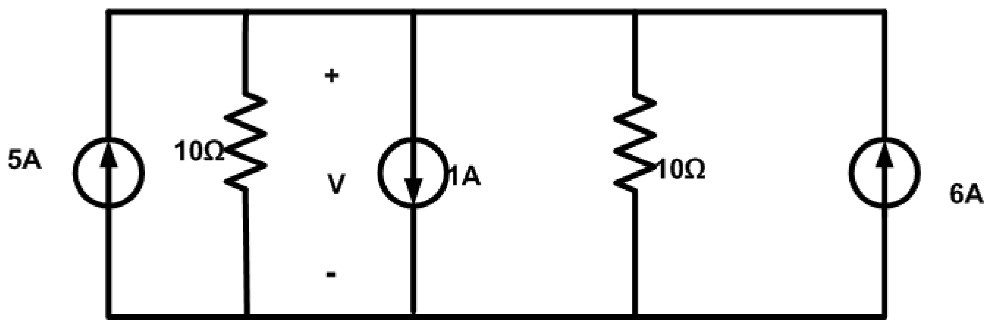
# Series connections

- All of the elements in the circuit shown below carry the same current then said to be connected in series.



# Parallel Connection

- Elements in a circuit having a common voltage a cross them are said to be connected in parallel.



**Two key laws for analyzing circuits:**

Kirchhoff's Voltage Law (KVL)

Kirchhoff's Current Law (KCL)

## Kirchhoff's Voltage Law (KVL)

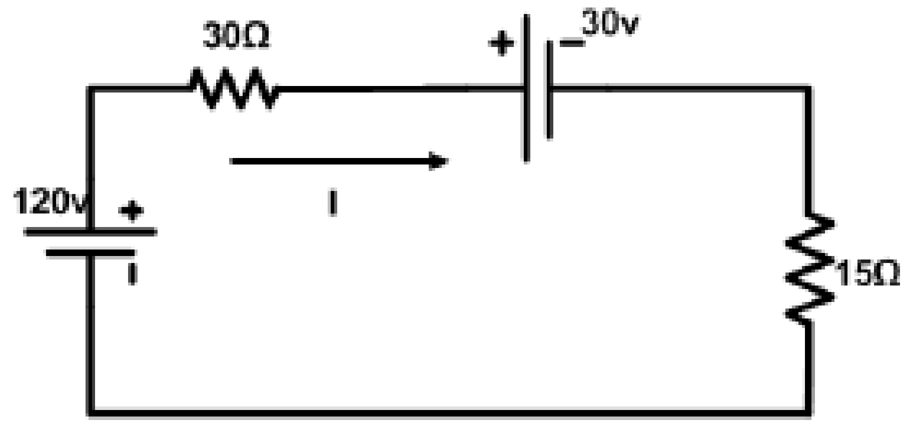
Definition: "The algebraic sum of the voltages around any closed path equals zero."

**Notes:**

- Start at any point in a path
- Go around the loop in either direction until you return to the starting point
- Use a consistent sign convention

# Analysis of a single- loop circuit

Find I?



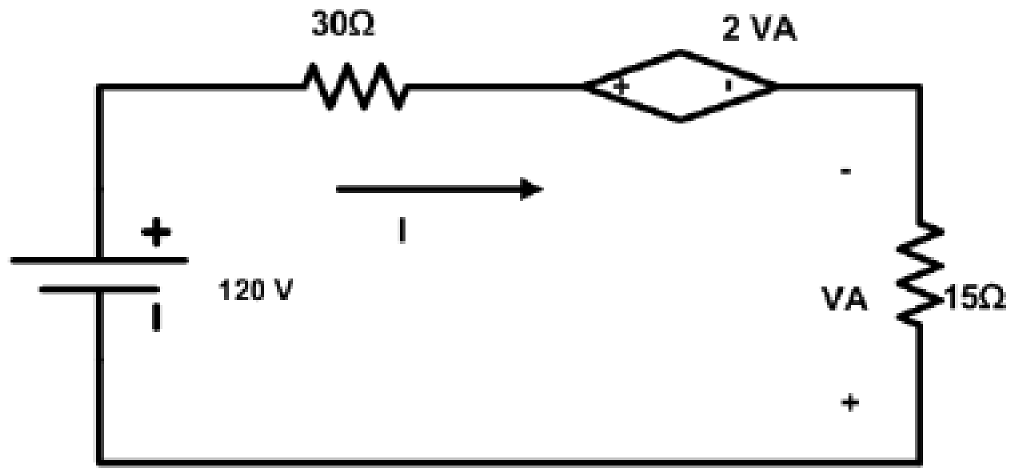

**KVL**

- 30 I + 30 + 15 I - 120=0 ➔
- 45 I=90 ➔ I=2 A
- V(30Ω) = (30 Ω).(2 A) = 60 V
- V(15Ω) = (15 Ω) (2 A)= 30 V

# Analysis of a circuit containing a dependent source .

- Find I?

and calculate power absorbed by each circuit element



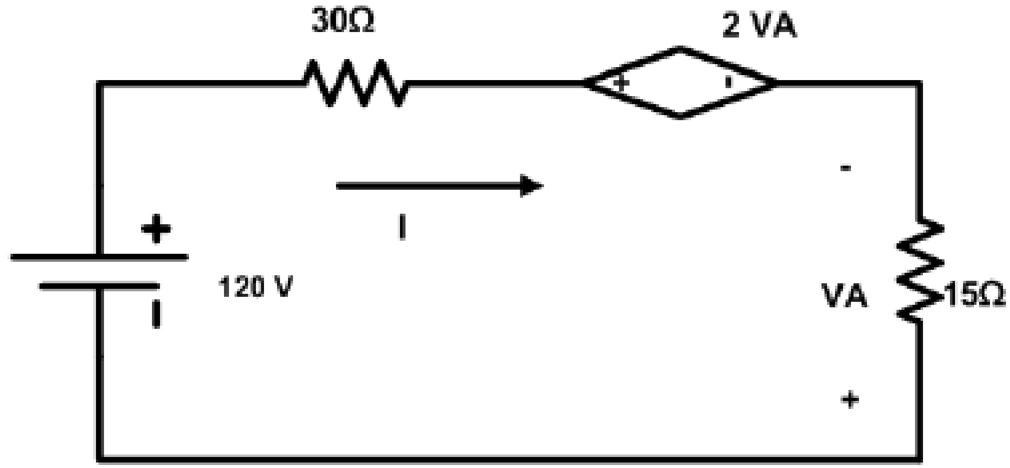

$30I + 2V_A + 15I - 120 = 0$

➔ $V_A = -15\ I$

➔ $I = 120/15 = 8A$

➔ $V_A = -120\ V$

# Analysis of a circuit containing a dependent source




- Find I?

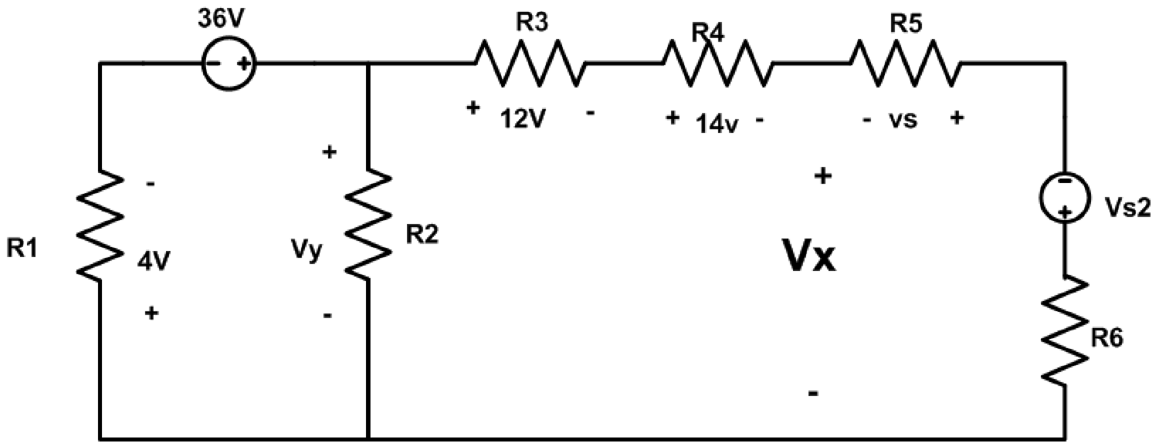
and calculate power absorbed by each circuit element

- Answers:
- P(120v) = -960 W
- $P(2V_A)$= - 1920 W
- P(30Ω) = 1920 W
- P(15Ω) = 960 W

I = 120/15= 8A

$V_A$ = -120 V

# Applying KVL




- Find Vx and Vy
- KVL for 1-st loop: 4 – 36 + Vy=0

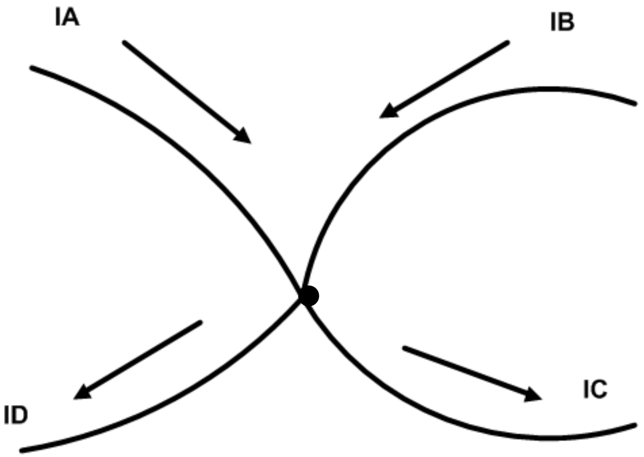
➔ Vy = 36 - 4 = 32 V

- KVL for second loop: -Vy + 12 + 14 +Vx=0

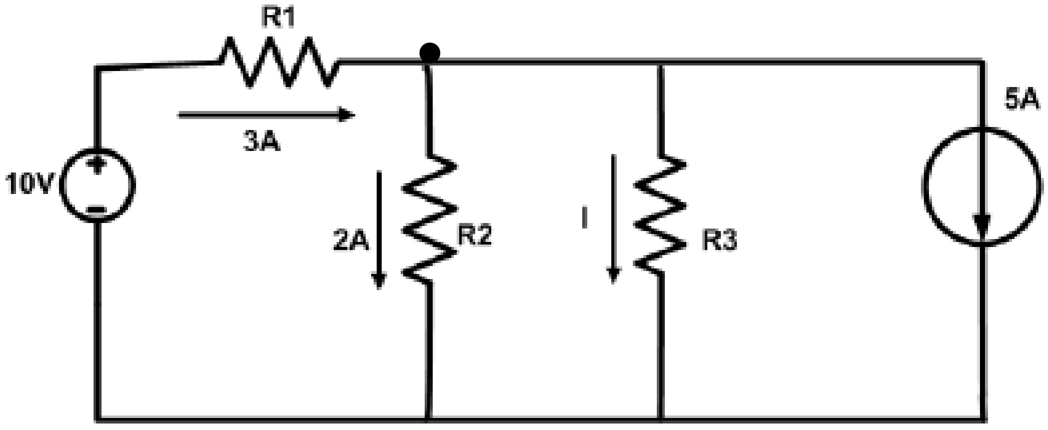
➔ Vx= -14-12+32 =6 V

# Kirchhoff's current law : KCL

- KCL : the algebraic sum of the current entering any node is zero
- $I_A + I_B - I_C - I_D = 0$
- KCL: Alternative form
- Sum of Currents In= Sum of Currents out
- $I_A + I_B = I_C + I_D$



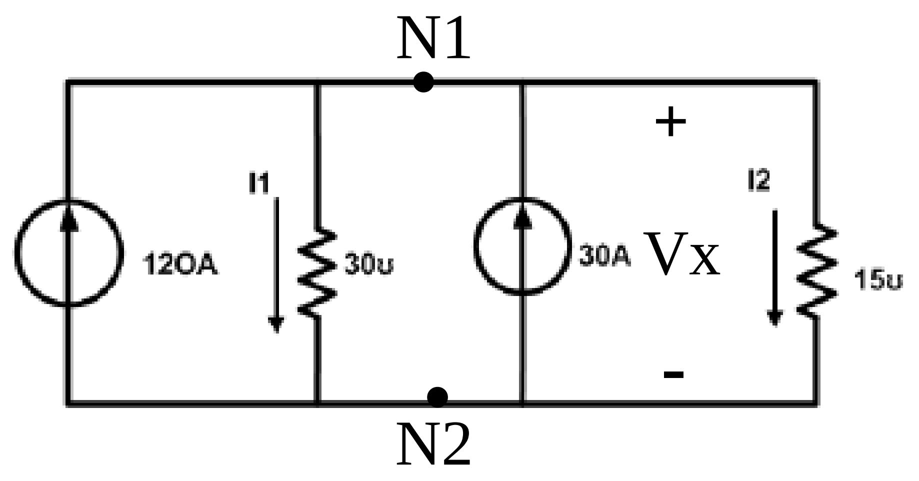
# KCL Application




- Find I?
- KCL :
- 3 = 2+ I + 5

➔ I = -4A

# Single node-pair circuit



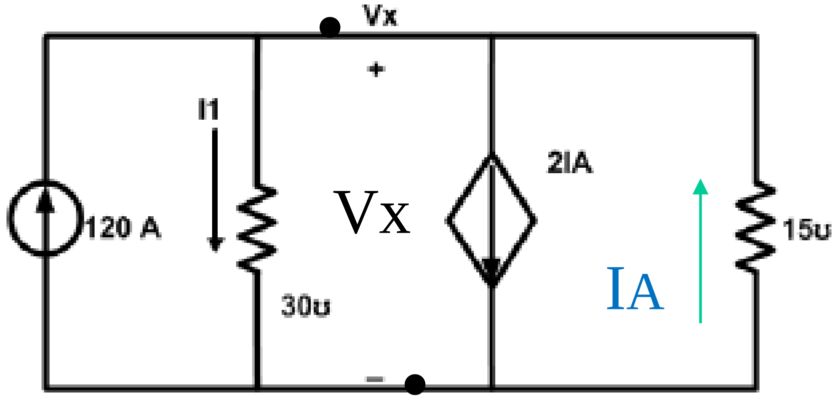

- Find Vx?
- Remember I = G . V
- KCL at node1 : 120 + 30 = I1 +I2

  120 + 30 = 30Vx +15Vx

➔ Vx = 3.33 V

- I(30ʊ ) = 100 A
- I(15 ʊ ) = 50 A

# Analysis of circuit containing dependent sources




- Find Vx

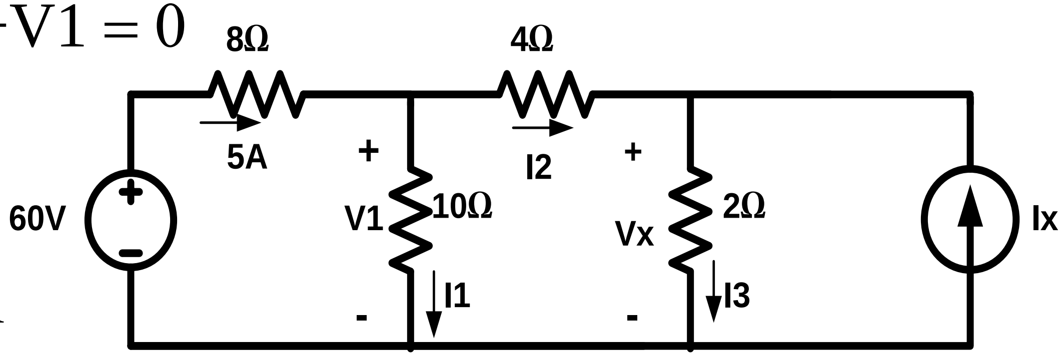
KCL ;

- $120 + I_A = I_1 + 2 I_A$
- $I_A = - 15Vx$
- $I_1 = 30Vx$

∴ **Vx = 8 V**

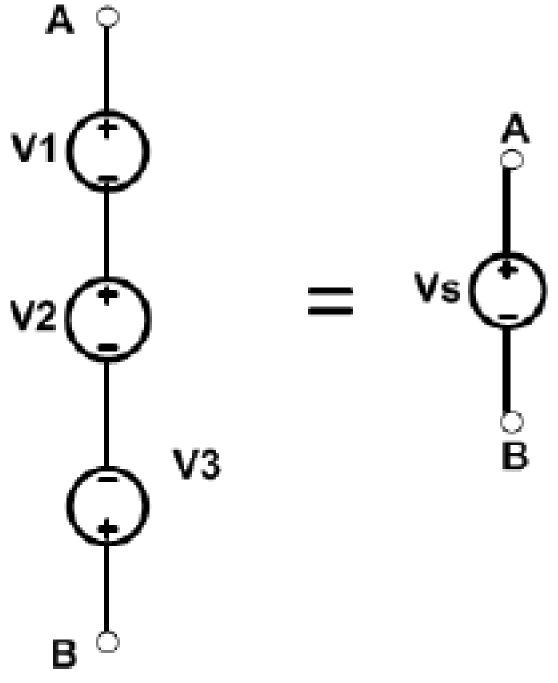
# Applying KVL and KCL

- Solve for Vx and ix
- KVL : -60+(5A.)(8 Ω)+V1 = 0
- ➔ V1= 60 – 40 = 20 V
- ➔ I1= 20/10 = 2 A
- ➔KCL : I2 = 5–2 = 3A
- ➔ KVL : I2 (4 Ω) +Vx – V1 = 0
- ➔ Vx = 8V
- I3 = 8/2 = 4 A
- KCL : ix = I3-I2 = 4 - 3 =1 A
- Answer : Vx = 8v and ix = 1A



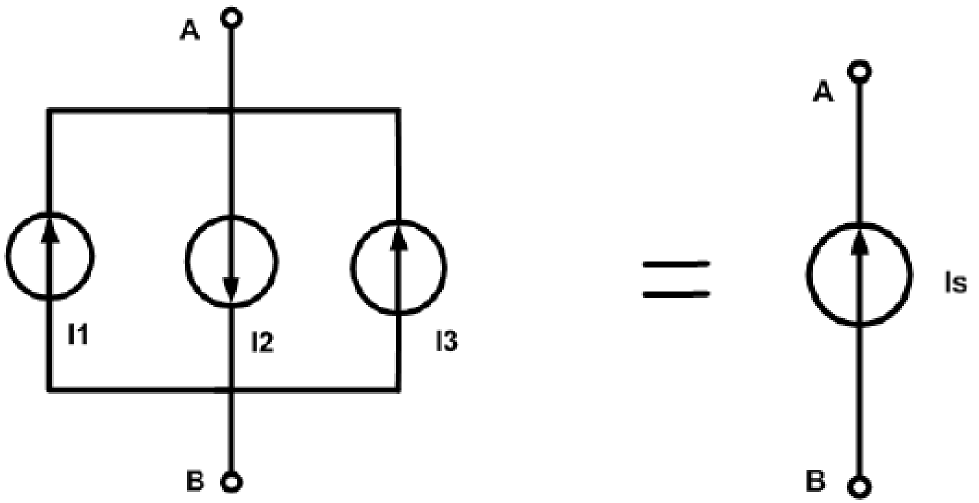
# Series and parallel sources

- Voltage sources connected in series can be combined into an Equivalent source :




$$\mathbf{Vs = V_1 + V_2 - V_3}$$

- Current sources connected in parallel can be combined in to an equivalent current source :




$$I_S = I_1 - I_2 + I_3$$

# Impossible Circuit Configurations