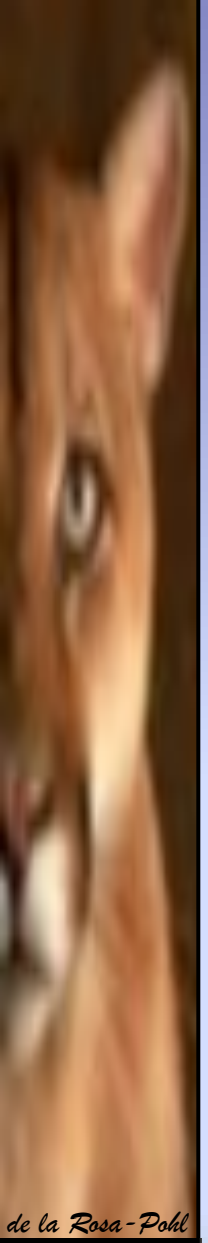

ECE 2300
Circuit Analysis

Circuits Made Easy Part I: Labeling and Ohm's Law

University of Houston
Len Trombetta

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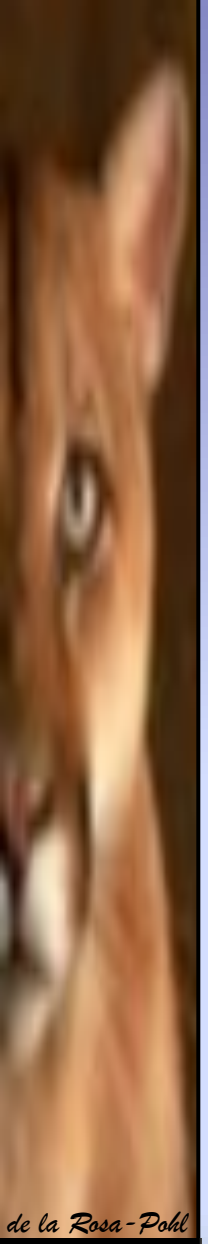

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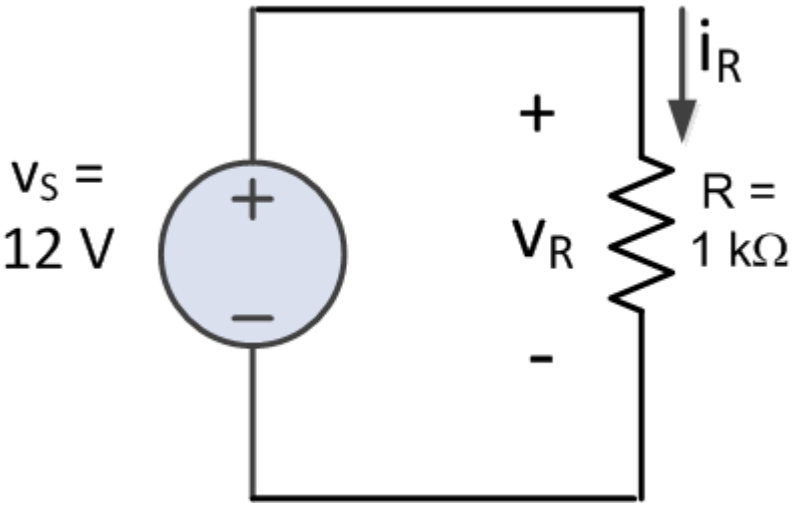
OHM'S LAW

Ohm's Law



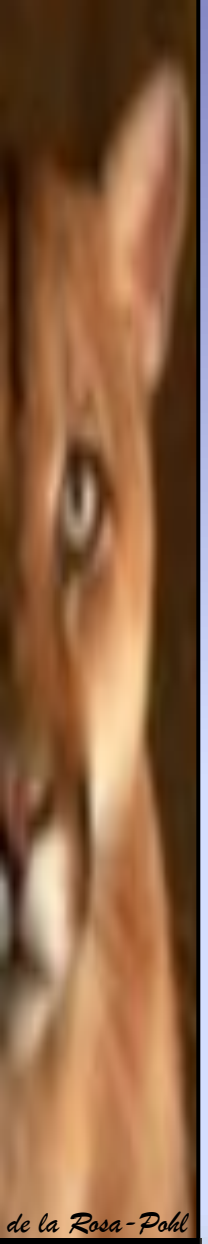
Ohm's Law gives the relationship between the voltage and the current for a resisotr…

$$v_R = i_R R$$

…but there are some details we need to worry about.

Current direction and voltage polarity: how do we know what these are? How did I decide to label them that way? We can of course measure them, but to do circuit analysis we will need to label them on circuit diagrams, even if we don't have a multimeter!

We need to know some labeling conventions…



VOLTAGE AND CURRENT LABELS

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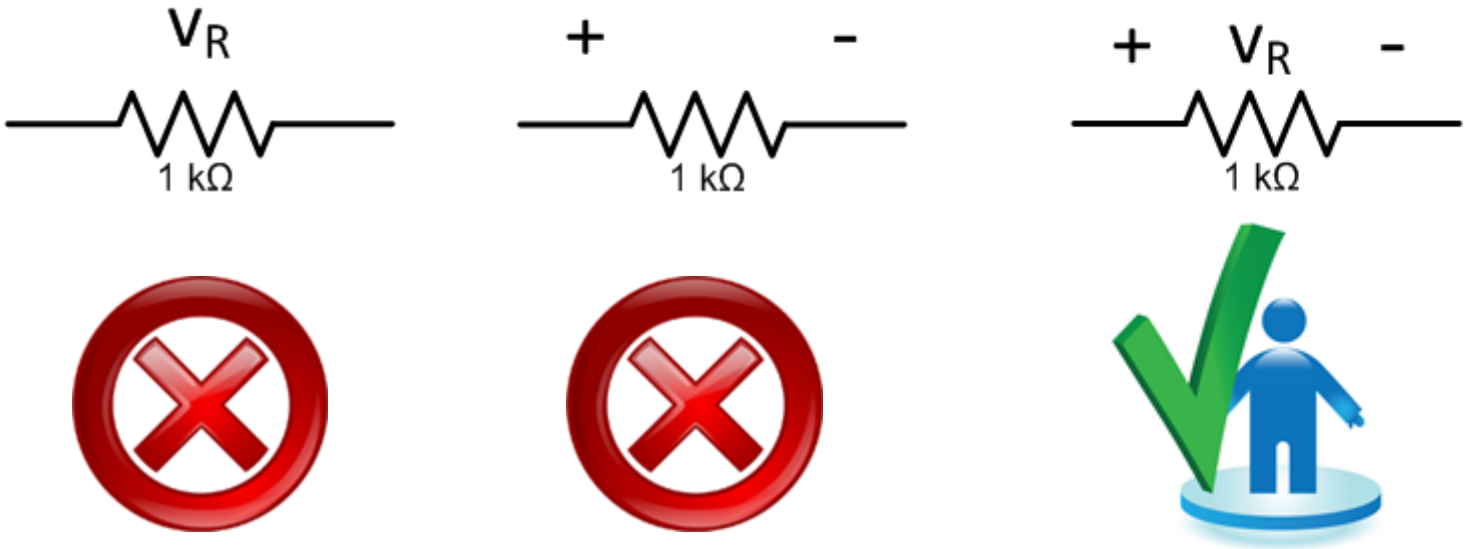
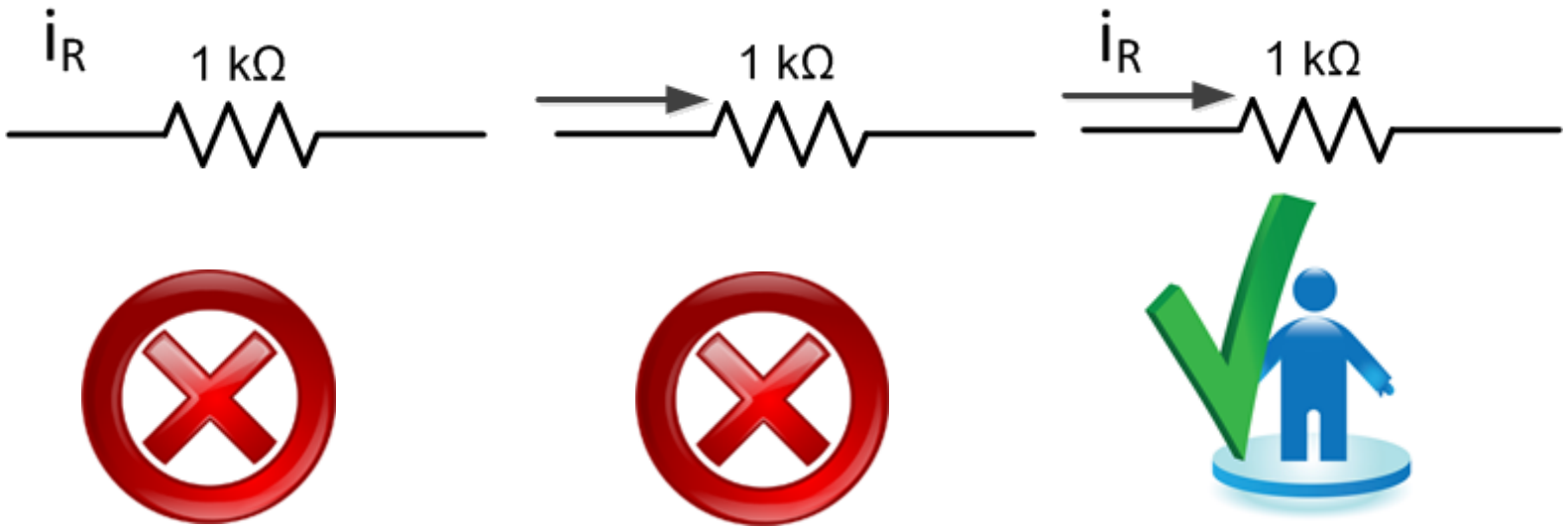
Voltage Label Rules

- Voltage labels get a ‘v’ with a subscript (e.g., v_R), and a ‘+’ and ‘-’.
- A ‘v_R’ without a ‘+’ and a ‘-’ means nothing.
- A ‘+’ and a ‘-’ without a ‘v_R’ mean nothing.



Current Label Rules

- Current labels get an ‘i’ with a subscript (e.g., i_R), and an arrow.
- An ‘i_R’ without an arrow means nothing.
- An arrow without an ‘i_R’ means nothing.



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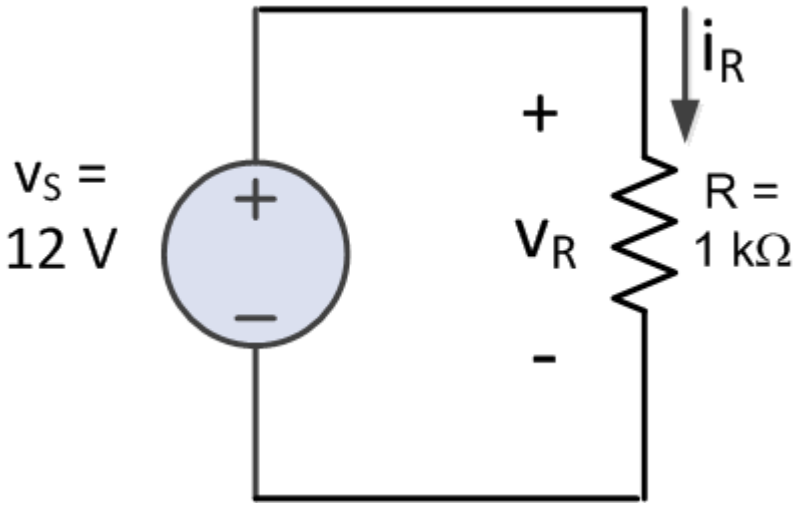
Voltage and Current Labels



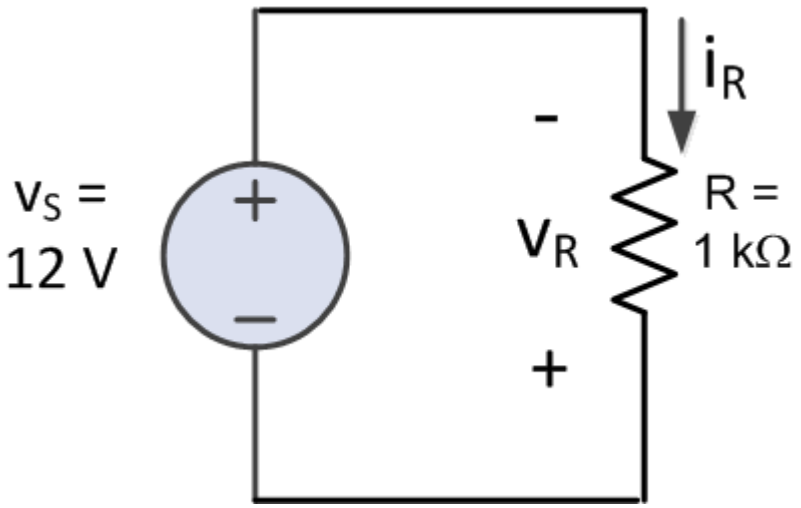
You can probably see that v_R = 12 V.

We could easily prove this using KVL (which we will do later).

We also have Ohm's Law: $v_R = i_R R$

…which means that (by Ohm's Law) i_R = 12 mA

Voltage and Current Labels



NOW what's v_R??
v_R = -12 V.

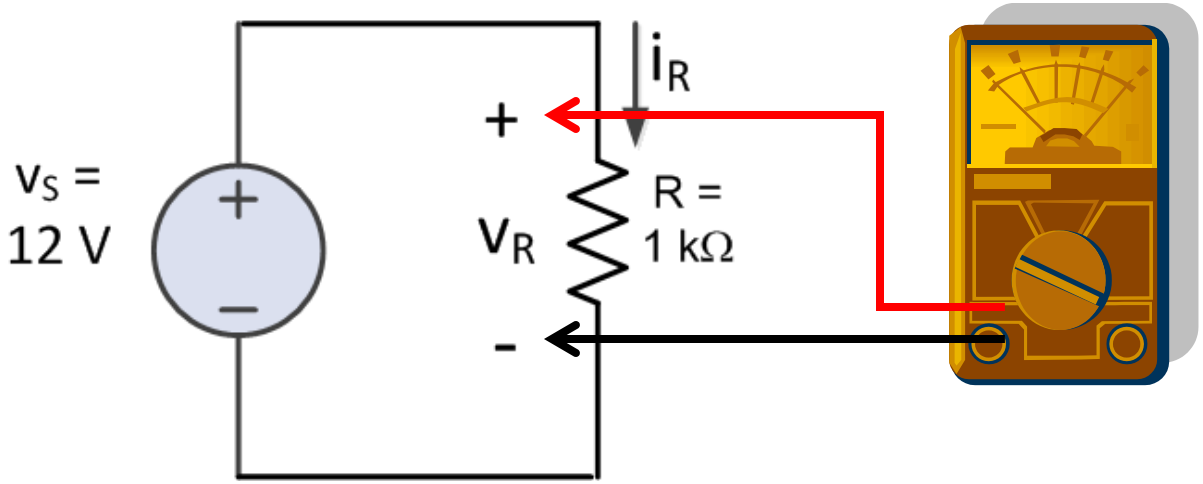
Again, we could prove this using KVL.

Q: Does it matter that I changed the label showing the voltage polarity?

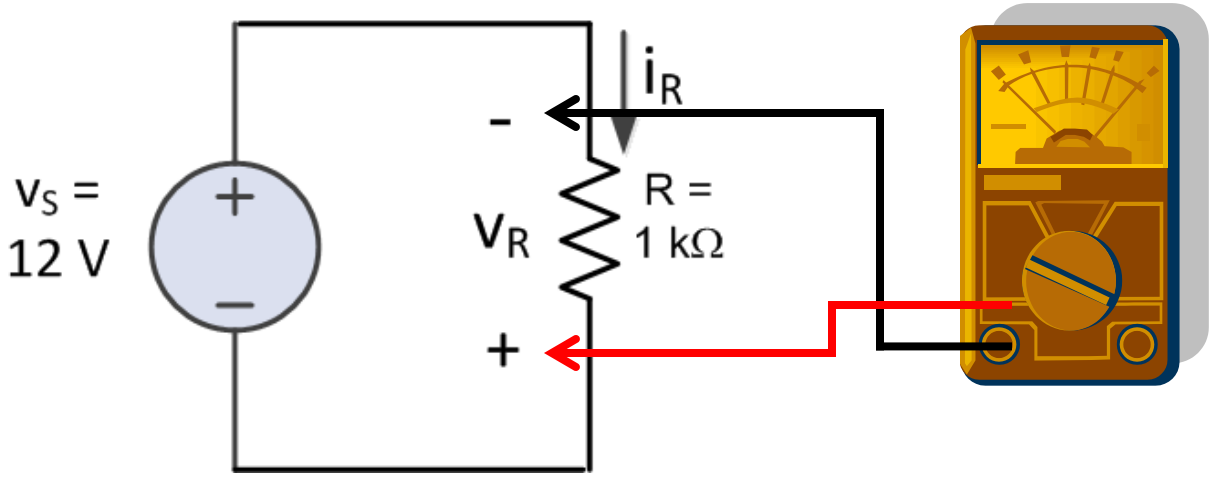
A: No. I can label the voltage polarity any way I like (well, there are only two choices, after all).

Voltage and Current Labels

If you find this strange or confusing, think about this: you already knew it!!



With RED at the top, you were measuring the voltage drop from top to bottom.



With RED at the bottom, you were measuring the voltage drop from bottom to top.

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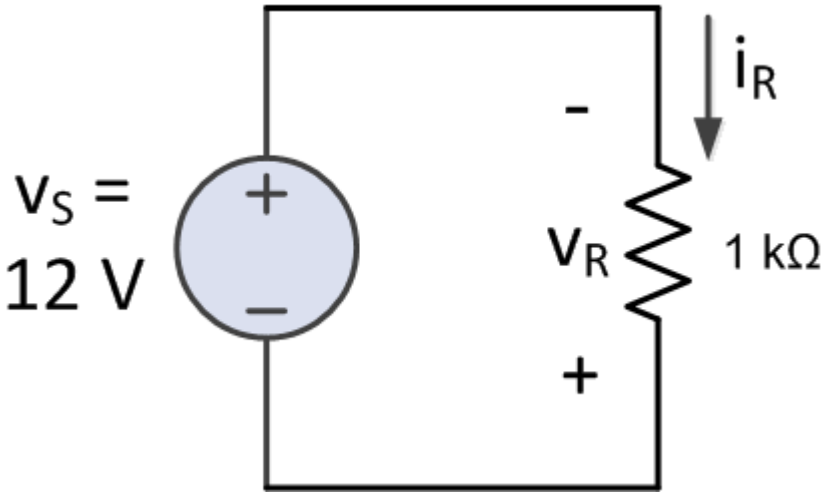
Voltage and Current Labels



We have
v_R = -12 V

So…what about the current?

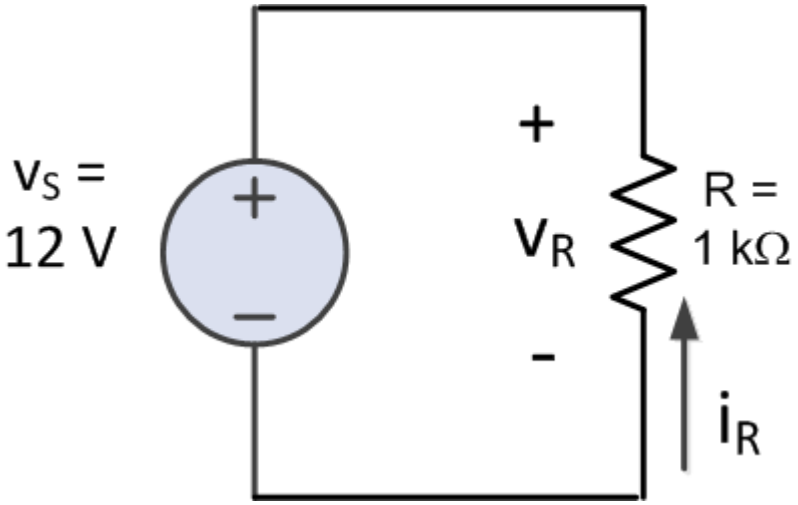
All we did was change a label - the circuit is exactly the same…

…which means i_R must still be = 12 mA

…which means that the correct form of Ohm's Law here is…

$$v_R = -i_R R$$

Voltage and Current Labels



Back to the first drawing with v_R = 12 V.

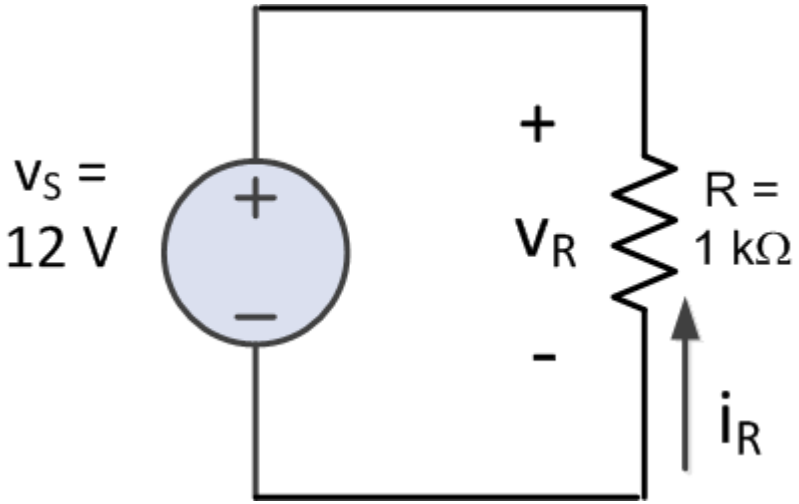
…but with the current direction changed.

Q: Does it matter that I changed the label showing the current direction?

A: No. I can label the current any way I like (well, there are only two choices, after all).

So…what is the current?

Voltage and Current Labels



We have again v_R = 12 V…

So…what about the current?

All we did was change a label - the circuit is exactly the same…

…which means i_R must be = -12 mA

…which again means that the correct form of Ohm's Law here is…

$$v_R = -i_R R$$

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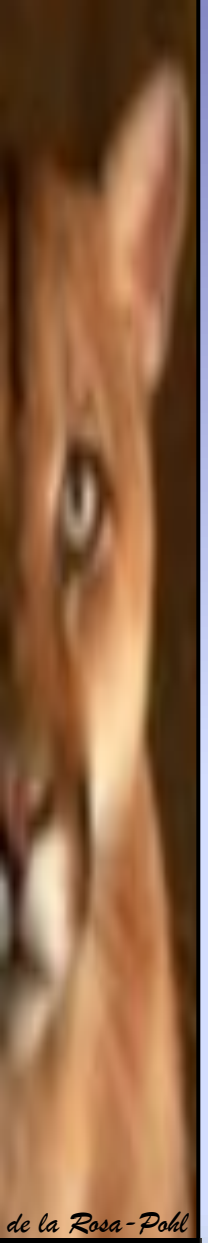

OHM'S LAW REVISITED

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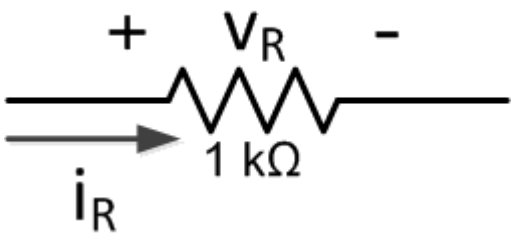
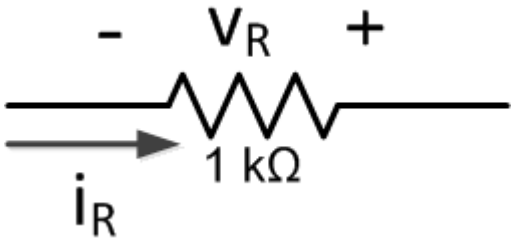
Ohm's Law Revisited

Ohm's Law depends on how we label current and voltage:

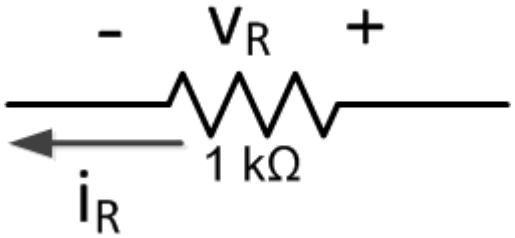


$$v_R = i_R R$$

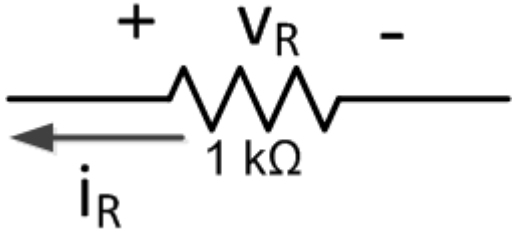


$$v_R = -i_R R$$

These are of course the same things…

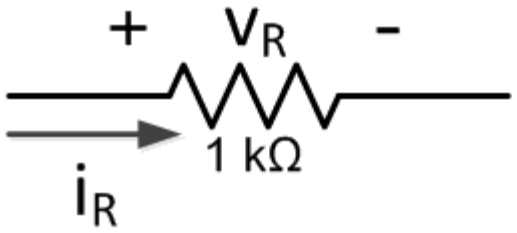


$$v_R = i_R R$$

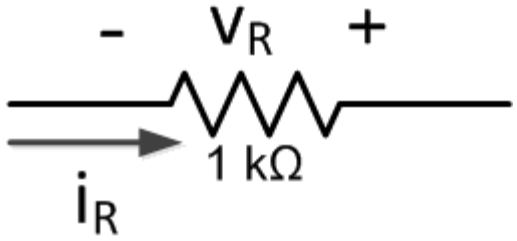


$$v_R = -i_R R$$

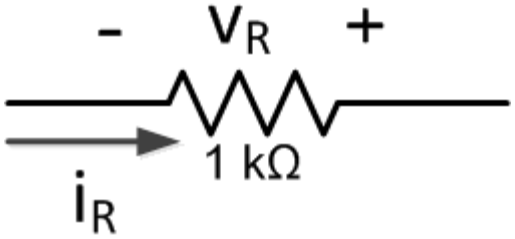
Let's Try Some



$v_R = 7$ V $\quad i_R = ??$

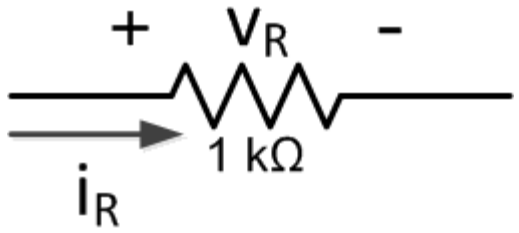


$v_R = 120$ V $\quad i_R = ??$

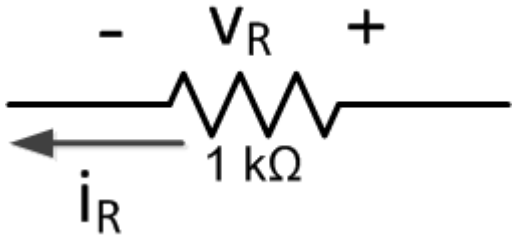


$v_R = -120$ V $\quad i_R = ??$

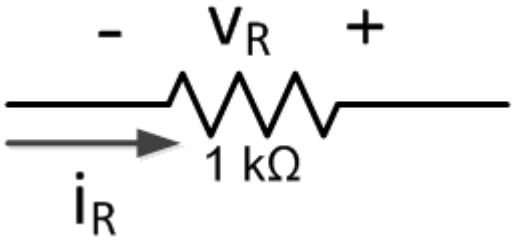
Let's Try Some



i_R = 7 mA v_R = ??



i_R = -12 mA v_R = ??



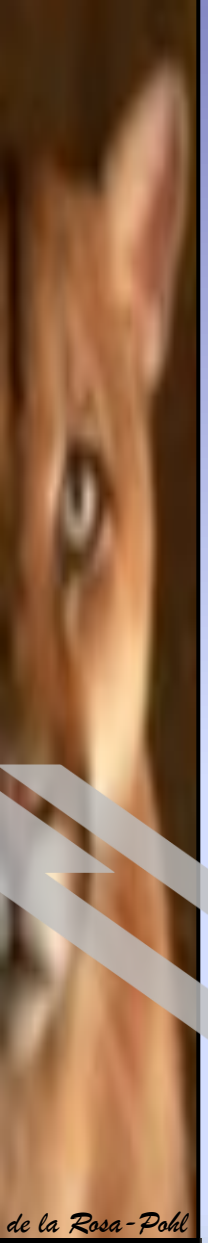
i_R = 50 mA v_R = ??

Actual vs. Reference Polarity

Because of this, we distinguish between:

Reference Polarity or Reference Direction: This refers to the polarity we label on a circuit diagram. We are free to put the +/ – in either direction, and to have the arrow point either way. We don't need to know which way the current is going or what the sign of the voltage really is.

Actual Polarity or Actual Direction: This refers to which way the current is really going, and which side of the device really has the higher potential. We do not have to label voltages and polarities with actual directions if we don't feel like it. When we calculate or measure the voltage or current, we will know from the sign whether the actual polarity is the same as the reference polarity we chose.



The End

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