~~I was on page 849~~

Electric Circuits

SI units

m - meter
A - ampere (s)
kg - kilograms
K - kelvin
s - seconds
cd - candela

Symbols Electrical Engineers use

Quantity	Symbol	Unit
Time →	t →	s
Frequency →	f →	s^{-1}
Radian frequency →	$\omega = 2\pi f$ →	$rad\,s^{-1}$
Energy →	W →	J
Power →	P →	W (J/s)
Charge →	q →	C

Voltage $\longrightarrow$ V ——— V

<u>Current</u>

$$q(t) = C$$

unit for current ~ A $\left(\frac{C}{s}\right)$

How do we find current from the charge expression?

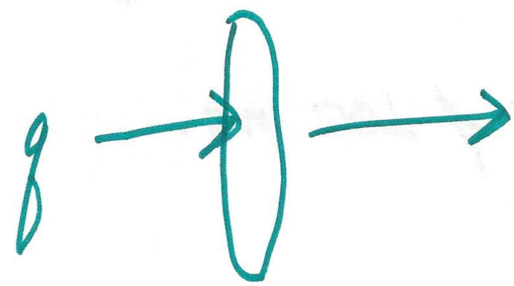
recall from Physics I,

<u>$m(t)$</u> $\qquad v$?

$$v = \frac{m}{s} = \frac{d}{dt} m(t)$$

$$a = \frac{d^2}{dt^2} m(t) = \frac{m}{s^2} \qquad \underline{i = \frac{d}{dt} q(t)}$$

$1\ C/s = 1\ A$



$$V = \frac{d}{dq} W(q) = J/C$$

$1\ J/C = 1\ V$ work done per charge unit

power:

$$P = \frac{d}{dt} W(t) = \frac{dw}{dq}\frac{dq}{dt} = (v)(i)$$

$$W_T = \int_{t=0}^{t_0} p\,dt$$

Example

The current thru a circuit element is 50mA.
find the total charge and the number of electrons transferred during a period of 100 ns.

$$i = \frac{d}{dt} q(t)$$

$$q_T = \int_0^{10^{-7}} 50\times10^{-3}\, dt = 50\times10^{-10}\ C = 5\,nC$$

$$q_{e^-} = \cancel{6.25\times10^{18}}\ C$$

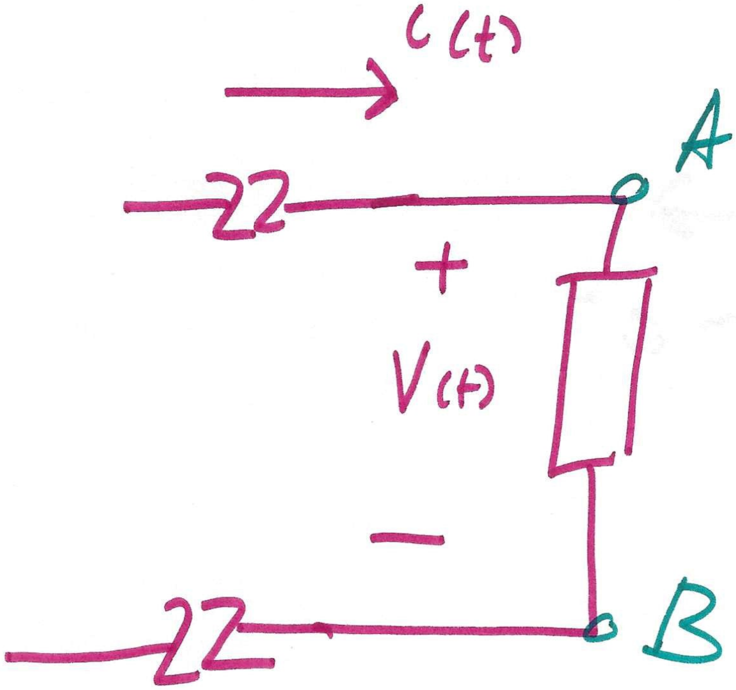
$$\rightarrow \quad 5\times10^{-9}(6.25\times10^{18}) = 31.25\times10^{8}\ e^-$$

$$q_{e^-} = \_\_\_\_\_\_\ C$$

$$\frac{5\,nC}{q_{e^-}} = 5nC\left[\frac{1}{q_{e^-}}\right]$$

Passive Sign Convention

we usually don't deal with charge and energy but voltage, current, and Power



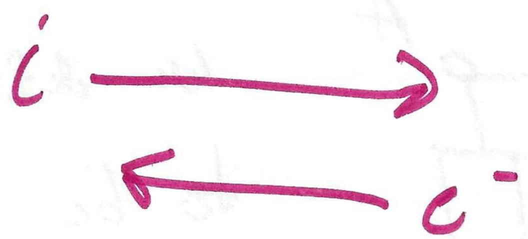
We define this to be passive sign convention!

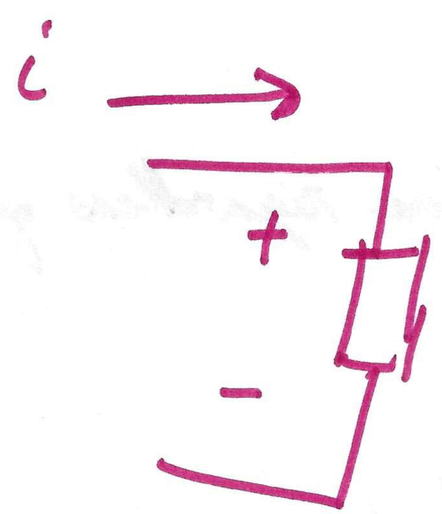
The physical phenomenon happens regardless of the assigned polarity

if $i > 0$, i flows into A from Left to Right

if $i < 0$, i flows from A, from Right to Left

In summary, the algebraic sign of the answer together with arbitrarily assigned reference marks tells us the actual direction of a voltage or current variable





Passive sign convention

$p(t) > 0$ when the device absorbs power

$p(t) < 0$ device delivers power

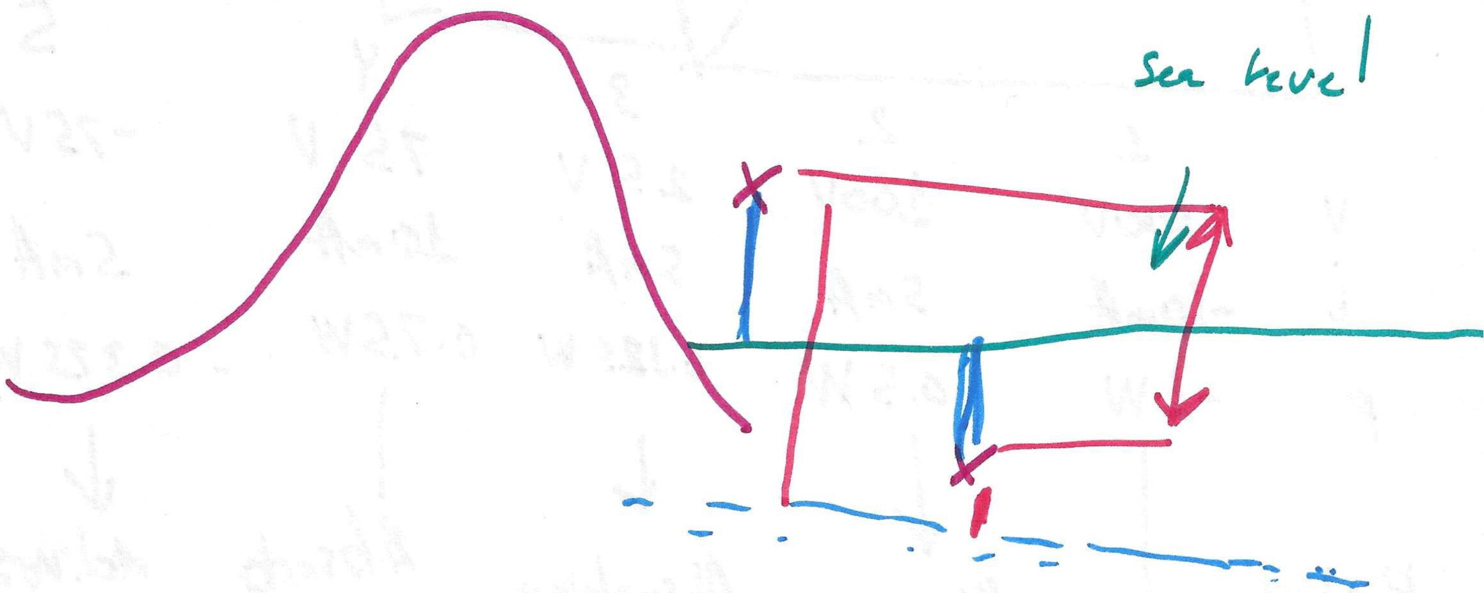
For battery S

$p(t) > 0$, battery is being charged

$p(t) < 0$, battery is being discharged.

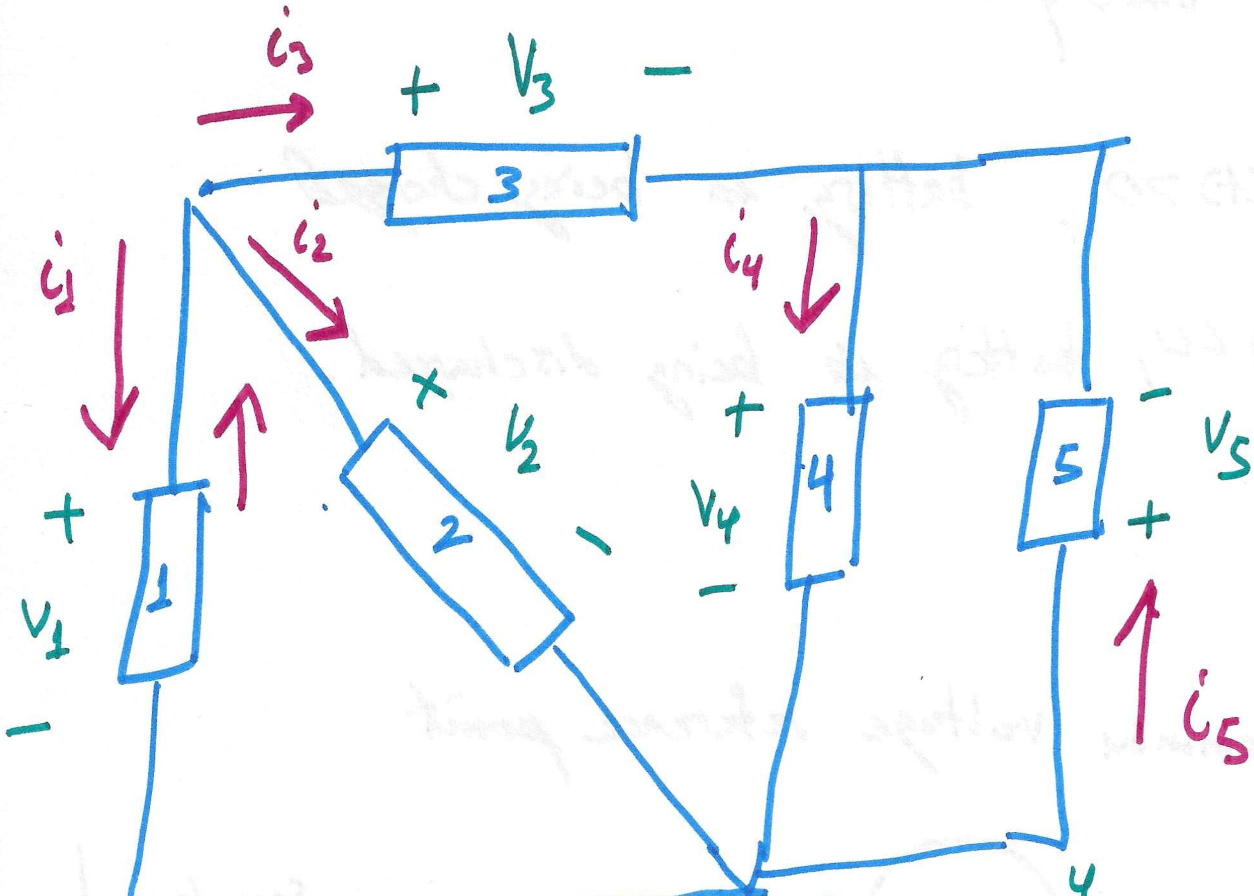
Ground

- Common voltage reference point



~~Sea~~ Sea Level is a assigned Ground

$P = VI$



	1	2	3	4	5
V	100V	100V	25 V	75 V	−75V
i	−10mA	5mA	5mA	10mA	5mA
P	−1W	0.5W	0.125W	0.75W	−0.375W
	delivers	Absorb	Absorbing Power	Absorb	delivers

$P = VI$

As your can see, total Power is zero!

For Linear Circuits Total Power will Always be zero!

2-1 Element Constraints!

A two terminal device is described by an <u>i-v characteristic</u>

→ The relationship between Voltage and current in the device

A circuit element is a model of a real world device!

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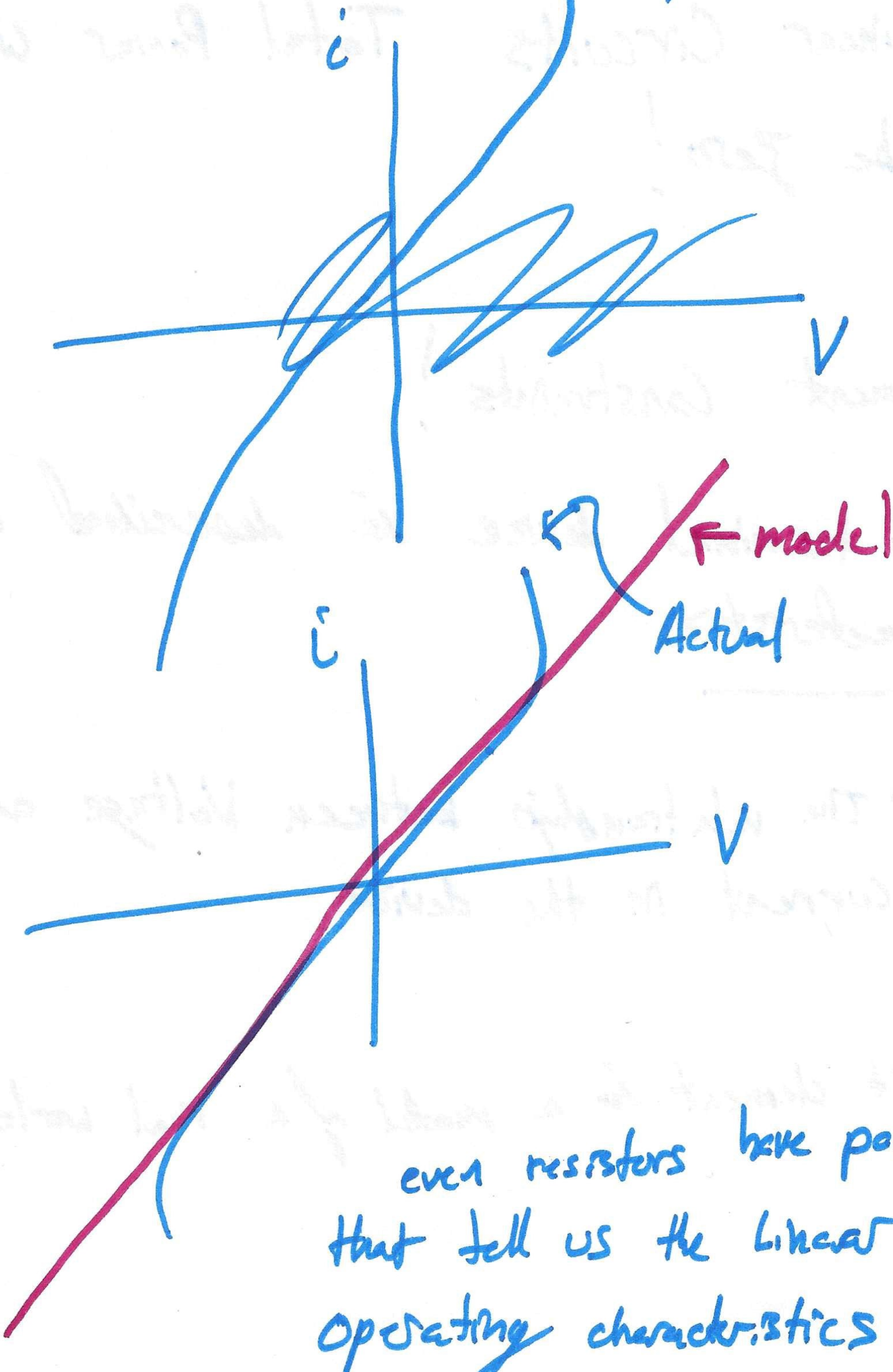
The Linear Resistor

The actual I-V characteristic of a resistor



even resistors have power ratings that tell us the linear range of its operating characteristics

$V = iR$ or $i = GV$ Ohm's

$G = \frac{1}{R}$ R - resistance Ω

G - conductance $\Omega^{-1} = S$

Siemans

mho ℧

Ohm's Law presumes that the passive sign convention is used to assign the reference marks to voltage and current.

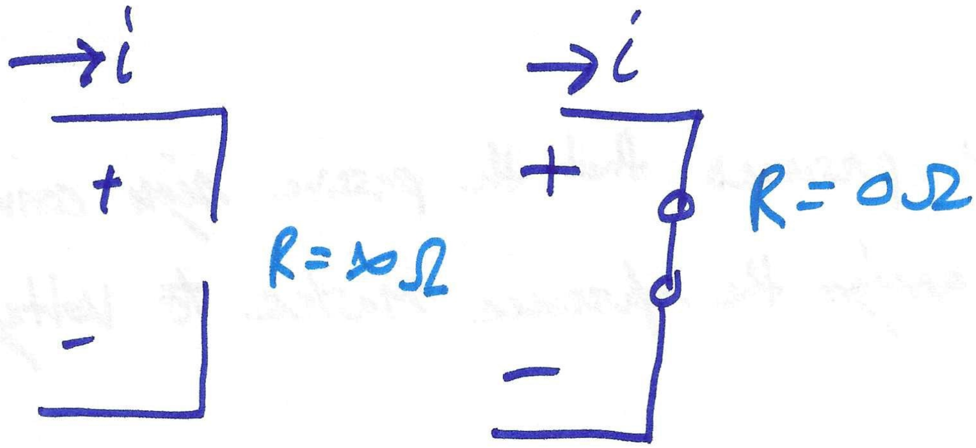
I-V characteristic for the Ohm's Law model says the circuit element is Linear and Bilateral

i-V curve has odd symmetry about the origin

→ A curve $i = f(v)$ has odd symmetry if
$$f(-v) = -f(v)$$

Limiting Cases of the Resistor

→ Open and Short Circuits



$V = 10\,V$ $\quad R = 1\,\Omega \rightarrow i = 10\,A$

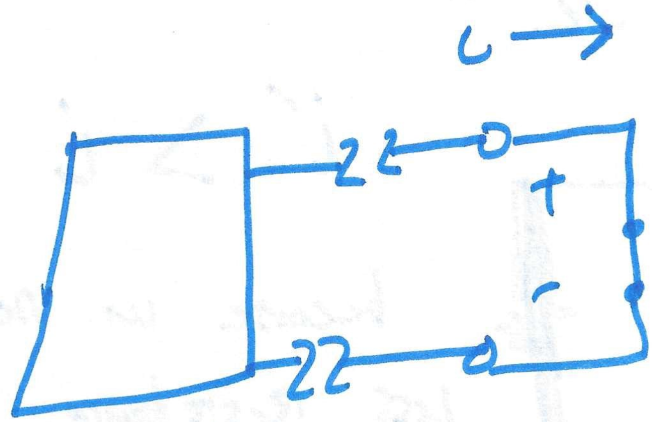
$V = 10\,V$ $\quad R = 100\,\Omega \rightarrow i = 0.1\,A$

$V = 10\,V$ $\quad R = 1\,M\Omega \rightarrow i = 10\,\mu A$

$R = \infty\,\Omega \rightarrow i = 0\,A$

What happens to the current and Voltage when $R \to 0$

well $V \to 0$, $V = IR$

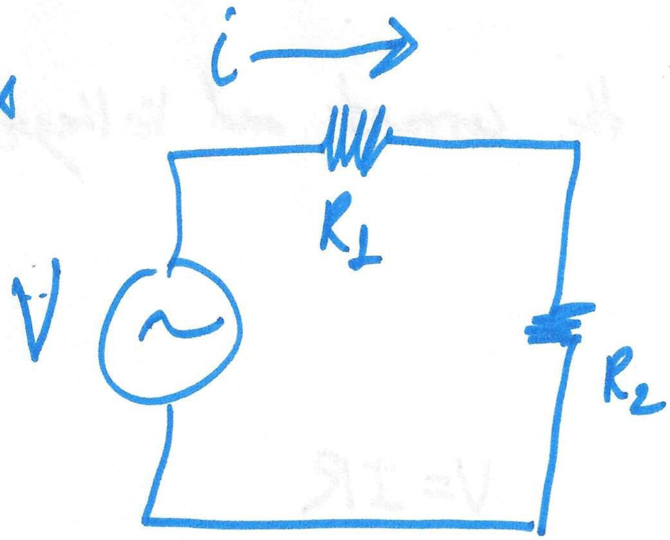


The current i, is supplied by the rest of the circuit,

If we ~~get~~ go from R to 0Ω,

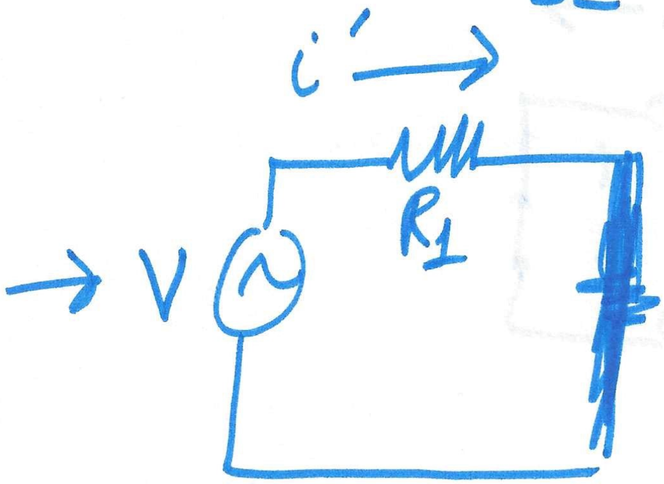
the current is no Longer delivering Power (Energy) to the Resistor as there is no Resistor anymore

Ex



i goes thru both R_1 and R_2

Let $R_2 \to 0\ \Omega$



$i' > i$

because we now have Less Resistance.

$V = IR \to$

In the first case

Power delivered is $P = VI = \cancel{\ } I^2(R_1 + R_2)$

Second case (Less Power delivered)

Power delivered is $P = I^2(R_1 + 0)$