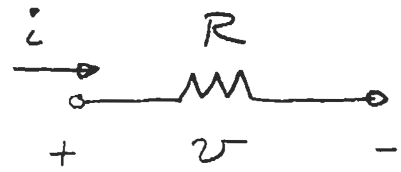
Lecture 52 9/11/00

<u>From last time:</u>



The constitutive relation is

$v = iR$ "Ohm's law"

Why do we choose the sign convention this way?

If $v > 0$...

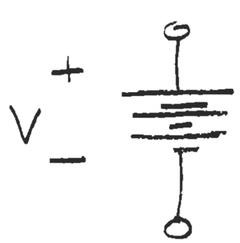
+ terminal is at higher potential than − terminal, so...

+ charges move toward lower potential, − charges move toward higher potential, so...

current is + if drawn as shown.

Why is Ohm's law linear? Cannot easily derive — it's an experimentally observed fact about many materials.

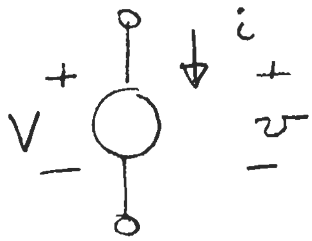
The battery symbol is



What is the constitutive relation for a battery?

(Will say more later...)

The Voltage Source



Constitutive relation:

$$v = V \text{ for all } i$$

Is this a good model for a battery?

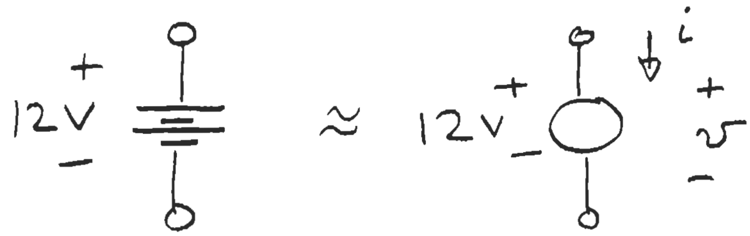
[Do Battery Model concept test here]

Sometimes, a voltage source is a good model for a battery, sometimes it is not, depending on the current draw and the length of time it is used.

[Do Model Definition turn-to-partner exercize.]

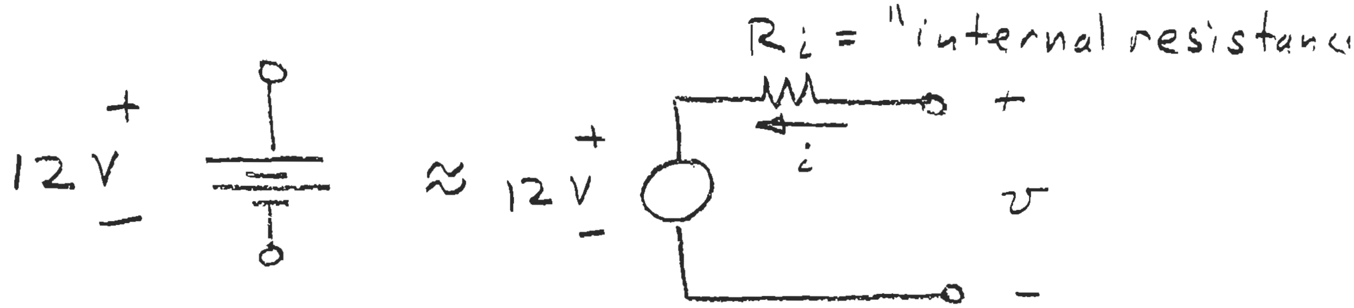
<u>Example</u> Models of a battery

<u>Case 1</u> Current is low enough that battery voltage is nearly constant. Then the model is



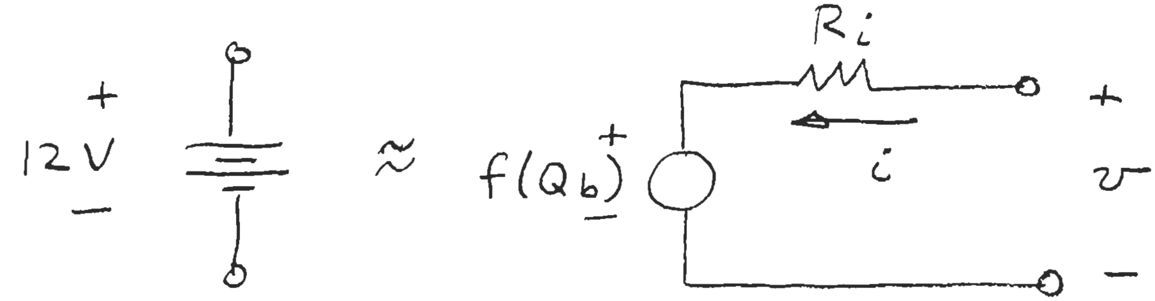
$$v = 12 \text{ volt}$$

Case 2 Current is significant enough that voltage varies due to current flow.



$$\Rightarrow \quad v = 12V + i R_i$$

Case 3 As in case 3, but battery runs long enough to be discharged, so voltage drops over time



$$v = f(Q_b) + i R_i$$

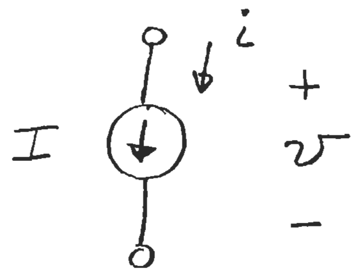
Q_b = battery charge

$$= Q_i + \int_0^t i \, dt$$

↑ initial charge

R_i might also be a function of Q_b.

The Current Source



Constitutive relation:

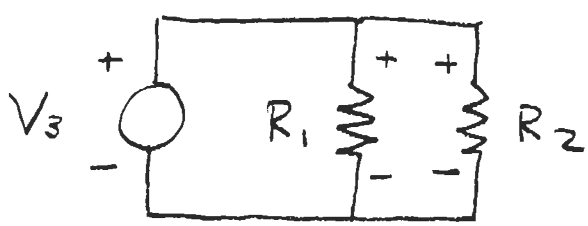
$i = I$ for all v

Current sources are useful idealizations of circuits that produce a nearly constant current for a range of loads. They are often seen in transistor amplifier circuits.

Solving networks

By "solving," we mean finding all the branch currents and branch voltages in the circuit.

Simple example:



"Parallel" resistors

Find $v_1, v_2, v_3, i_1, i_2, i_3$:

$$v_1 = v_2 = v_3 = V_3 \quad \text{(why?)} \quad (1)$$

$$i_1 = \frac{v_1}{R_1} = \frac{V_3}{R_1} \quad \text{(constitutive relation for } R_1\text{)}$$

$$i_2 = \frac{v_2}{R_2} = \frac{V_3}{R_2} \quad \text{(constitutive relation for } R_2\text{)}$$

$$i_3 + i_1 + i_2 = 0 \quad \text{(why?)} \quad (2)$$

$$\Rightarrow i_3 = -\left(\frac{1}{R_1} + \frac{1}{R_2}\right) V_3$$

$$= -\frac{V_3}{R}$$

$$R = R_1 \| R_2 = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{R_1 R_2}{R_1 + R_2}$$

To solve, we used the constitutive relations for the elements, plus <u>Kirchhoff's laws</u>

(1) comes from Kirchhoff's Voltage Law (KVL)

(2) comes from Kirchhoff's Current Law (KCL)