CEN6215 - Circuits & Electronics

Engineering is purposeful use of science. Science provides an understanding of natural phenomena. Abstraction provides bridge between real world / experimental data and practitioners / engineers who want to use specific phenomena to achieve their goals.

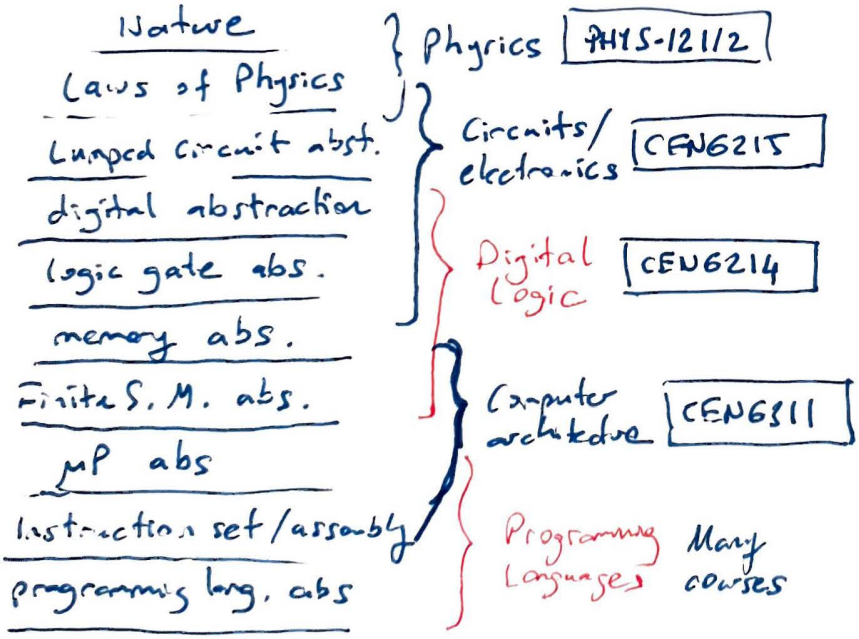
Newton's laws of motion : $F = ma$ (Model / abstraction)

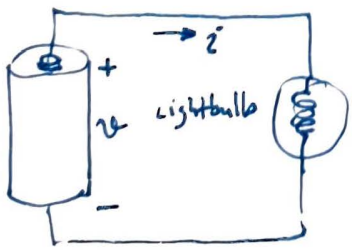
Einstein : $m = m_0 / \sqrt{1 - v^2/c^2}$

: Actually complex but this model ignores many details about the system.

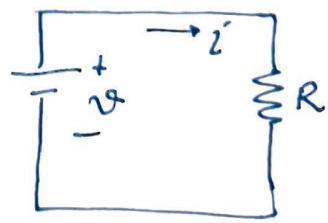
Electrical engineering and computer science is the purposeful use of Maxwell's equations (abstractions). Elk. Eng creates a new abstraction : Lumped circuit abstraction !

There are also other abstractions :





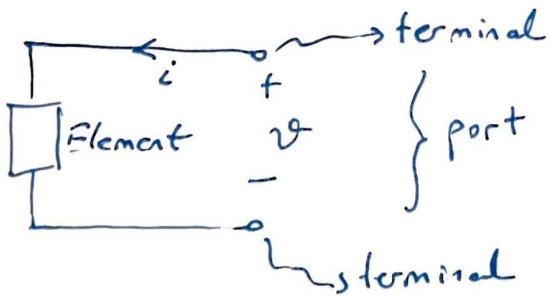
Model →



$$i = \frac{v}{R} \iff v = Ri$$

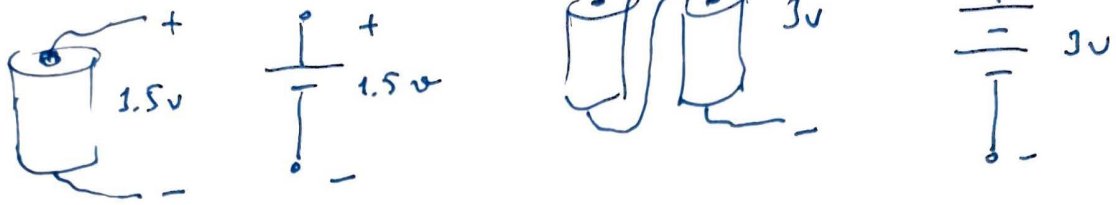
Lumped Elements / Black box approach

Two-terminal elements:



Element: battery, resistance, capacitor, inductor...

Batteries:



$p = v \cdot i$ (Power in Watt)

if p is constant over interval T, energy w is supplied:

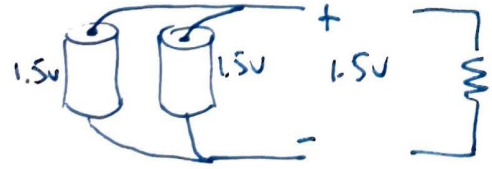
$$w = p \cdot T \quad \text{(joules)} \qquad \text{or} \qquad w = \int_{t_1}^{t_2} v(t)\, i(t)\, dt$$

Watt-seconds

* if battery supplies 1 w power over 1 second, it delivers 1 joule energy.
* Car battery: 12 v, 50 Ah (Ampere-hours)
  It can provide 1 A for 50 hours.
  100 A for 30 minutes

Energy stored: $12 \cdot 50 = 600$ W.hours $= 600 \cdot 3600 = 2.16 \cdot 10^6$ joules

* To increase the energy, double batteries in parallel:

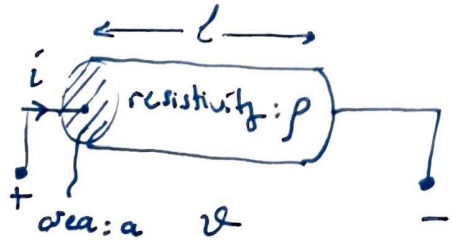


→ Power is dissipated here in the form of heat or light

$v = R \cdot i$

$v = 1.5$v, $R = 10\,\Omega$ (lightbulb) $\Rightarrow i = \frac{v}{R} = 150$ mA

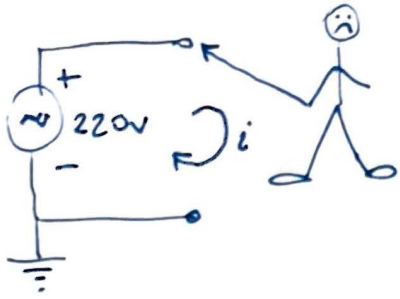
Study: [... T, G, M, k, m, μ, p, f ...]



$R = \rho \cdot \frac{l}{a}$ resistance of a piece of material is proportional to its length, inversely prop. to its cross-sectional area.

For a wire: $R = \rho \cdot \frac{l}{\pi r^2}$

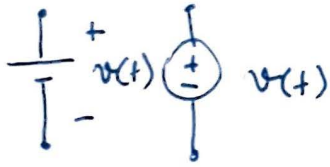
Question: What kills a human? Voltage or current?

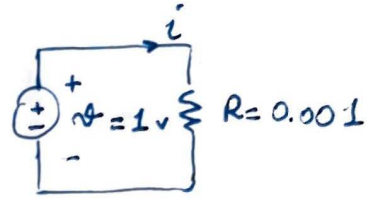


$i \geq 100$ mA kills!

$R \cong 2$ kΩ

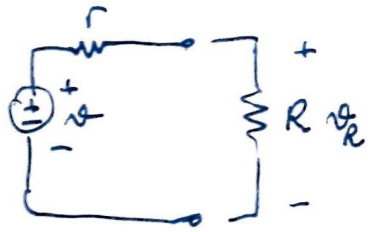
* Ideal Voltage Source, wire, resistor





$i = 1000$ A (?)
not possible for a simple source to provide 1000 A.

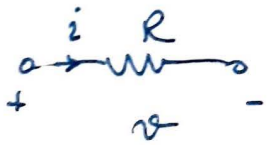
Voltage source is modeled as:



r is unwanted internal resistance. e.g. $r = 0.1\ \Omega$

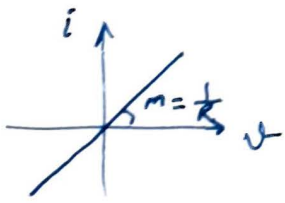
even for $R = 0.001$ $\quad i \cong \frac{1}{0.1} = 10$ A

$\Rightarrow v_R \cong 0$ v



$v = R \cdot i$ (ohm's law) $\quad$ R: resistance (ohm)

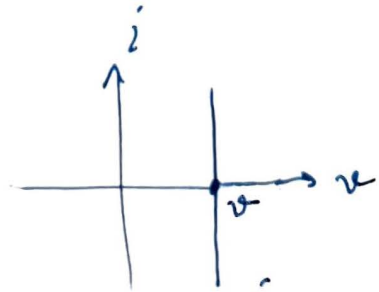
$i = G \cdot v$ $\left(R = \frac{1}{G}\right)$ $\quad$ G: conductance (Siemens)

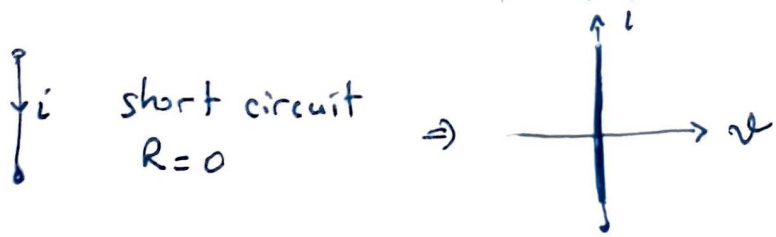


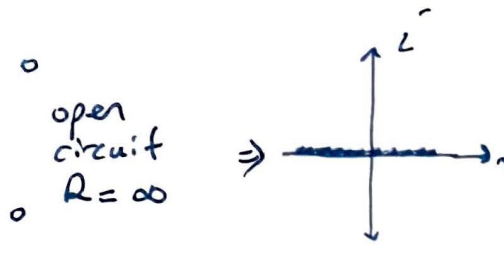
(R)

v-i characteristic

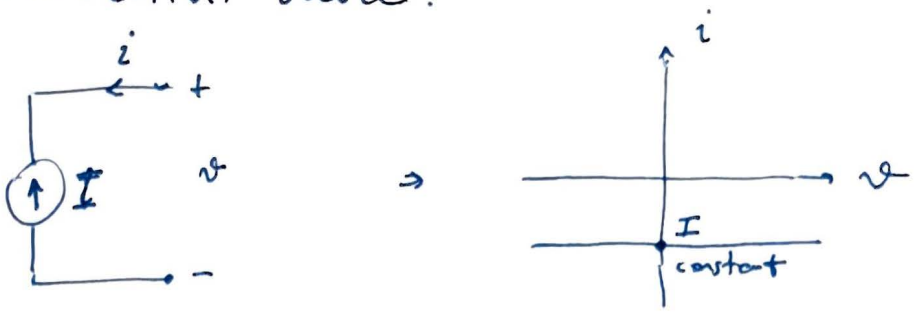
ideal voltage source:







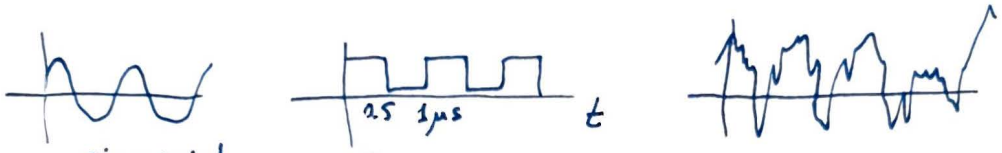
ideal current source :



SIGNALS

ANALOG : signals in phyrical world. Spanning continous values.

- How many values a voltage source can take between 0v and 5v ?
  The aswer is infinite ! ∞



sinussid

square wave
frequency = 1 MHz

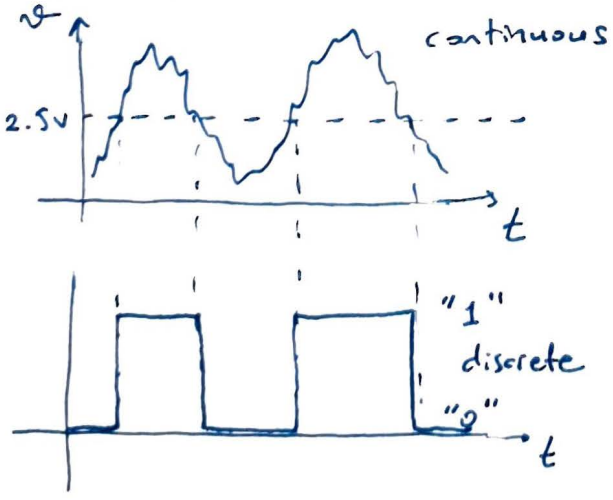
a signal
(not periodic !)

$$v(t) = A \sin(\omega t + \phi)$$

time

amplitude — frequency — phase

DIGITAL

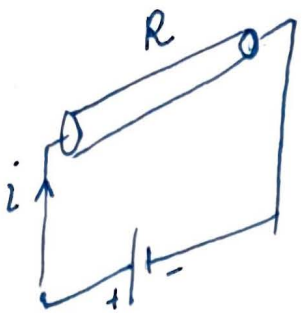


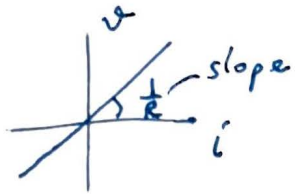
digital abstraction :
signal is quantized into Two values.
:⇒ Binary signal.

Advantage is "Better noise immunity"

Other Lumped Devices

Resistance

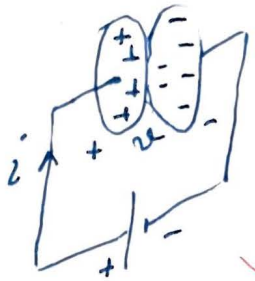


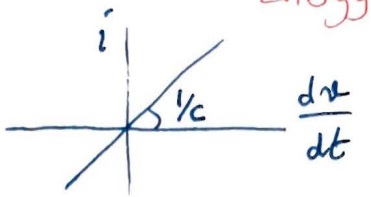


$$v = R \cdot i$$

resistance (Ohm: Ω)

Capacitance

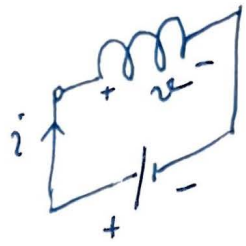


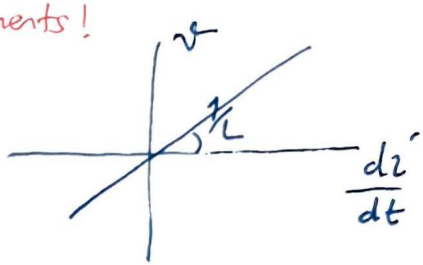


$$i = C \frac{dv}{dt}$$

capacitance (Farads: F)

Inductance





$$v = L \frac{di}{dt}$$

inductance (Henry: H)

Energy storage elements!

* Capacitance is a measure of the ability of a device to store energy in the form of seperated charge or in the form of an electric field.
* Inductance is a measure of the ability of a device to store energy in the form of moving charge or in the form of magnetic field.
* They store energy and can give it back!
* Resistance is a measure of the ability of a device to dissipate power irreversibly!