Unit - I

1.2 Introduction and Basic Concepts

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Batteries

→ Li-ion ✓

Lead-acid

→ 3.3V ± 1mV

Data transfer

→ Wired

NEC

Syllabus

R

L

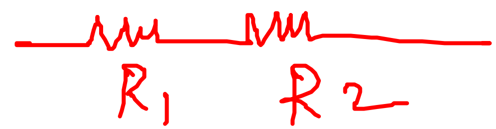
C.

UNIT – I **10 Periods**

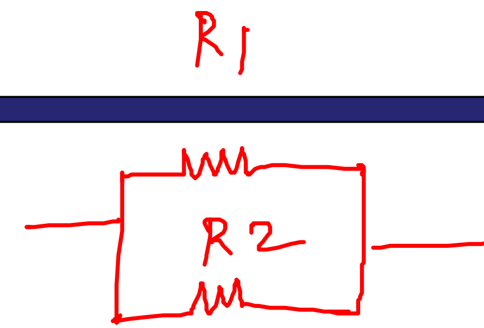
Introduction and Basic Concepts: Concept of Potential difference, voltage, current - Fundamental linear passive and active elements to their functional current-voltage relation - Terminology and symbols in order to describe electric networks - Concept of work, power, energy and conversion of energy- Principle of batteries and application.

Principles of Electrostatics: Electrostatic field - electric field intensity - electric field strength - absolute permittivity - relative permittivity - capacitor composite – dielectric capacitors - capacitors in series & parallel - energy stored in capacitors - charging and discharging of capacitors.

Resistors →

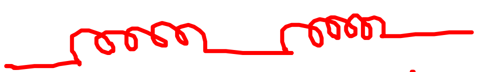


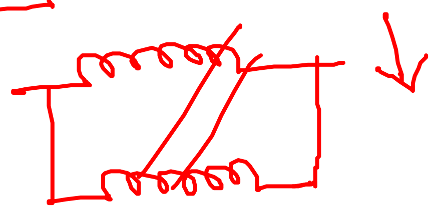
$R_{eq} = R_1 + R_2$

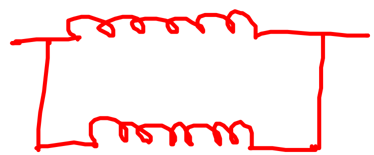


$$R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

Inductors





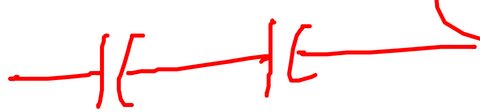


$E = \frac{1}{2} C V^2$

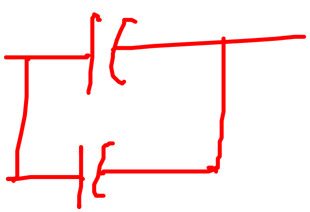
μF

F

Capacitors



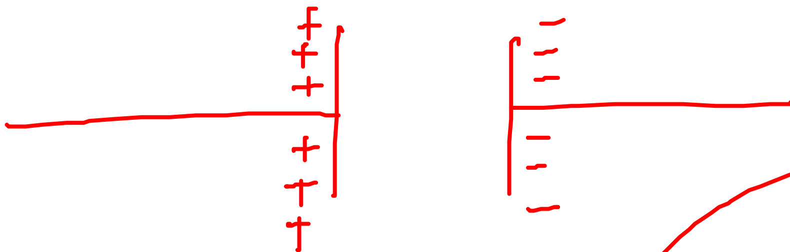
DC



Ultracapacitors

Supercapacitors

Capacitors



$$E = \frac{1}{2} CV^2$$

$$C = \frac{Q}{V}$$

adsorption

Capacity ↑ 1F, $\frac{50F}{1.3V}$

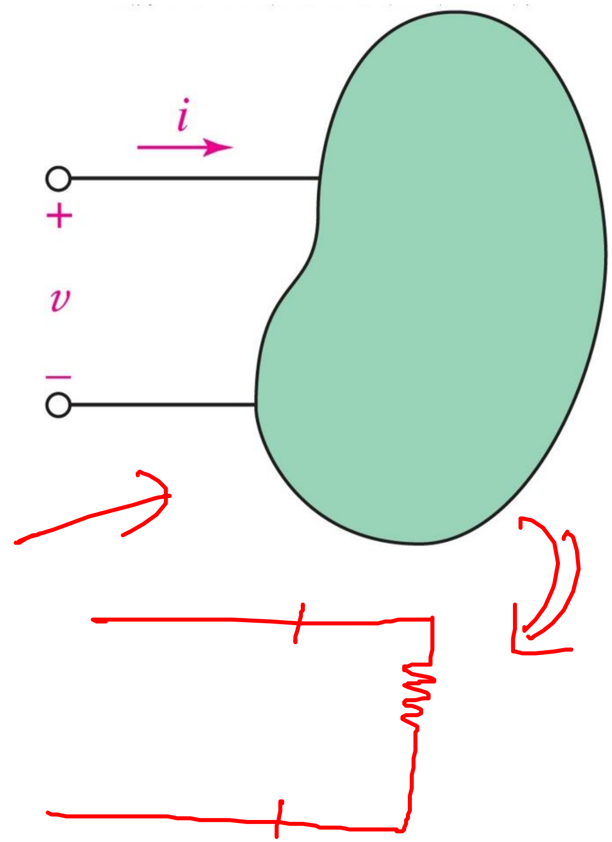
Discharge →

Circuit Elements

Lumped circuit abstraction

- A circuit element usually has two terminals (sometimes three or more).

- The relationship between the voltage *v* across the terminals and the current *i* through the device defines the circuit element model.



Linear Elements and Circuits

- a linear circuit element has a linear voltage-current relationship:
  R, L, C
  - if $i(t)$ produces $v(t)$, then $Ki(t)$ produces $Kv(t)$
  - if $i_1(t)$ produces $v_1(t)$ and $i_2(t)$ produces $v_2(t)$, then $i_1(t) + i_2(t)$ produces $v_1(t) + v_2(t)$,
- resistors, sources are linear elements[1]
- a linear circuit is one with only linear elements

[1]Dependent sources need linear control equations to be linear elements.

Voltage

Current

Sources

Wind

Tidal

Hydro

Solar PV

Thermal

Nuclear

Hydrogen / Fuel.

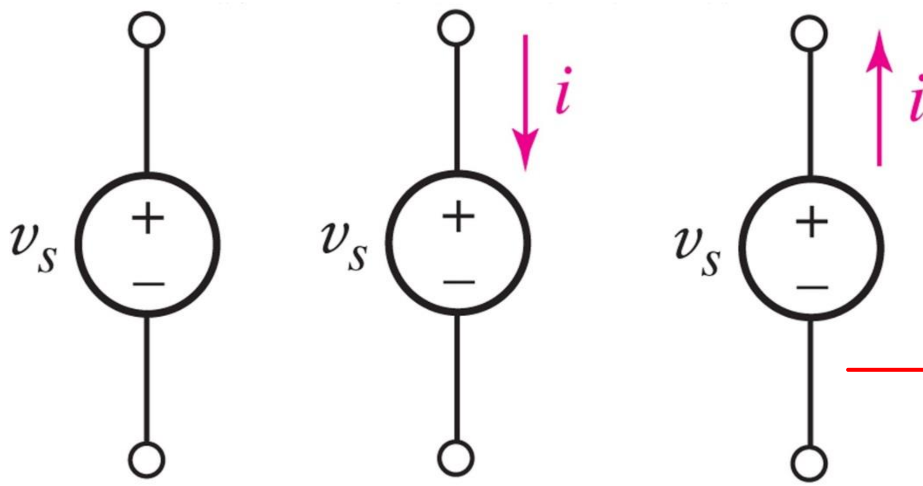
Fuel cells

Generators (

Batteries

Voltage Sources

- An ideal voltage source is a circuit element that will maintain the specified voltage v_s across its terminals.
- The current will be determined by other circuit elements.



(a) (b) (c)

Battery

↓

Grid Voltage

$1\phi \rightarrow 230V$

50Hz

$230 \pm 6\%$

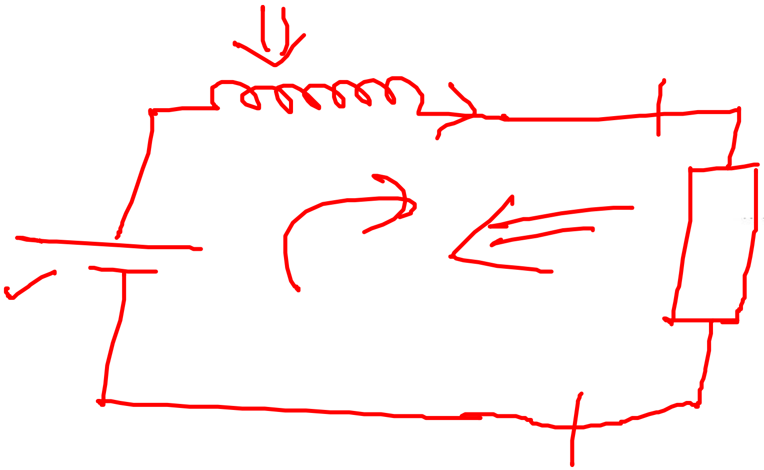
$TV \rightarrow 230$

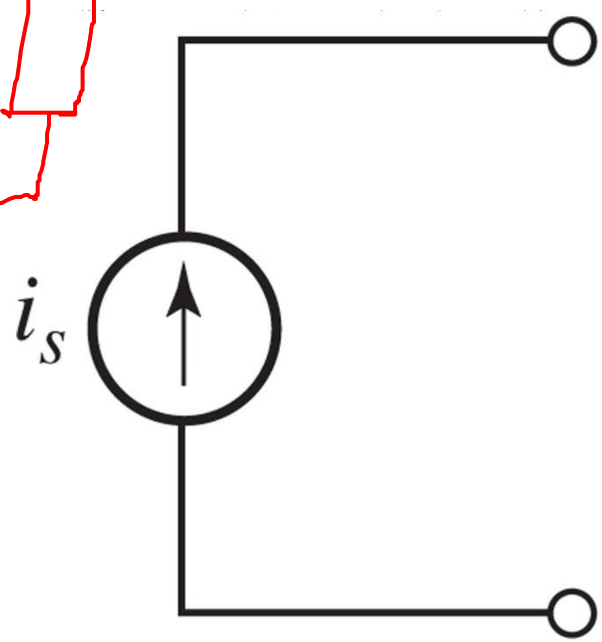
↓

$\rightarrow 242$

Current Sources

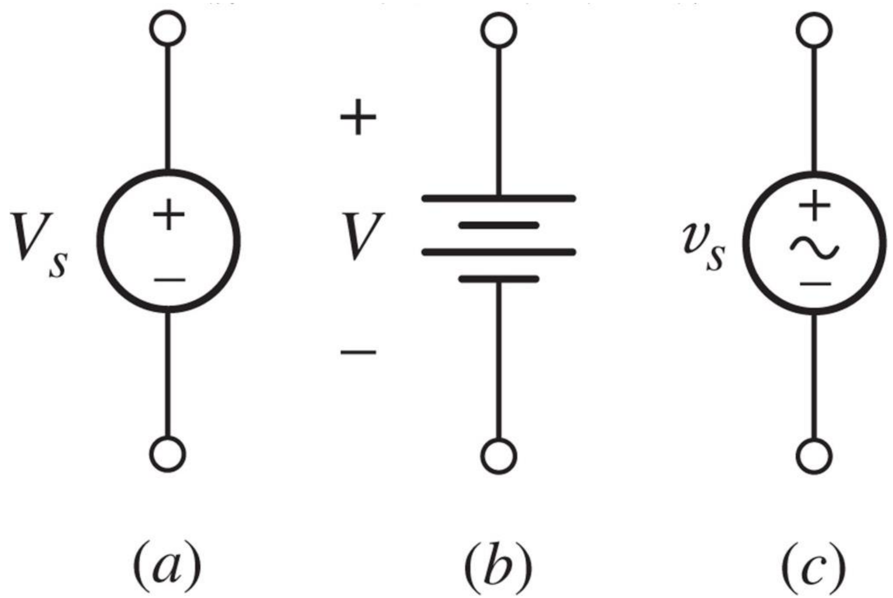
- An ideal current source is a circuit element that maintains the specified current flow i_s through its terminals.
- The voltage is determined by other circuit elements.





Battery as Voltage Source

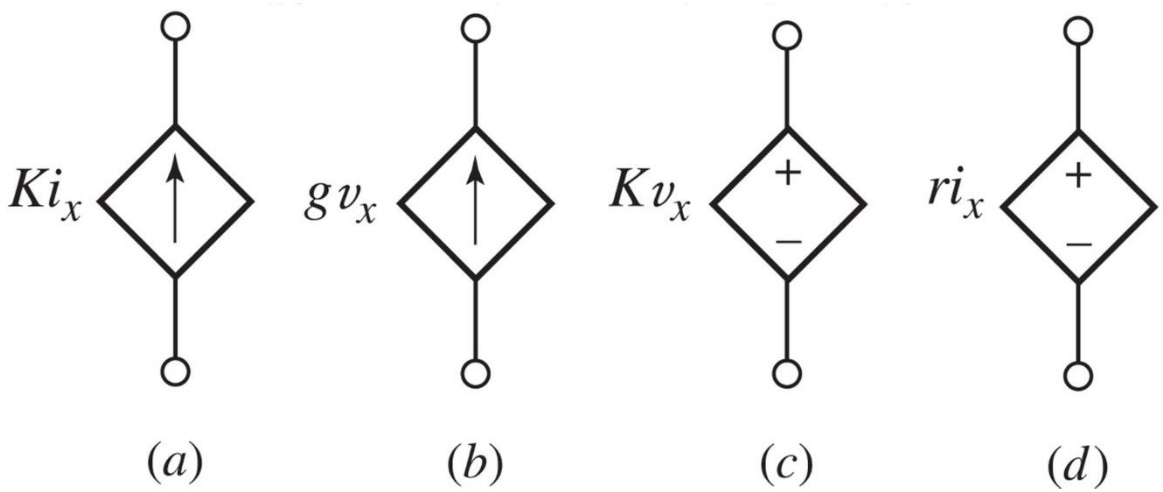
- A voltage source is an idealization (no limit on current) and generalization (voltage can be time-varying) of a battery.
- A battery supplies a constant "dc" voltage V but in practice a battery has a maximum power.



Dependent Sources

- Dependent current sources (a) and (b) maintain a *current* specified by another circuit variable.

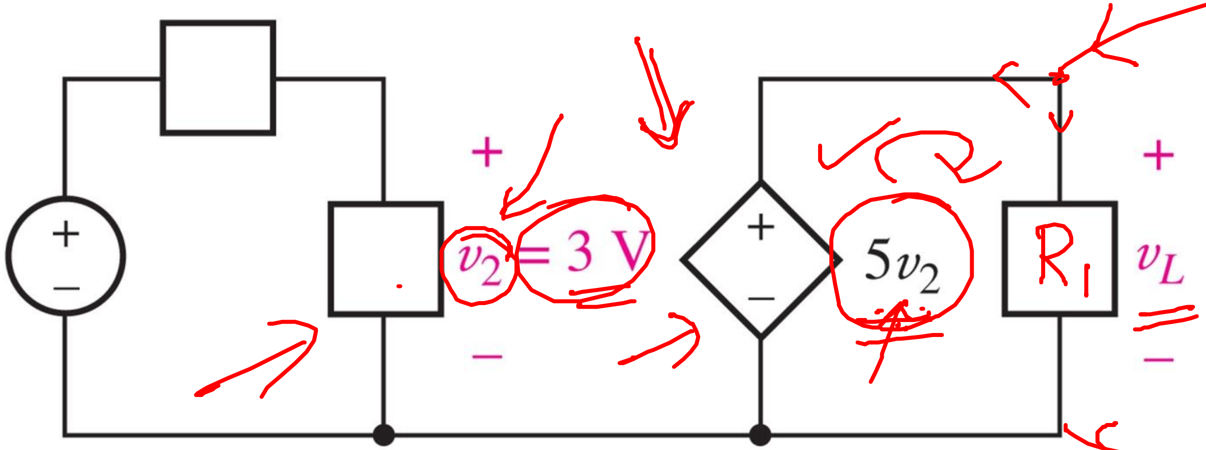
- Dependent voltage sources (c) and (d) maintain a *voltage* specified by another circuit variable.



Example: Dependent Sources

Find the voltage v_L in the circuit below.

5V



$5V_2$

$= ?$

$5V_L - V_L = 0$

$V_L = 5V_2$

$v_L = 5V_2$

$= 5 \times 3 = 15V$

Ohm's Law: Resistance

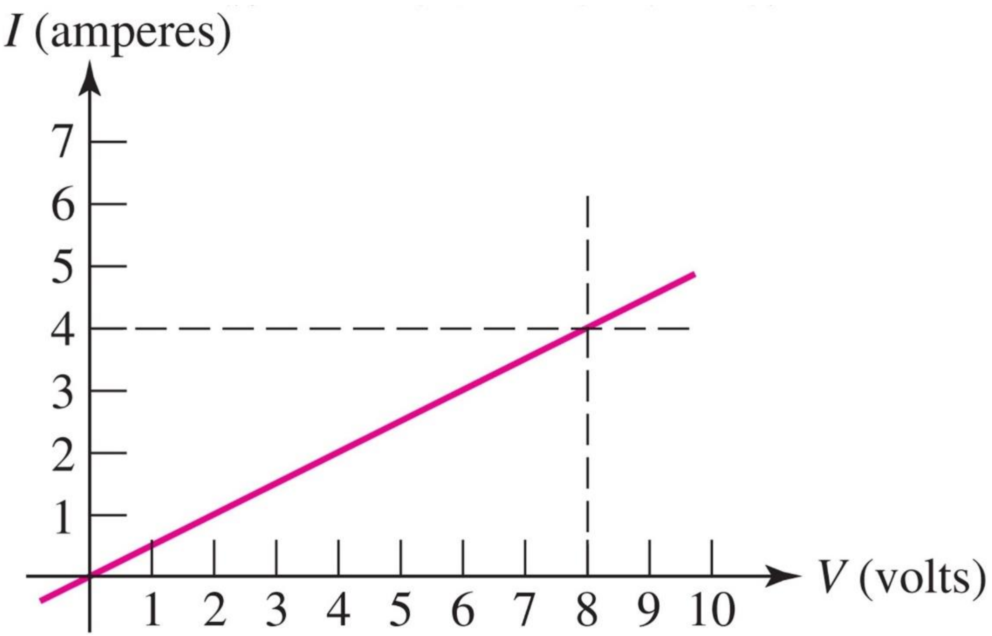
- A (linear) resistor is an element for which

$$v = iR$$

- where the constant R is a resistance.
- The equation is known as "Ohm's Law."
- The unit of resistance is ohm (Ω).

The i-v Graph for a Resistor

For a resistor, the plot of current versus voltage is a straight line:



In this example, the slope is 4 A / 8 V or 0.5 Ω^{-1}.

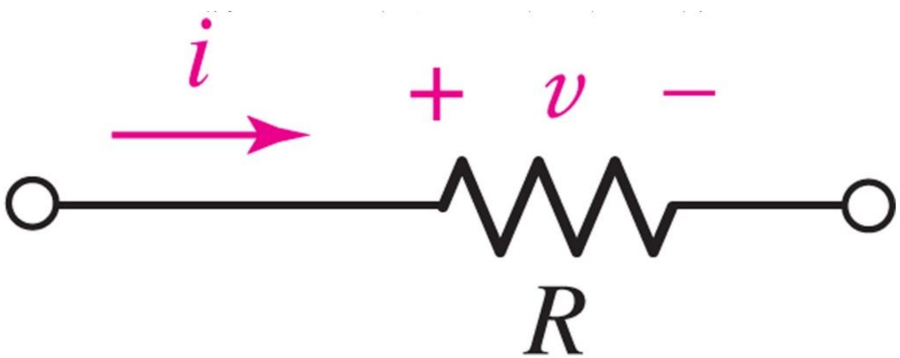
This is the graph for a 2 ohm resistor.

Power Absorption

Resistors absorb power: since $v=iR$

$$p=vi = v^2/R = i^2R$$

Positive power means the device is absorbing energy. Power is always positive for a resistor!



Example: Resistor Power

A 560 Ω resistor is connected to a circuit which causes a current of 42.4 mA to flow through it. Calculate the voltage across the resistor and the power it is dissipating.

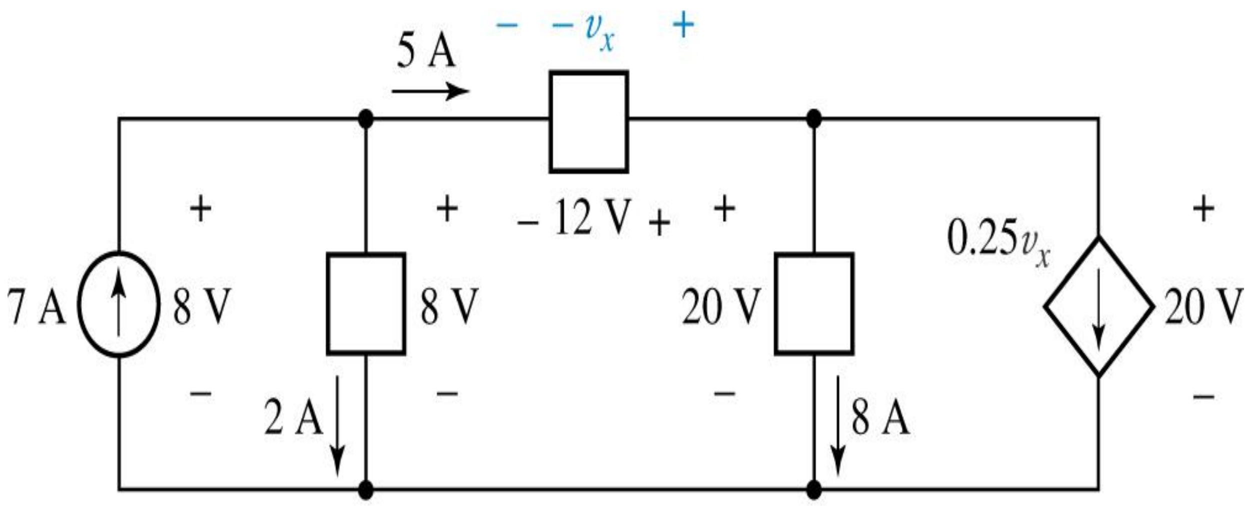
$v = iR = (0.0424)(560) = 23.7 \text{ V}$

$p = i^2R = (0.0424)^2(560) = 1.007 \text{ W}$

Power

Exercise

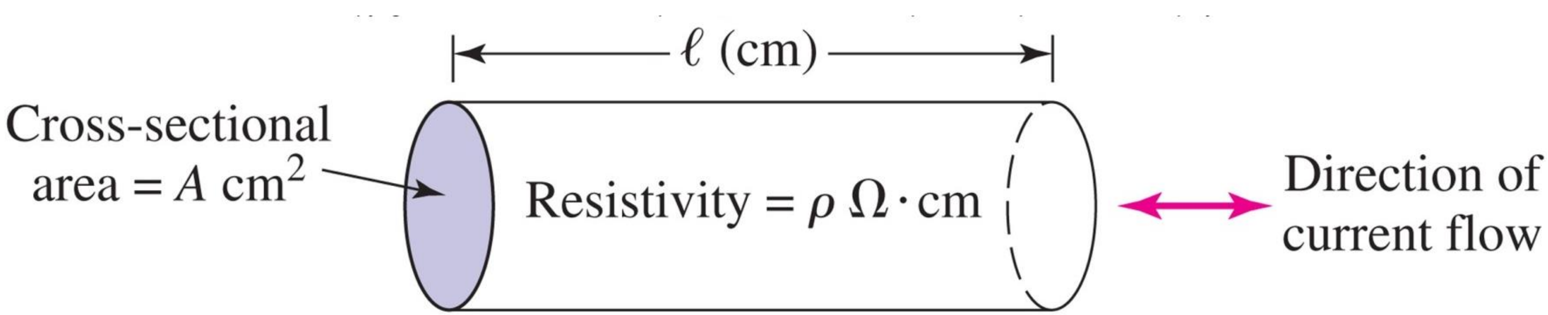
Find the power absorbed by each element in the circuit below.



Wire Gauge and Resistivity

The resistance of a wire is determined by the resistivity of the conductor as well as the geometry:

$$R = \rho\, l / A$$



[In most cases, the resistance of wires can be assumed to be 0 ohms.]

Conductance

- We sometimes prefer to work with *the reciprocal of resistance* (1/R), which is called conductance (symbol G, unit siemens (S)).

- A resistor R has conductance G=1/R.

- The *i-v* equation (i.e. Ohm's law) can be written as

$$i=Gv$$

Summary

Iron box

* Lumped circuit abstraction →

Source → Dependent

→ Indep.

Elements → Linear

↓

Resistance →

Exercise