EE215 – FUNDAMENTALS OF ELECTRICAL ENGINEERING

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WEEK 2
SIMPLE RESISTIVE CIRCUITS

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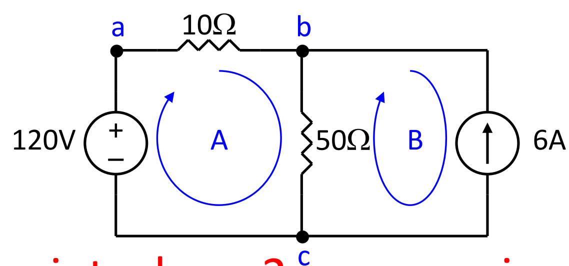
QUESTIONS TO ANSWER

- Kirchoff's Laws
  - What are KVL and KCL?
  - How to apply both laws on an electric circuit?
- Simplifying Resistive Circuits
  - How to simplify circuits using resistors in series and /or in parallel?
- Voltage Division and Current Division
  - How to develop more than one voltage level and current level using the techniques?
  - How to apply the techniques to measure circuit variables and parameters?

KIRCHHOFF'S LAWS



- Def.: <u>Node</u> – a point where 2 or more circuit elements meet. A point of connection.

- Def.: <u>Loop</u> or <u>Closed Path</u> – path that follows circuit elements from node to node until returning to the starting point.

KIRCHHOFF'S CURRENT LAW (KCL)

- A node is just a point - it can't store charge. So charge flowing in to a node must flow out of it. Flow of charge is just current, of course. A clever way to say this is:

- (We could also say the sum of currents flowing out of a node is zero. But we say "into" because a guy named Kirchhoff said into, and got his name on the saying as)

KIRCHHOFF'S CURRENT LAW (KCL)

$$\sum_{\text{Node}} i_j = 0$$

- Examples:
  (a)

  (b)

KIRCHHOFF'S VOLTAGE LAW (KVL)

- The sum of voltages around a closed path is zero.

$$\sum_{\text{Loop}} v_k = 0$$

- Examples:

(a)

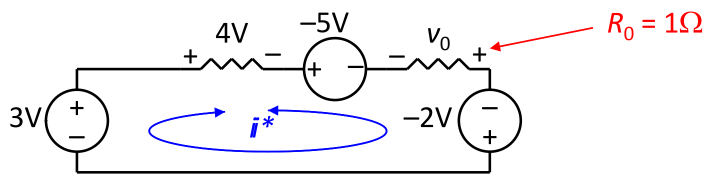
(b) What is v_0 ?

KIRCHHOFF’S VOLTAGE LAW (KVL)

- To deal correctly with polarity:

- IT DOES NOT MATTER WHICH CHOICE YOU MAKE AS LONG AS YOU APPLY IT CONSISTENTLY.

MORE ON THE LAST EXAMPLE

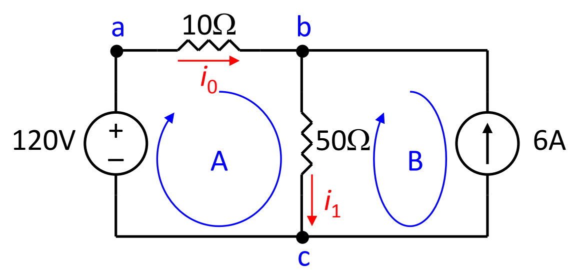


– Going around circuit loop <u>counterclockwise</u>:

– Alternatively, going around the circuit loop <u>clockwise</u>:

BACK TO PREVIOUS EXAMPLE

- Example 2.8:



- KCL at b: (1)
- KVL at cabc: (2)
- With Ohm's Law: (2')
- Two equations, two unknowns (i_0 and i_1):

DEVELOPED / DISSIPATED POWER

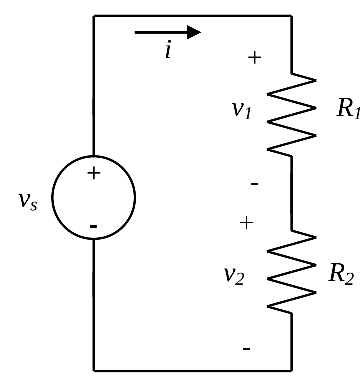
- Power at voltage source:
- Power at current source:
- Power at $R_0 = 10\Omega$ resistor:
- Power at $R_1 = 50\Omega$ resistor:

RESISTORS IN SERIES

- We often find resistors in *series*. (Connected to the same node at one end, and different nodes at opposite ends. Nothing can be connected to the middle node.) The same current flows through both resistors (a basic test for series connection).

RESISTORS IN SERIES

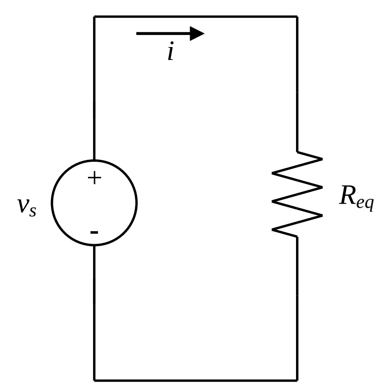
- There are two things that are easy to do when you see a two (or more) resistors in series. They are:



- Note that you can't do both at the same time! If you combine resistors, the node between them goes away!

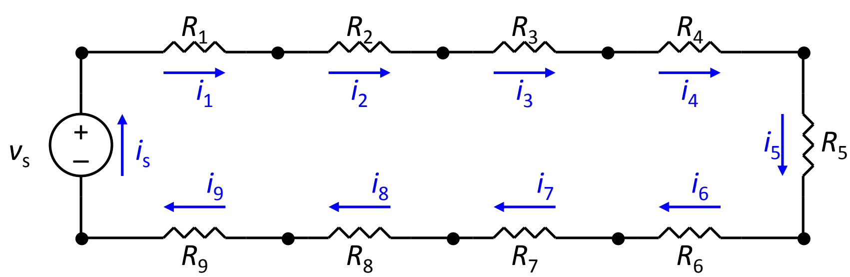
RESISTORS IN SERIES

- Let's do replacement first.
- We want to find R_{eq} such that current i is unchanged, for a given voltage v_s.
- From KVL on the original circuit



RESISTORS IN SERIES

- Example:



- KCL:

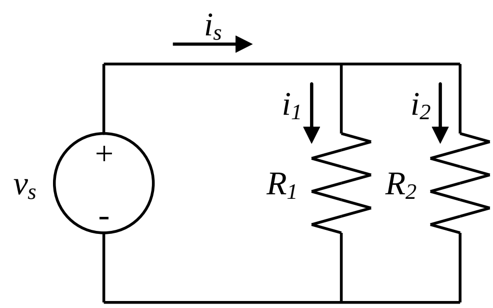
- KVL:

The 9 resistors can be replaced by a single resistor:

-

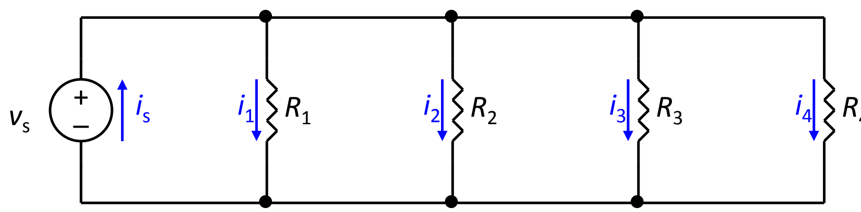
RESISTORS IN PARALLEL

- We often find resistors in parallel - connected to same node at both ends. Voltage across resistors is the same.
- Can we replace?



RESISTORS IN PARALLEL

- Example:



- KCL:
- Ohm's Law:

  So:

  Substitute:

  The 4 resistors can be replaced by a single resistor:

RESISTORS IN PARALLEL

- Special case – 2 resistors:

- Special case – 3 resistors:
  - Is this formula correct?

- Correct formula:

VOLTAGE DIVIDER

- Often, developing more than one voltage level from a single voltage supply is useful.

- Output voltage

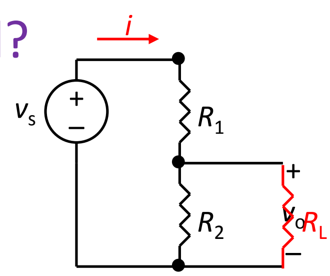
CURRENT DIVIDER

- Similarly to the voltage divider, we can develop various currents from a single current source.

- Or in terms of conductance:

VOLTAGE DIVIDER (2)

- What happens under load?



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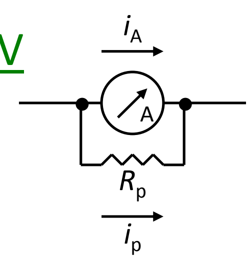
MEASURING VOLTAGE AND CURRENT

- Def.: Ammeter – instrument to measure current.
  - Ideally,
  -

AMMETER

- **Example:**
  - Ammeter with range limit 1mA at 50mV
  - Want full-scale reading of 100mA (expand range 100x)



  - Internal resistance of ammeter
    -
  - We want 50mV at 100mA total current
    -
    -

MEASURING VOLTAGE AND CURRENT

- Def.: Voltmeter – instrument to measure voltage.
  –
  – Ideally,
  –

MEASURING VOLTAGE AND CURRENT

- The instrument should be set to its highest range before being connected into the circuit.
- For the greatest measurement accuracy, the best range to use is the one that gives the largest deflection not exceeding full scale.

MEASURING RESISTANCE THE WHEATSTONE BRIDGE

R_1, R_2 known

R_3 known, variable

R_x unknown

- Procedure:

MEASURING RESISTANCE
THE WHEATSTONE BRIDGE (2)

- Typically, a set of resistors R_1, R_2 with decimal ratio is provided: $1\text{m}\Omega$, $10\text{m}\Omega$, … $1\text{k}\Omega$