Electrical and Electronics Circuits (2010)

- Lecturer: Prof. Soonhoi Ha (301-408, x8382)
  sha@snu.ac.kr, http://peace.snu.ac.kr/sha

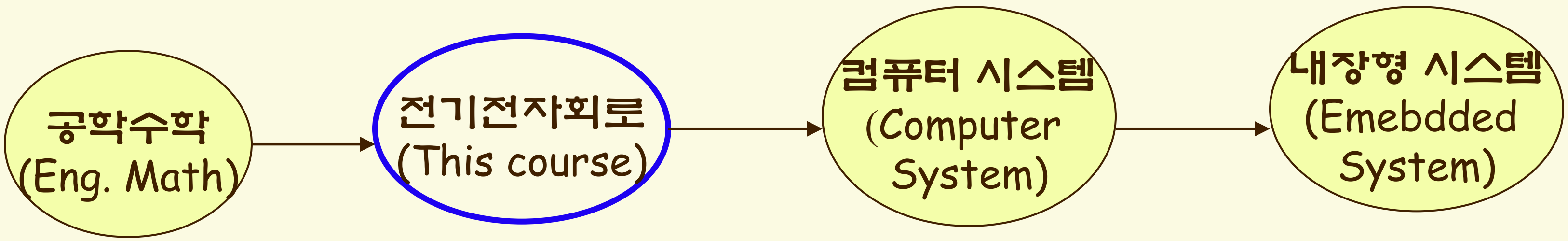
- Textbook: Foundations of Analog and Digital Electronic Circuits

- Course homepage: http://peace.snu.ac.kr/courses & ETL

- Grades: 3 exams 30, 30, 30% homework + attendance: 10%

Tips for the course

- Do not leave the class until you understand the contents.
- Exercise is the best way to learn the key concepts.
- Better if you can prepare and review the class
- Why do you need this course
  - Pre-requisite for advanced system courses
  - Broad knowledge on IT-related issues



Chap. 1 Circuit Abstraction

Lumped Circuit Abstraction

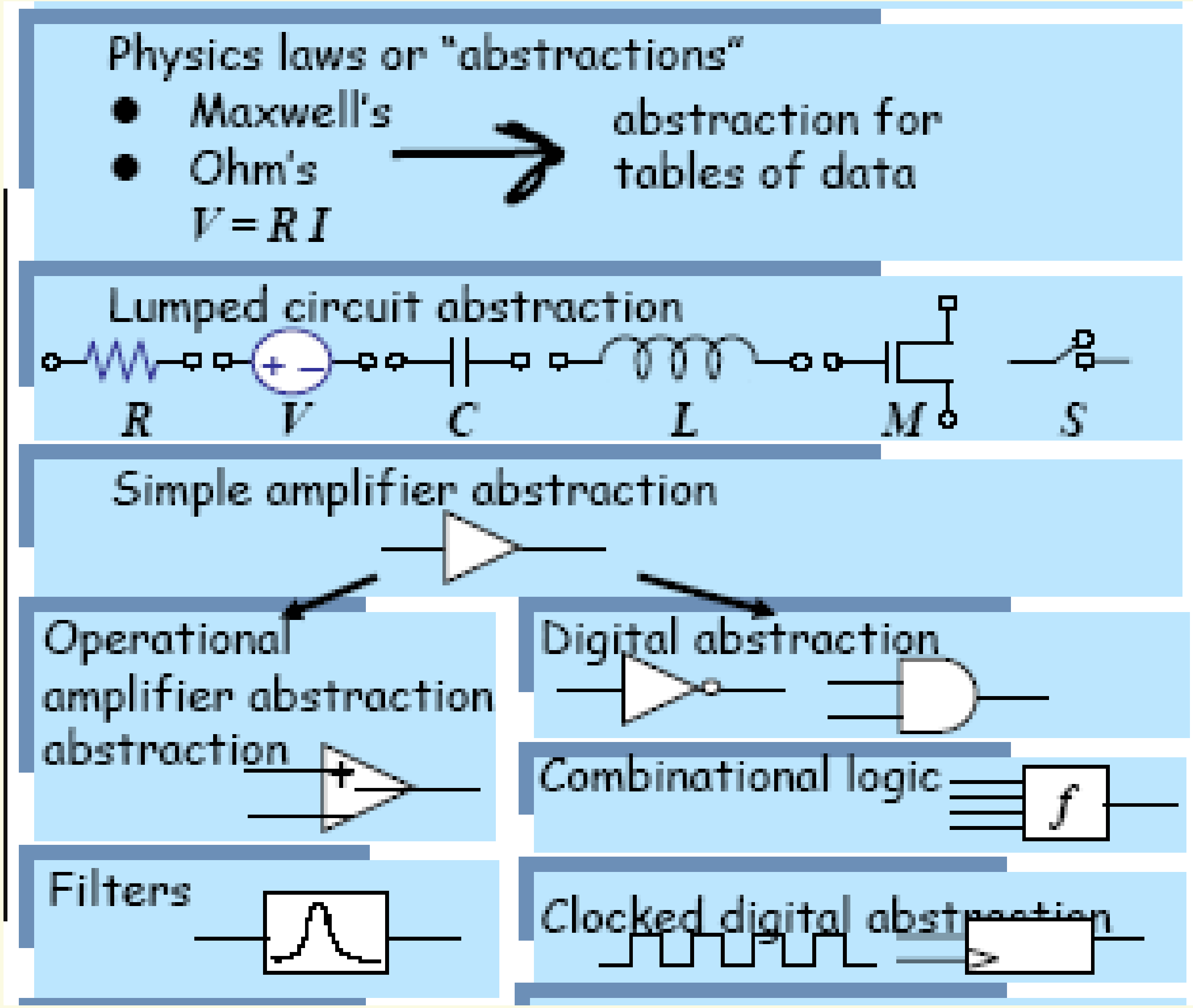
Practical Two-Terminal Elements

Electric power

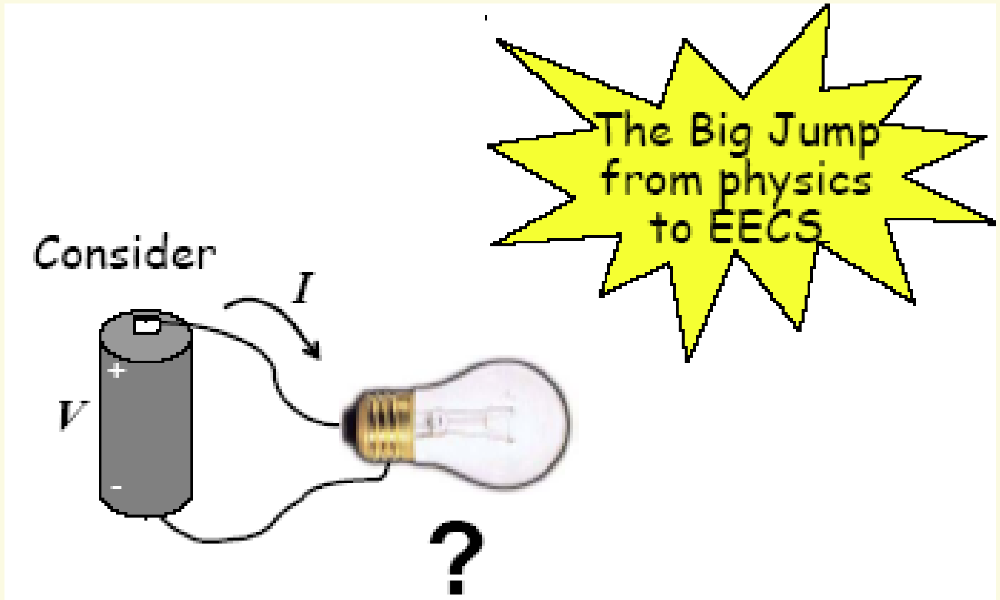
i-v characteristics

Resistors: Ohm's law

Abstraction



Lumped Circuit Abstraction

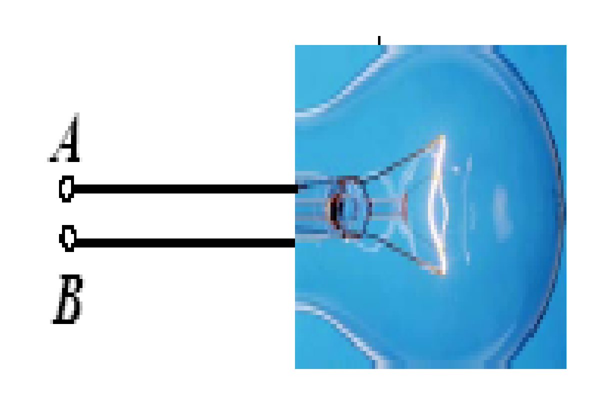


Physical element —Model→ Circuit Element

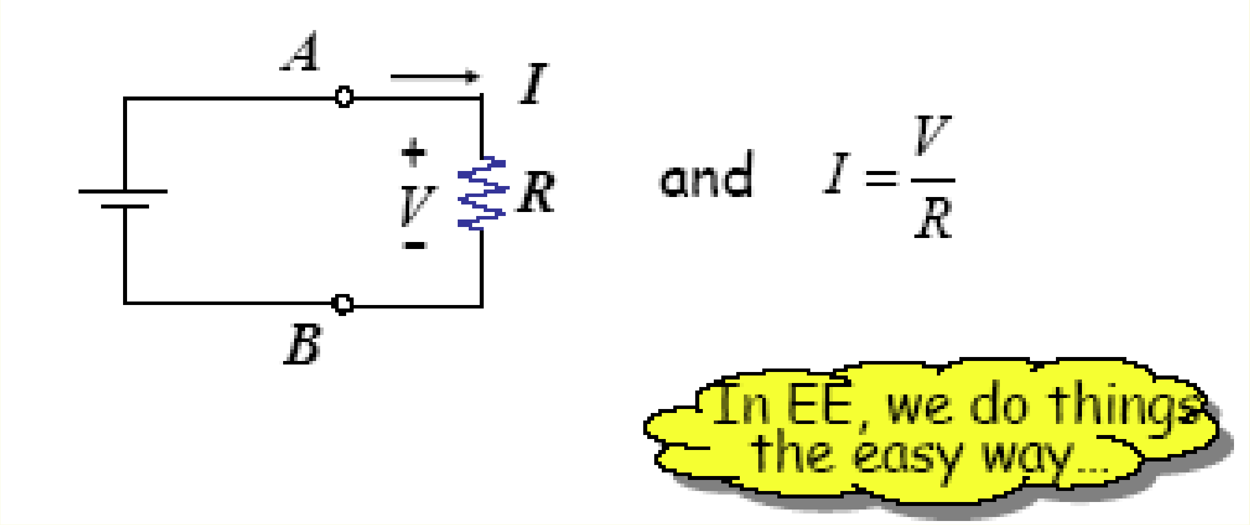
Interconnection ↓   ↓ Interconnection

Real circuit —Model→ Electric circuit

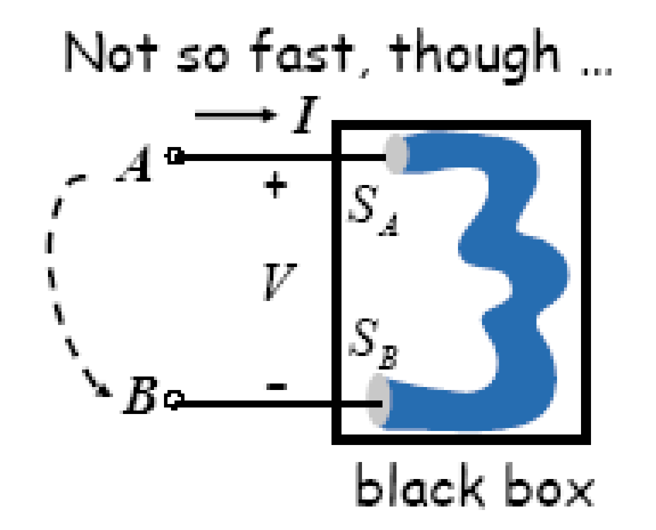
The Easy Way …



- R is the "lumped circuit abstraction" of the bulb.



Lumped Circuit Abstraction Assumption



- V and I must be defined for the element
- Element behavior is completely captured by its I-V relationship.

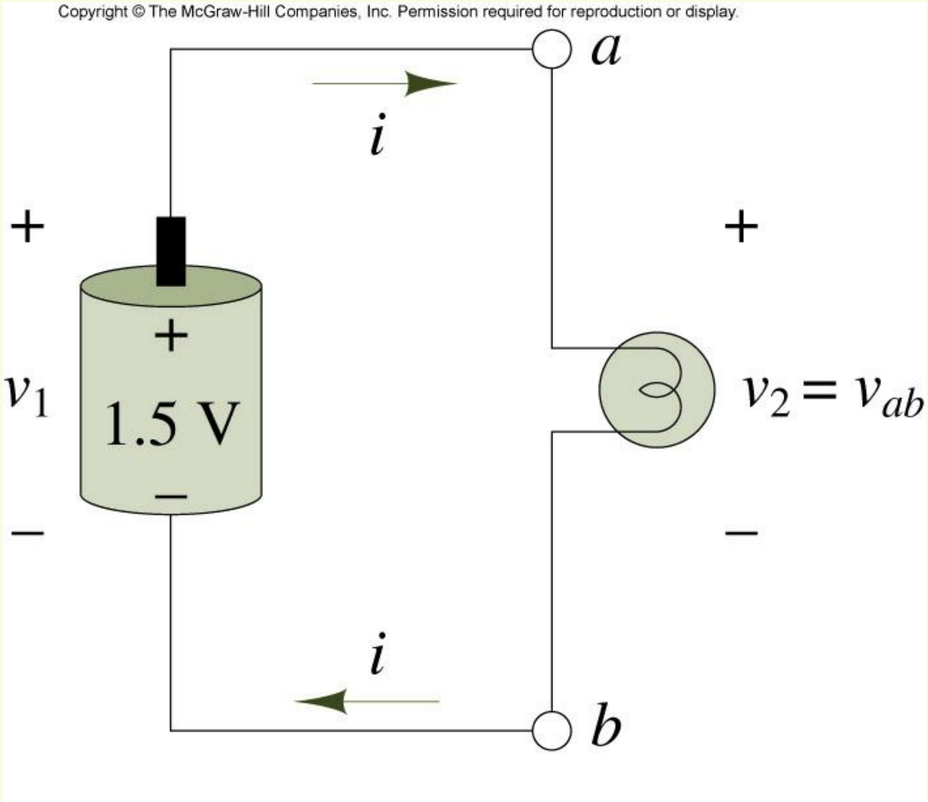
When you measure the current of a circuit, the measured value turns out to be 10 times higher than the analyzed one. What happens?

Charge and Current

- Charge Q

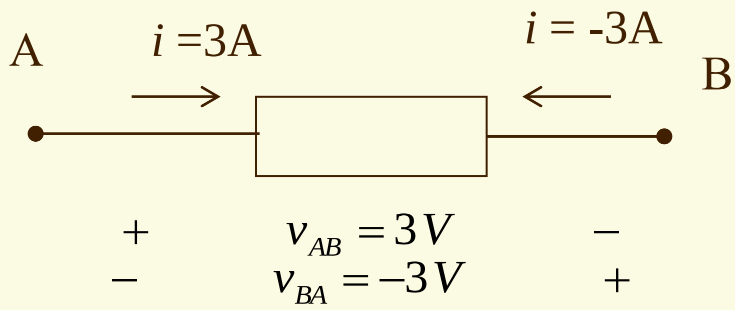
- Current $I = dq/dt$ ($C/sec = A$)

Voltages around a circuit

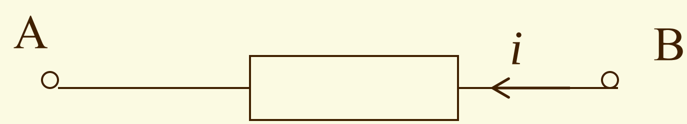


- Voltage = Joule/Coulomb

Direction of Current and Voltage



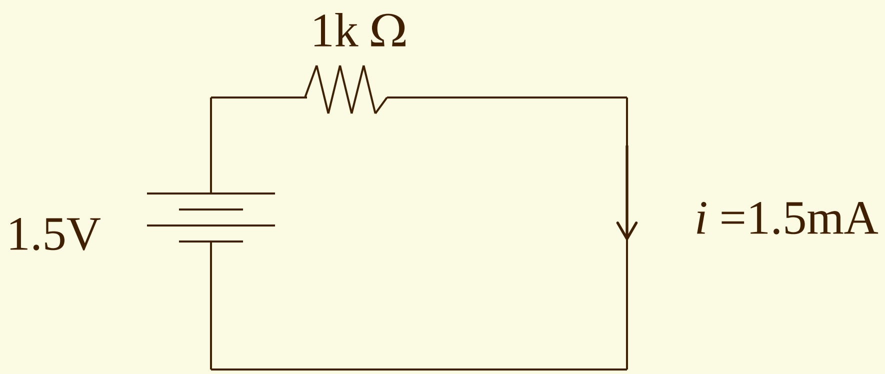
5A Current flows from A to B. What is the value of current i?



Power and Energy

- Power = work/time = work/charge * charge/time
  = voltage * current

- P = VI

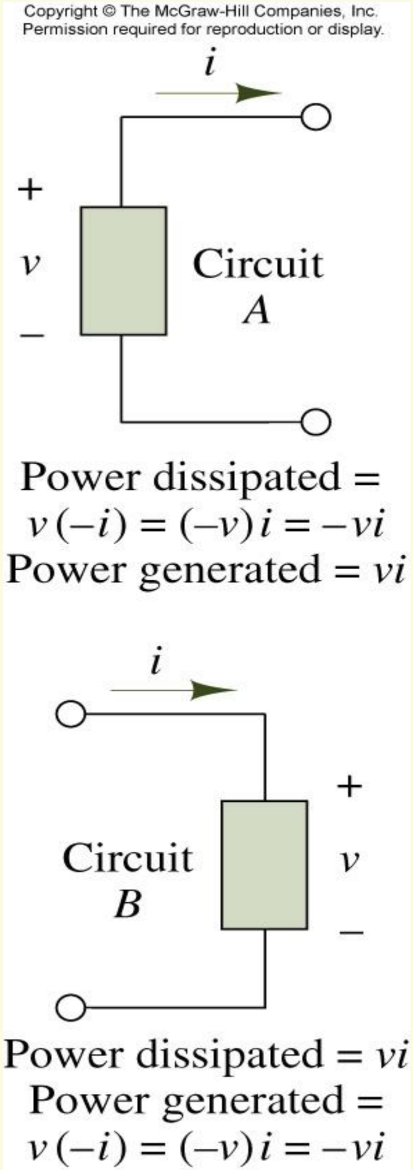


Power consumed by the resistor: 2.25 mW

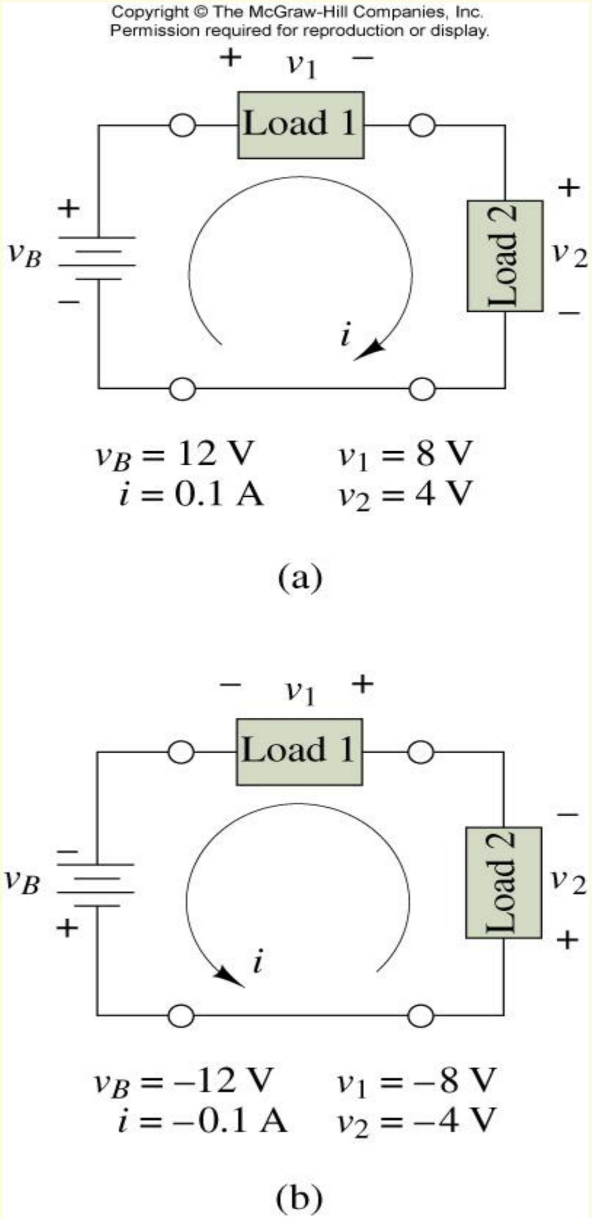
Power consumed by the battery? -2.25 mW

$$\text{Energy} = \int \text{power}\, dt$$

The passive sign convention

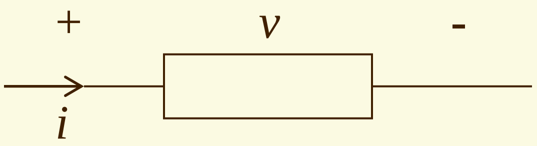


Find power dissipated by each element



i – v characteristics

- Generalized circuit element

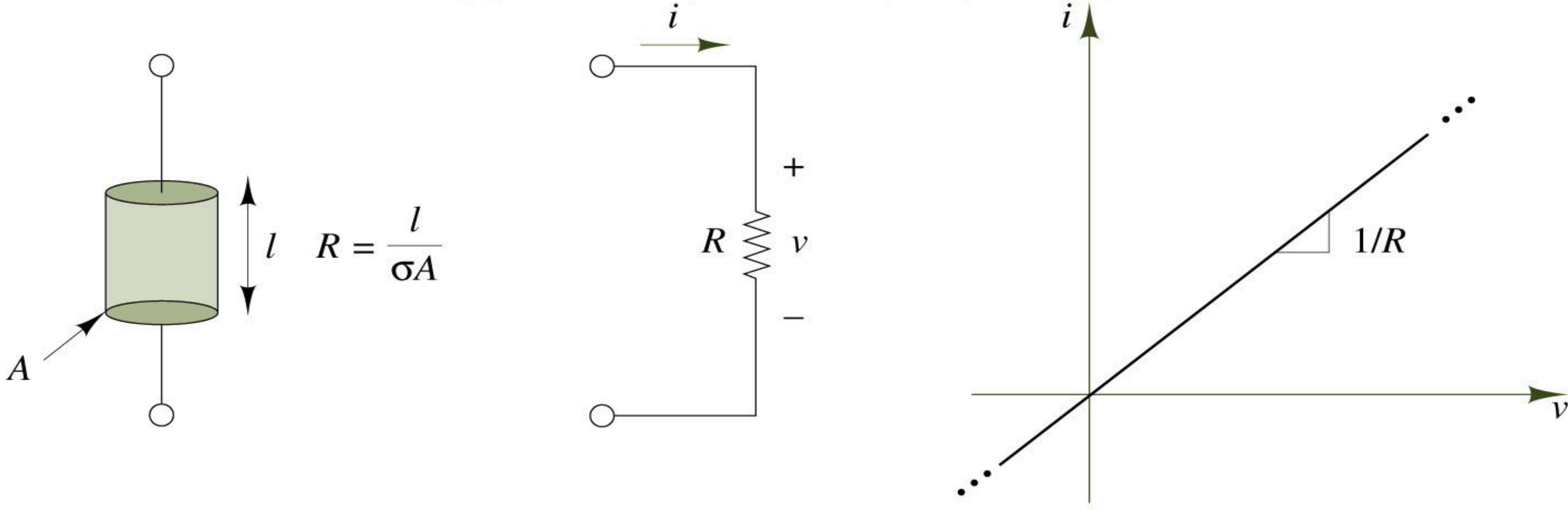


Resistor: $i = f(v)$, $v = g(i)$

In general, $F(v,i,t) = 0$

- i-v characteristics
  - Voltage source
  - Current source

The resistance element: Ohm's law



Physical resistors with resistance *R*. Typical materials are carbon, metal film.

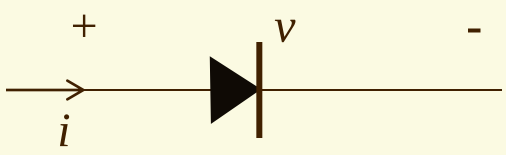
Circuit symbol

i-*v* characteristic

Conductance = 1 / resistance

P = VI

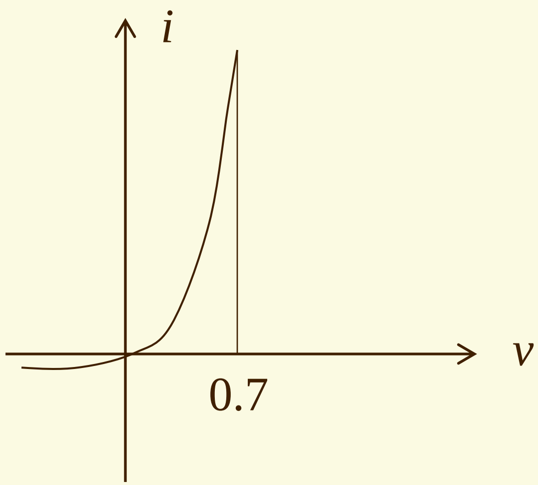
Diode: non-linear resistor



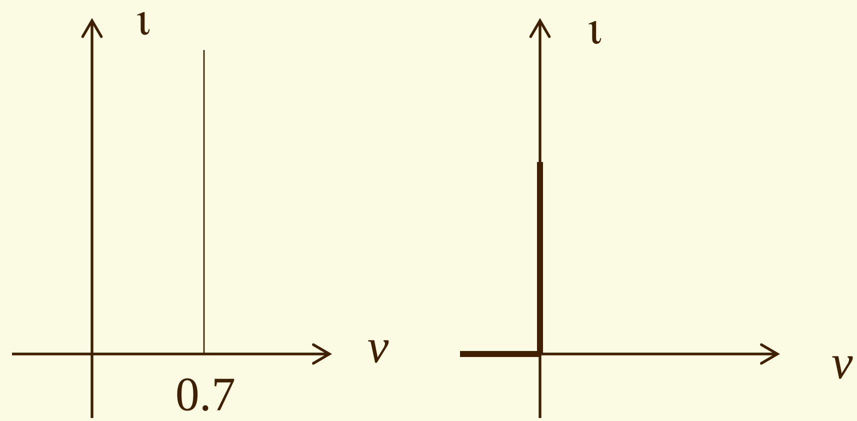
(a) Diode circuit symbol

$$i = I_0(e^{\frac{v}{V_T}} - 1)$$

(b) Characteristic equation



(c) i-v characteristic



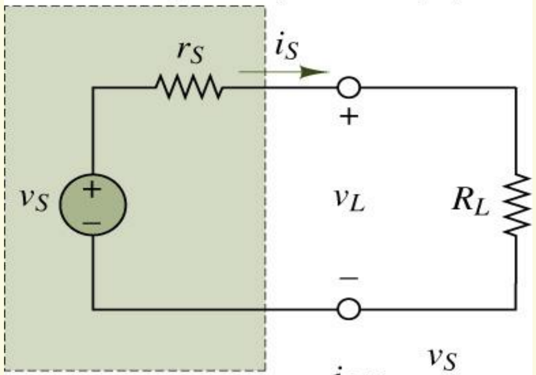
(d) simplified i-v characteristic

Open and short circuits

- Open circuit

- Short circuit

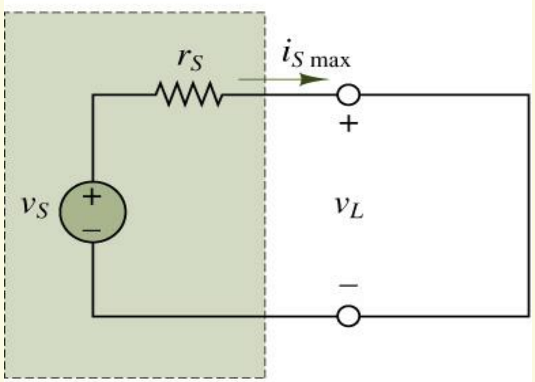
Practical voltage source



Practical voltage source

$$i_S = \frac{v_S}{r_S + R_L}$$

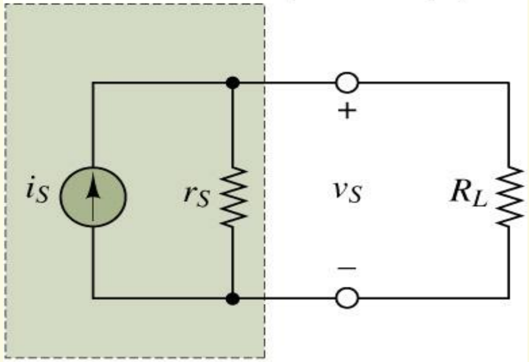
$$\lim_{R_L \to 0} i_S = \frac{v_S}{r_S}$$



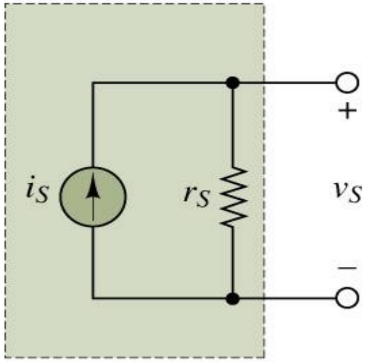
The maximum (short circuit) current which can be supplied by a practical voltage source is

$$i_{S\,\max} = \frac{v_S}{r_S}$$

Practical current source



A model for practical current sources consists of an ideal source in *parallel* with an internal resistance.

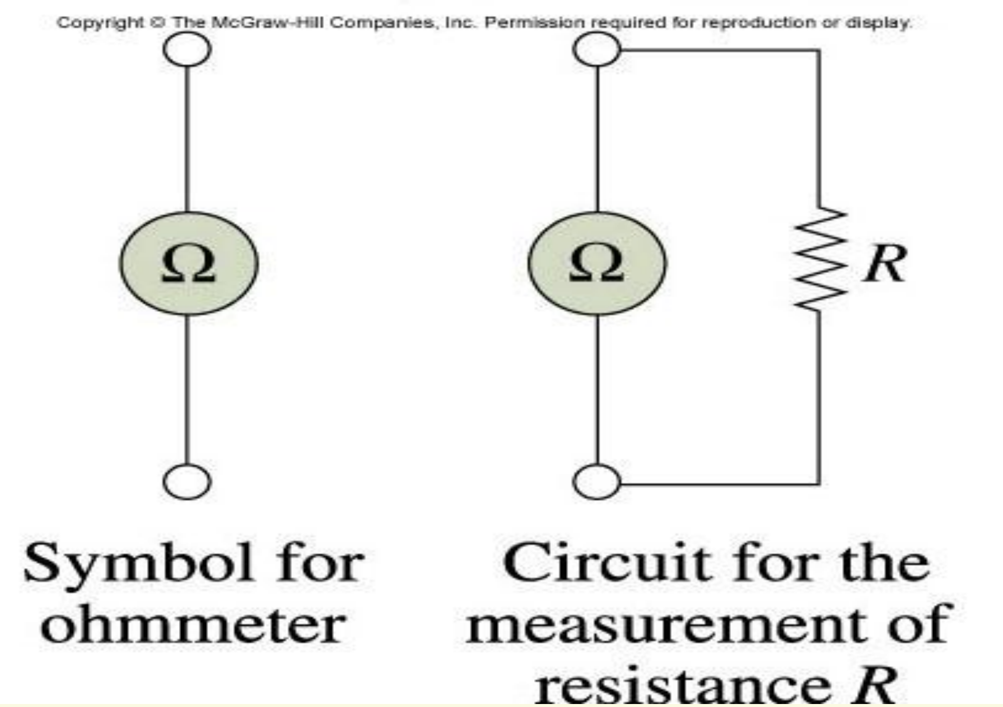


Maximum output voltage for practical current source with open-circuit load:

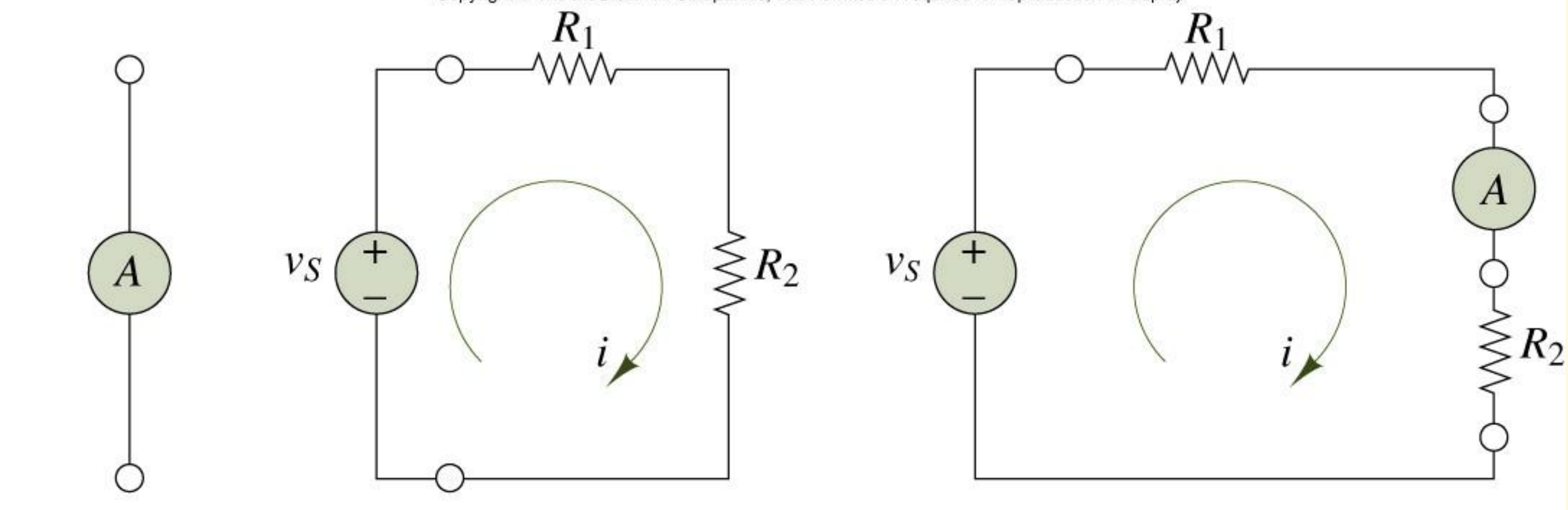
$$v_{S\,\max} = i_S r_S$$

Ohmmeter and measurement of resistance

Figure 2.48



Measurement of current

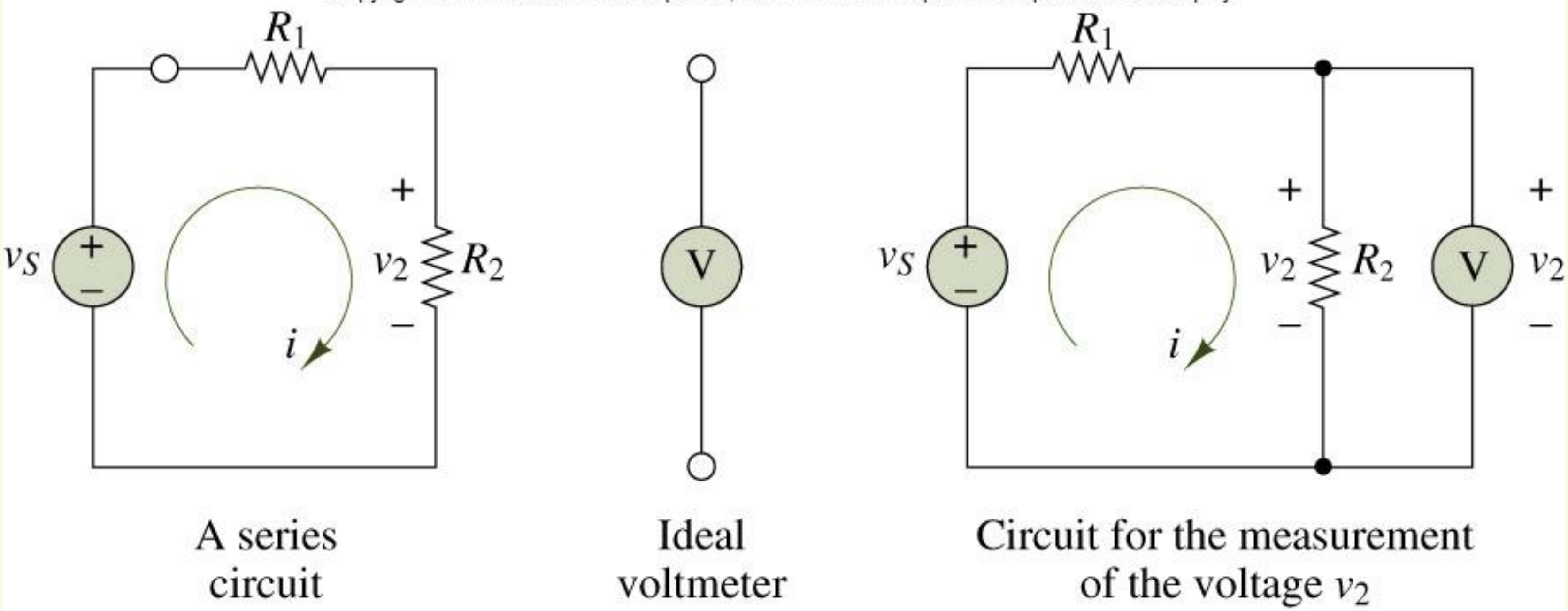


Symbol for ideal ammeter

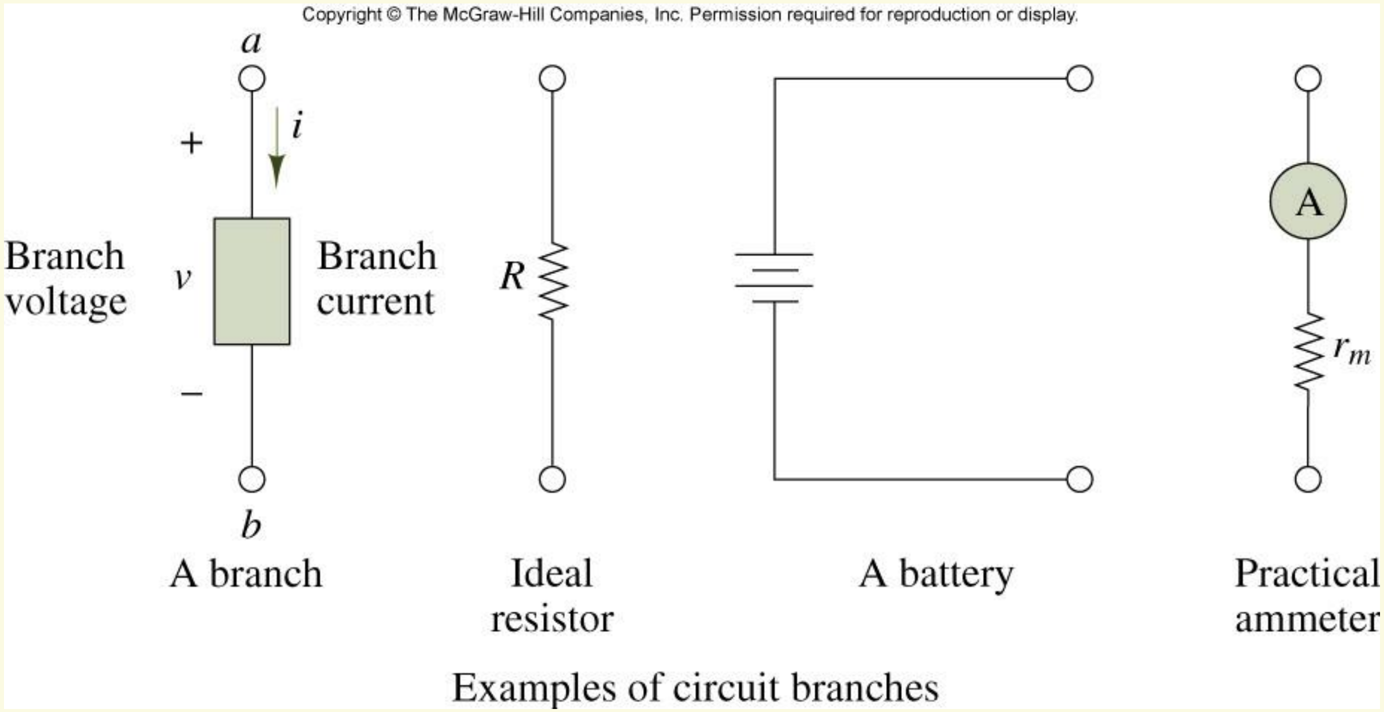
A series circuit

Circuit for the measurement of the current i

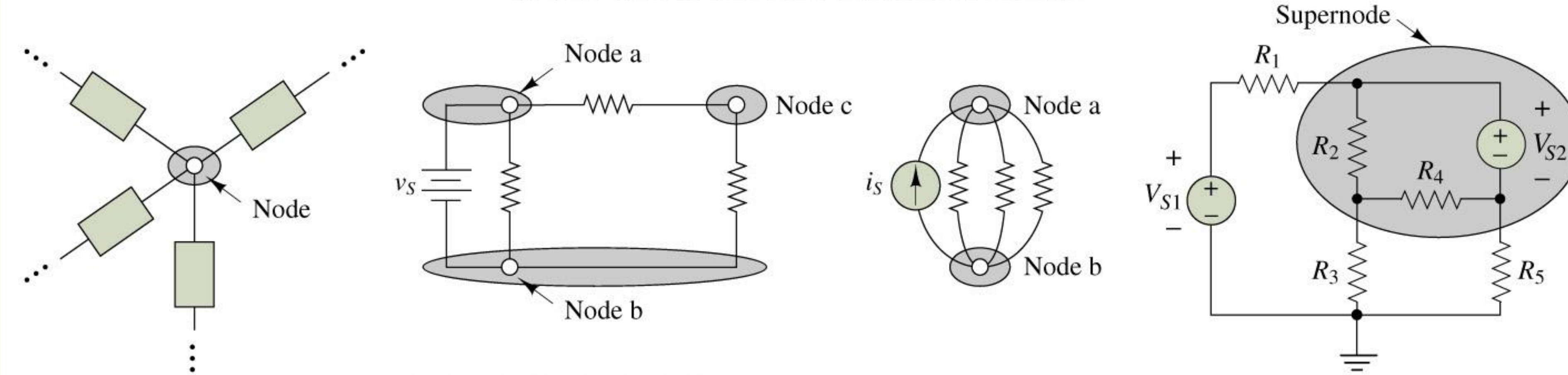
Measurement of voltage



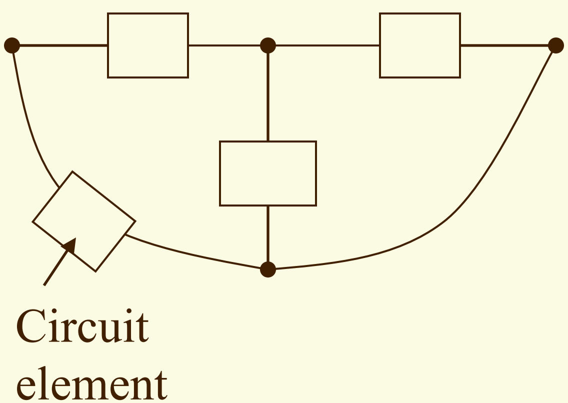
Definition of a branch



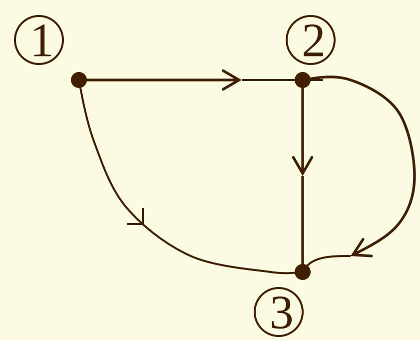
Definitions of node and supernode



Examples of nodes in practical circuits



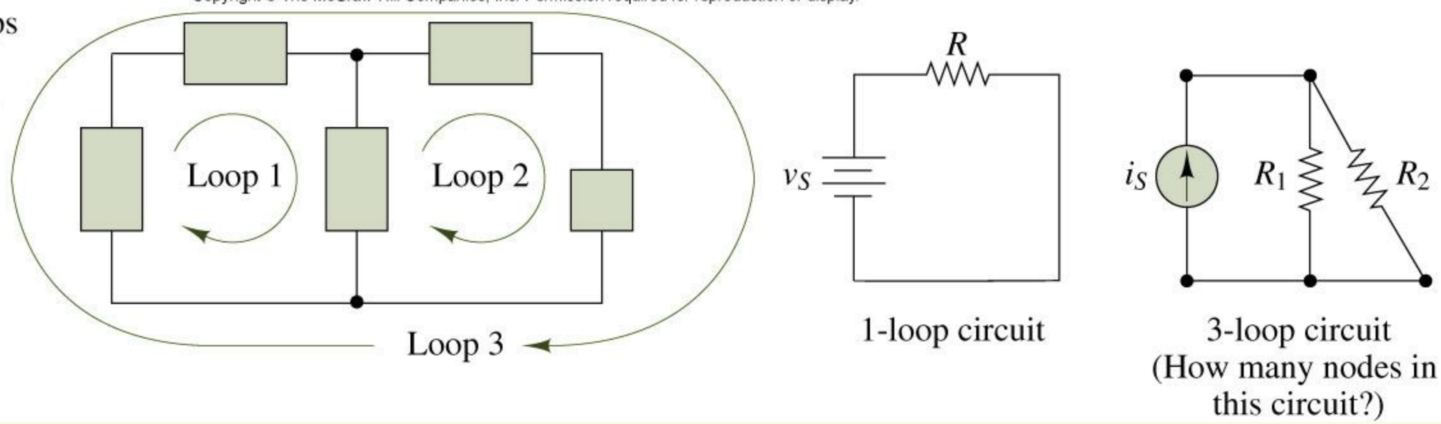
(a)

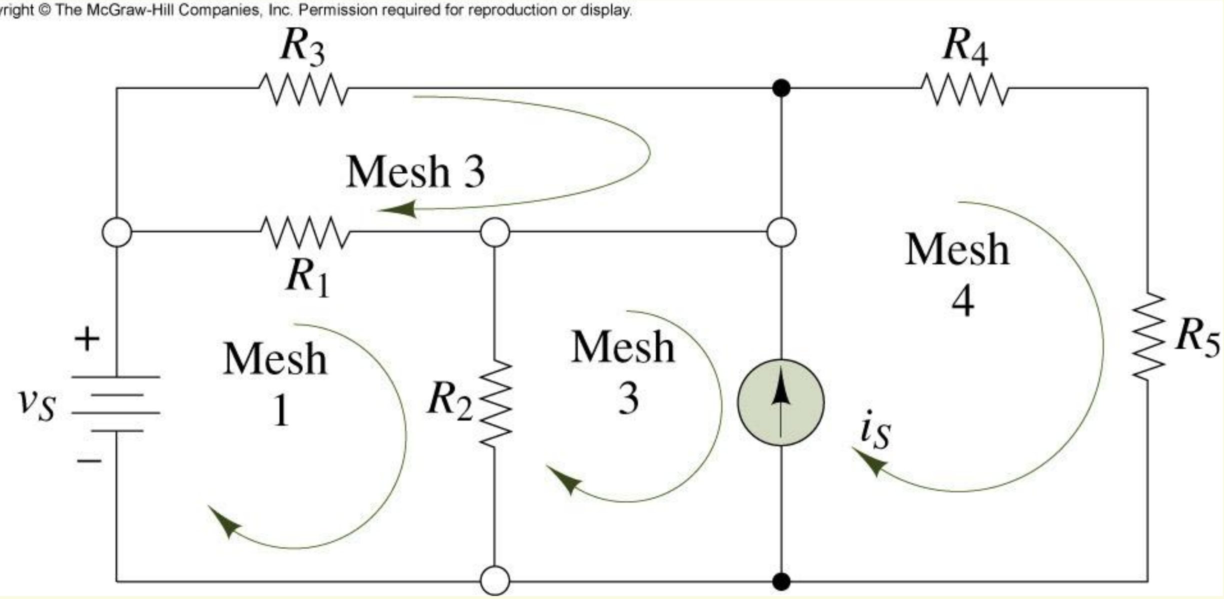


(b)

Definition of a loop and a mesh

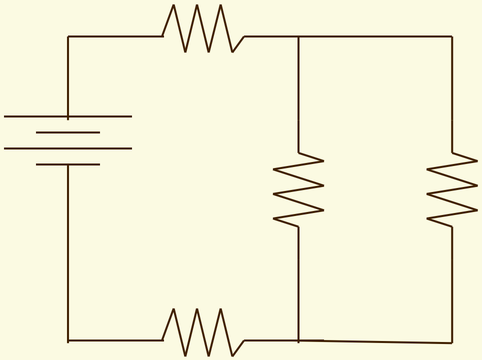
Note how two different loops in the same circuit may include some of the same elements or branches.

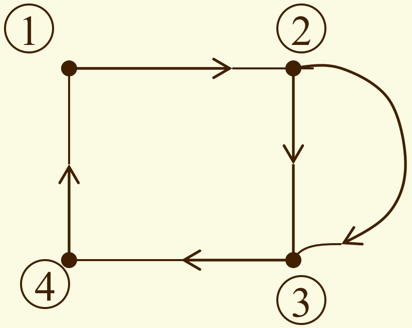




How many loops can you identify in this four-mesh circuit? (Answer: 14)

Draw the directed graph. How many nodes and edges exist?





Conclusion

- Lumped Circuit Abstraction
- Circuit Elements
- Power and Energy
- Circuit Graph: Branch and Node