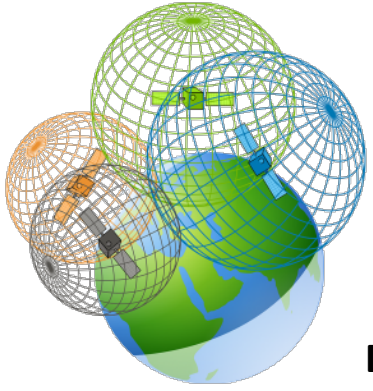


Welcome to EECS 16A!

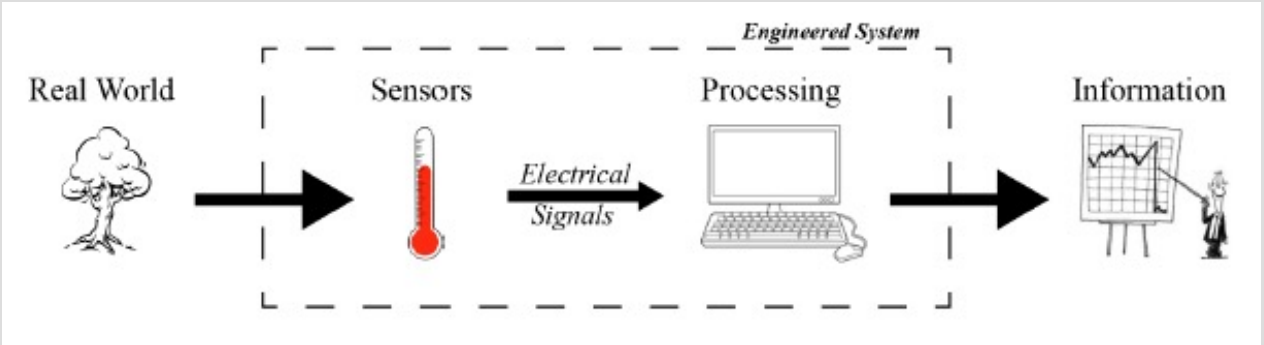
Designing Information Devices and Systems I

Ana Claudia Arias and Miki Lustig

Fall 2022

Module 2
Lecture 1
Introduction to Circuit Analysis
(Note 11)

Designing Information Devices and Systems



Module 2 – More tools to build systems

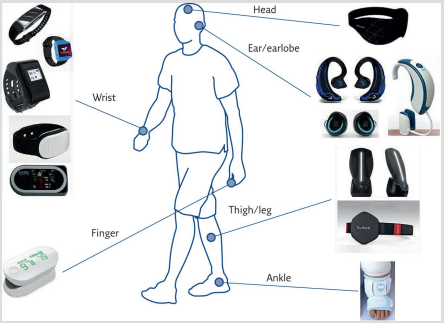
Analog World | Sensor | Processing | Actuation

Module 2 – More tools to build systems

Analog World | Sensor | Processing | Actuation

Module 2 – More tools to build systems

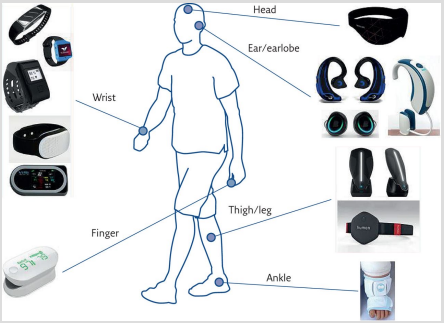
Analog World | Sensor | Processing | Actuation

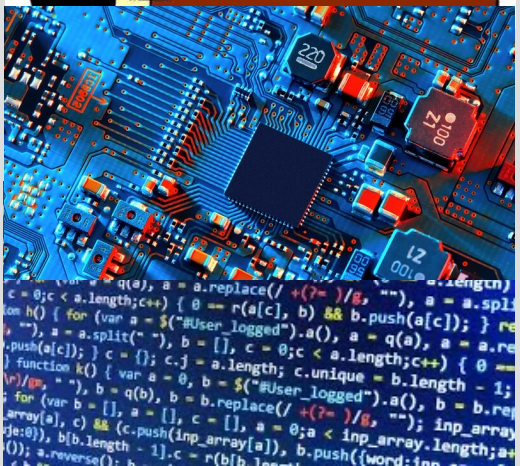


Module 2 – More tools to build systems

Analog World | Sensor | Processing | Actuation

16B

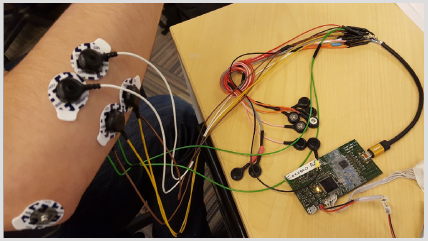




System Example - Electromyography

- ✓ Monitors muscle activity
- ✓ Used in gesture recognition
- ✓ Impact in rehabilitation

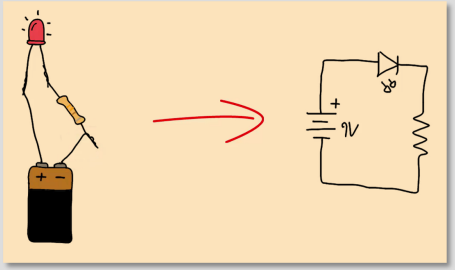
- X Bulky electrodes
- X Poor accuracy – low resolution
- X Computation performed on external devices



System Example - Electromyography

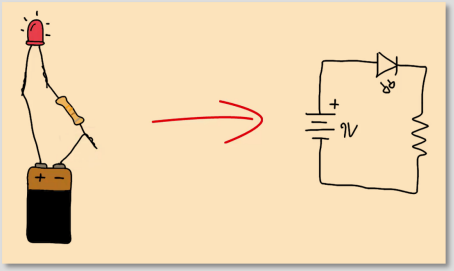
In Module 2 we will learn how to analyze circuits

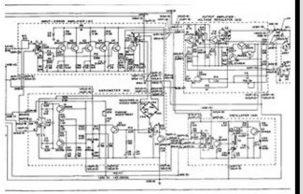
We need to be able to go from a real-world circuit, to a circuit model, and vice versa.



In Module 2 we will learn how to analyze circuits

We need to be able to go from a real-world circuit, to a circuit model, and vice versa.

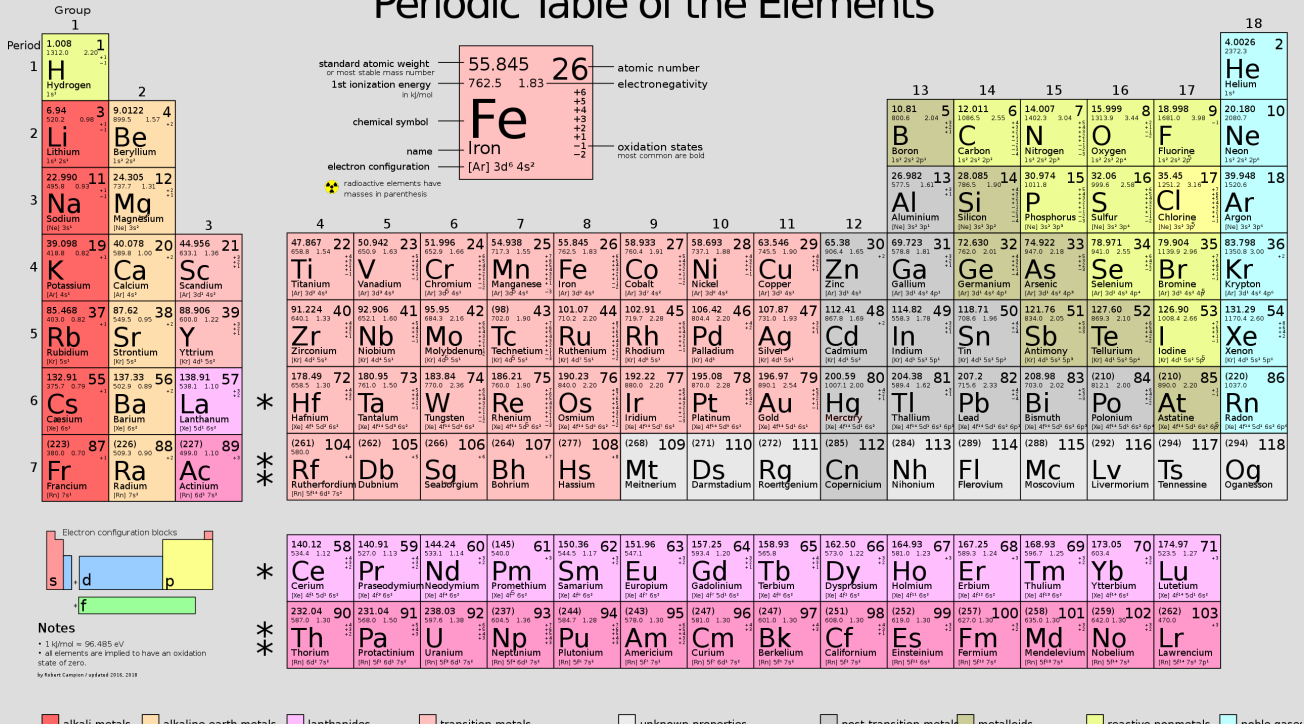


CLASS	HOPES	REALITY
Introduction to Electrical Engineering		

Then we need to know how to solve the model…

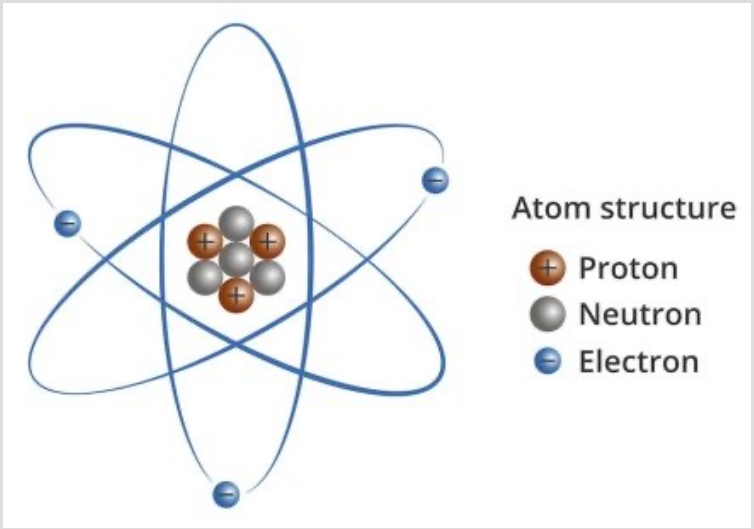
Note: the tool used by computers to analyze circuits is *linear algebra*!

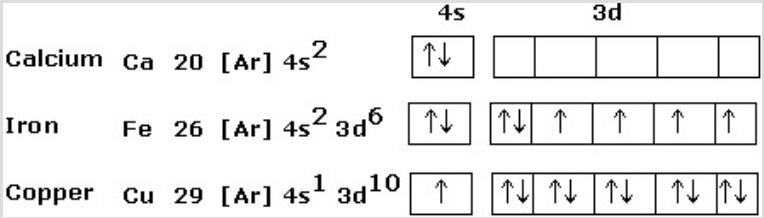
First: Science Review

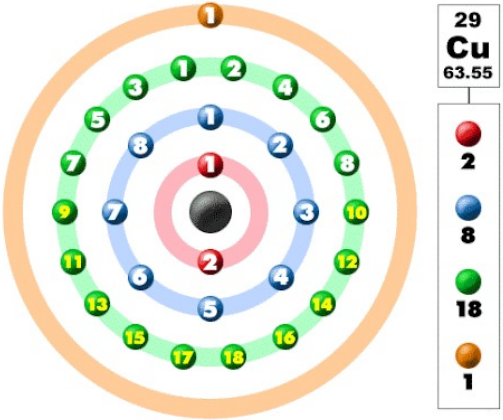


First: Science Review

First: Science Review

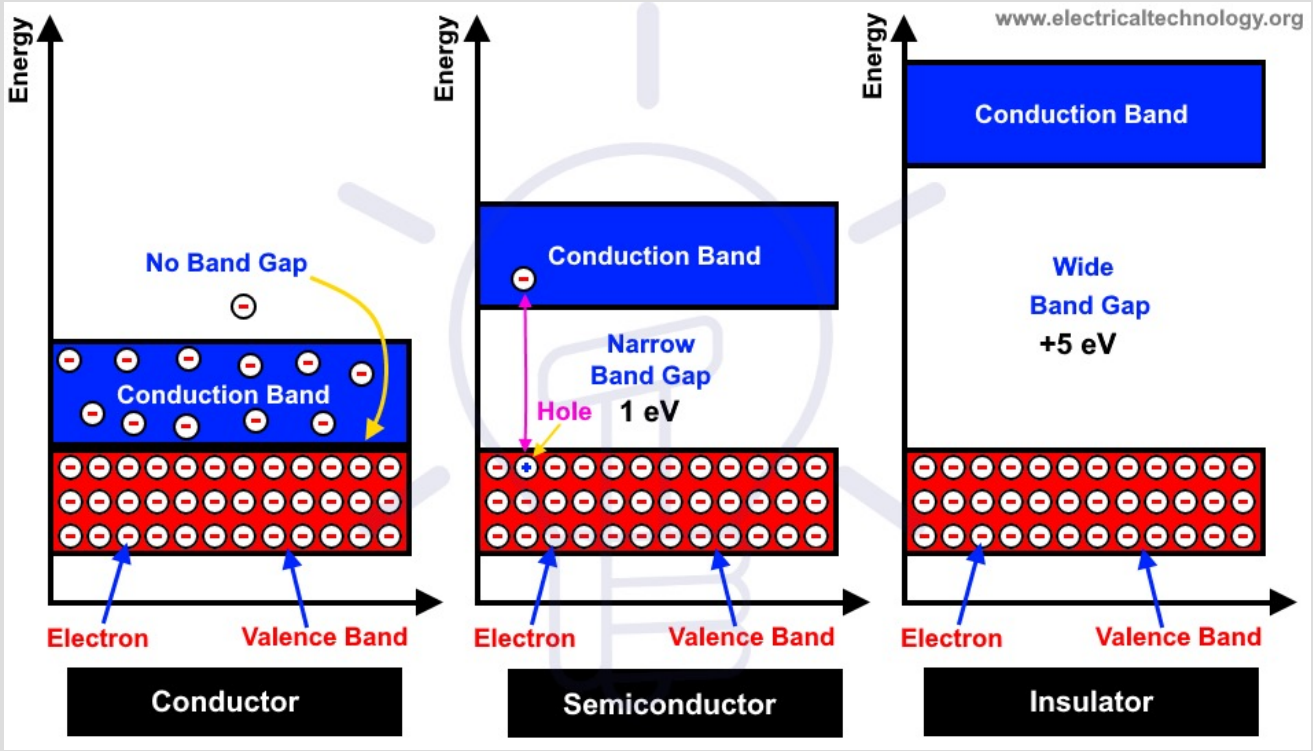






Element	Symbol	Electronic Configuration
Scandium	Sc	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$
Titanium	Ti	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$
Vanadium	V	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$
Chromium	Cr	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$
Manganese	Mn	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$
Iron	Fe	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$
Cobalt	Co	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$
Nickel	Ni	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$
Copper	Cu	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$
Zinc	Zn	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

Second: a tiny bit of Solid-State Physics



Electronic Devices depend on movement of charges

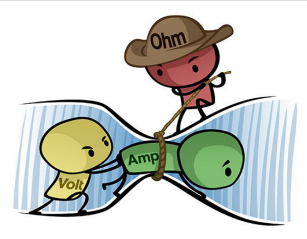
Electrical Quantities

Quantities	Analytical Symbol	Units
Current	I	Amperes (A)
Voltage	V	Volts (V)
Resistance	R	Ohms (Ω)

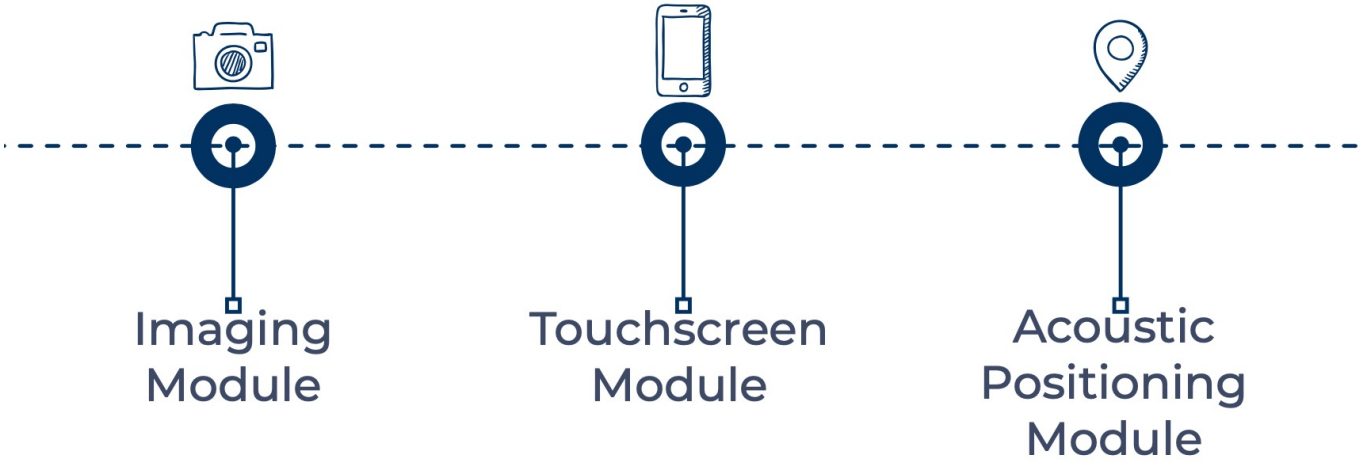
I ⇒ flows through an element

V ⇒ applied across an element

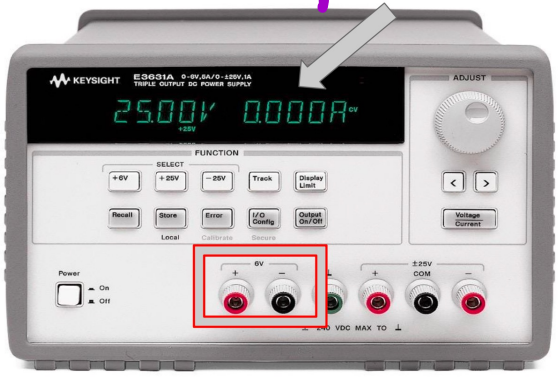
R ⇒ opposition to current flow



In the lab


Imaging Module
Touchscreen Module
Acoustic Positioning Module

In the lab

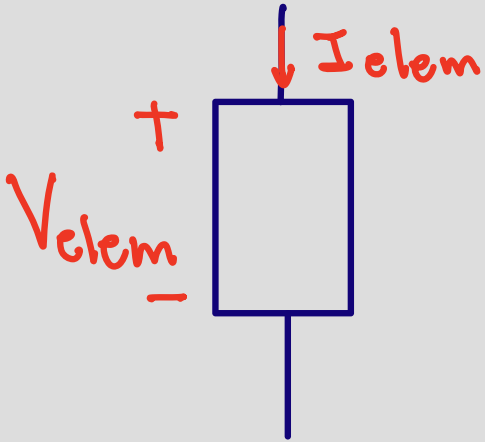

KEYSIGHT
E3631A
TRIPLE OUTPUT DC POWER SUPPLY
25.00V
0.000A
ADJUST
FUNCTION
SELECT
+6V
+25V
−25V
Track
Display Limit
Recall
Store
Error
I/O Config
Output On/Off
Local
Calibrate
Secure
Voltage Current
Power
On
Off
6V
±25V
COM
2nd VDC MAX TO

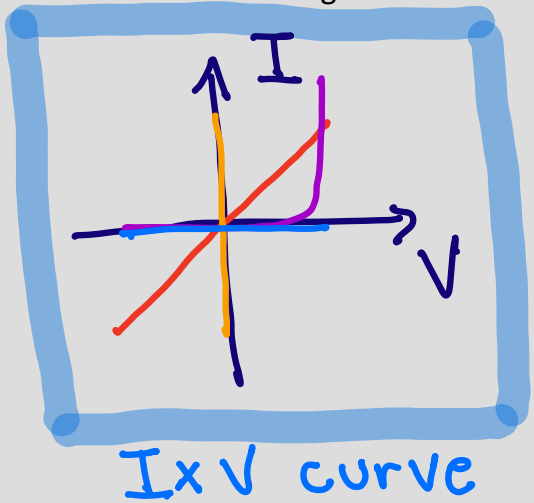

E
202M
12KV
EC
103


+
-

Definitions needed to analyze a circuit : Circuit Diagram

Collection of elements, where each element has some voltage across it and some current through it





Velem : Voltage across the element

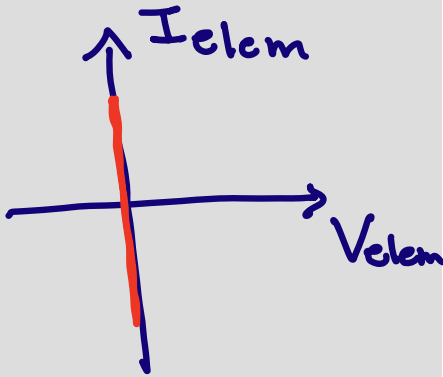
Ielem: Current across the element

Key circuit elements: Wire

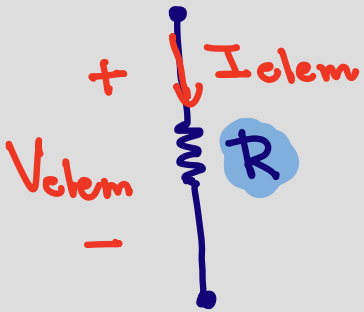
$V_{elem} = 0$

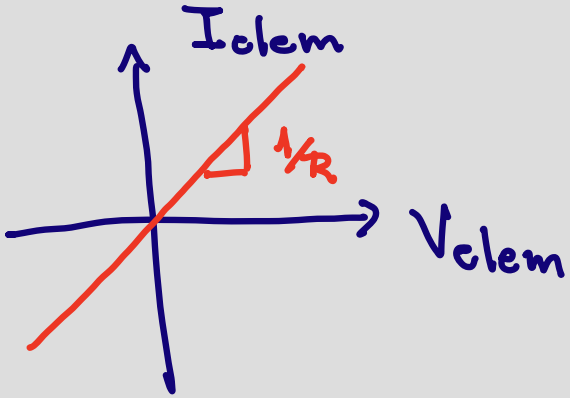
$I_{elem} = ?$

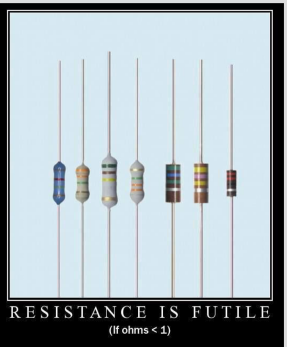
(set by the external circuit)



Key circuit elements: Resistor



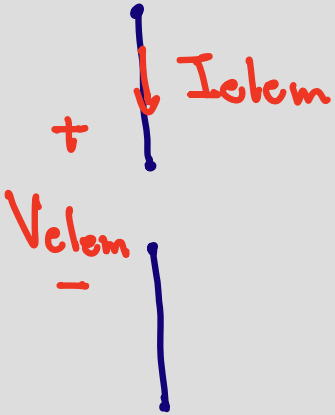




$$V_{elem} = R \cdot I_{elem}$$

Ohm's Law

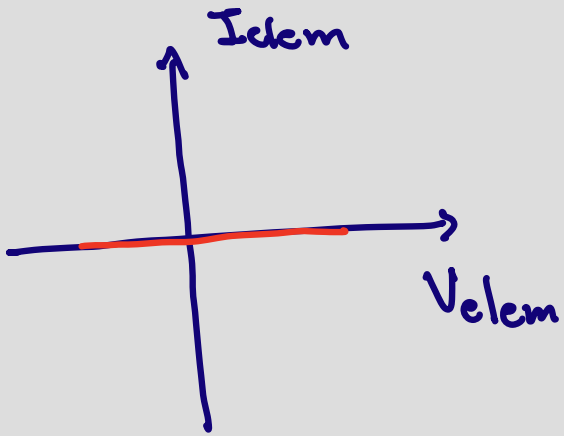
Key circuit elements: Open circuit



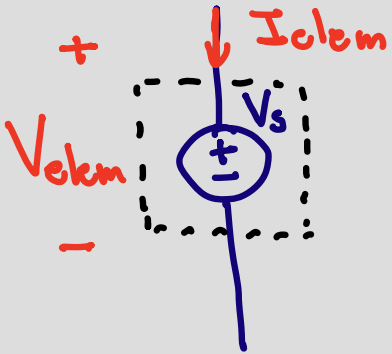
$I_{elem} = 0$

$V_{elem} = ?$

(V is set by the external circuit)



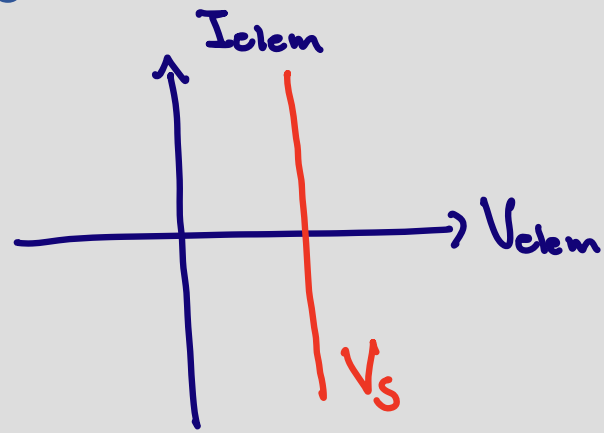
Key circuit elements: Voltage Source

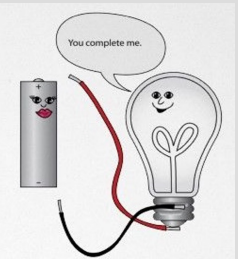


$V_{clem} = V_S$

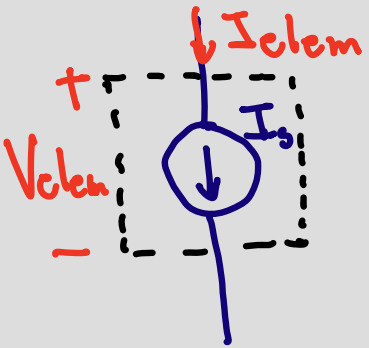
$I_{clem} = ?$

(I set by external circuit)





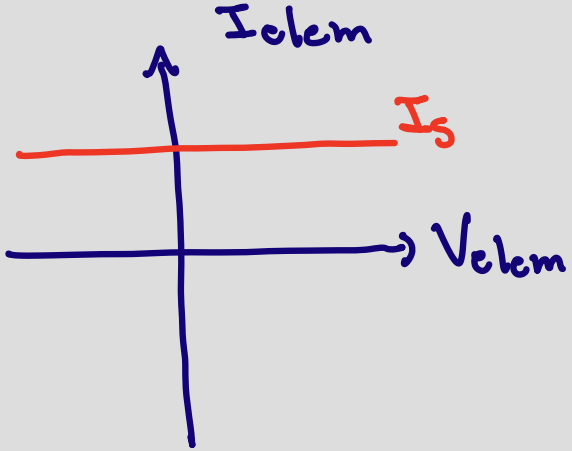
Key circuit elements: Current Source



$I_{elem} = I_s$

$V_{elem} = ?$

(V is set by external circuit)

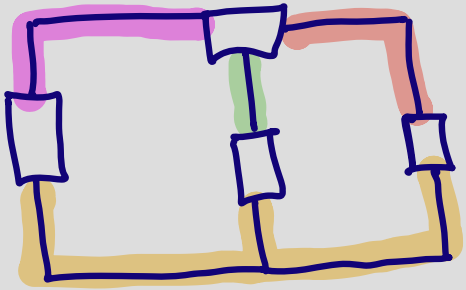


Velem and Ielem can be positive or negative

Definitions needed to analyze a circuit : Circuit Diagram

Collection of elements, where each element has some voltage across it and some current through it

Example



4 nodes

many junctions

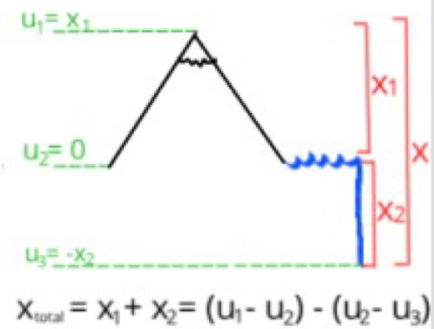
Nodes : point where elements meet

Junction : point where different materials meet

Circuit Analysis Algorithm

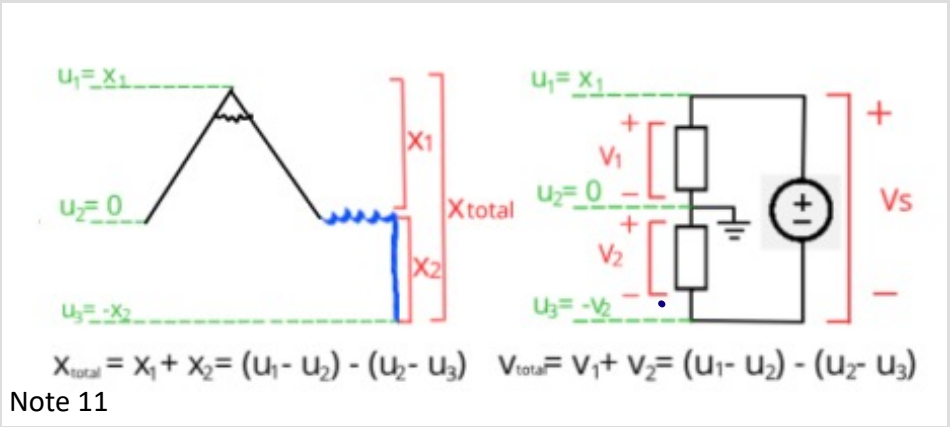
Voltage = difference of two potential

Find: currents through elements and potentials of inputs/outputs of each element (junctions)



Note 11

Electronic Devices depend on movement of charges



Note 11

U_1, U_2, U_3

potentials

$V_1 = U_1 - U_2$

$V_2 = U_2 - U_3$

$V_{total} = V_1 + V_2$

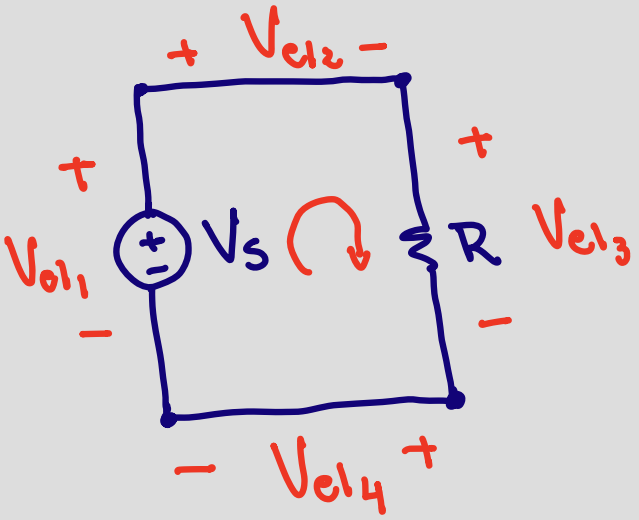
$V_{total} = V_S$

We always need to define a reference for potentials.

Ground = 0

Rules for circuit analysis: Kirchoff's Voltage Law (KVL)

Sum of Voltages across the elements in a loop equal zero



$$V_{el_1} - V_{el_2} - V_{el_3} - V_{el_4} = 0$$

$+ \; \overset{-}{+} \; V_{el_2}$

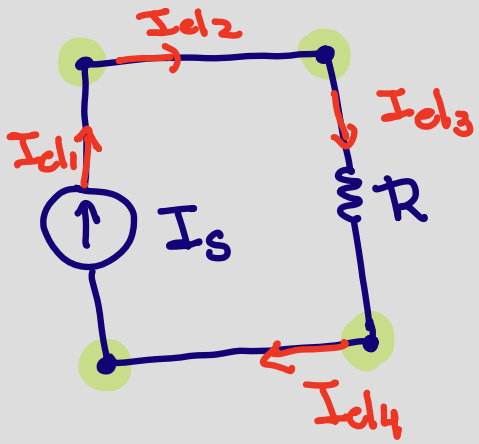
$V_{el_1} \; \overset{+}{-} \; V_{el_3}$

$- \; \overset{+}{-} \; V_{el_4}$

$$V_{el_1} = V_s$$

Rules for circuit analysis: Kirchoff's Current Law (KCL)

The current flowing into any junction must equal the current flowing out



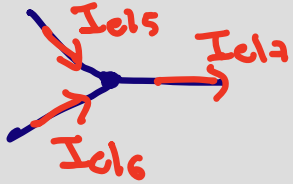
$$I_{cl_1} = I_{cl_2}$$

$$I_{cl_2} = I_{cl_3}$$

$$I_{cl_3} = I_{cl_4}$$

$$I_{cl_4} = I_{cl_1}$$

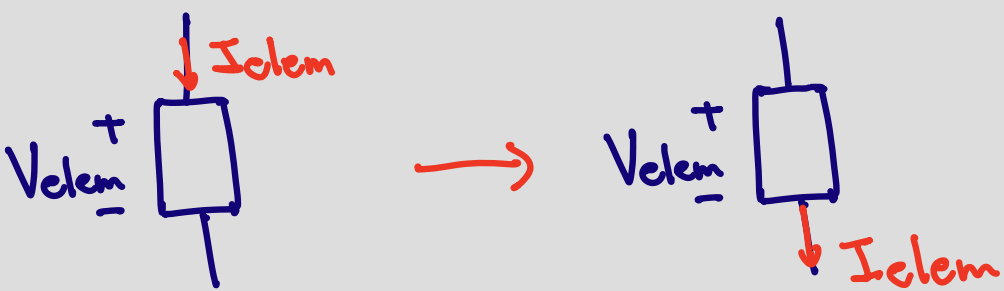
Example 2:



$$I_{cl_5} + I_{cl_6} = I_{cl_7}$$

Rules for circuit analysis: KCL within the element

The current flowing into any junction must equal the current flowing out



Same current!

Both are allowed.

Ielem goes into a (+) or out of a (−) terminal

Passive sign convention